Department of Automation and Robotics

FMTH0301/Rev.5.3

Course Plan

Semester: **V** Year: 2022-23

Course Title: Machine learning and ROS	Course Code: 18EARC301
Total Contact Hours: 40	Duration of ESA : 3 Hours
ISA Marks: 50	ESA Marks: 50
Lesson Plan Author: Mr. Shridhar Doddamani	Date: 20-Aug-2022
Checked By: Dr. Sachin Karadgi	Date: 20-Aug-2022

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Explain robotic operating system concepts like publisher, subscriber and messages.
2. Use the perspective of machine learning and also to apply computer programming skills to solve the problems.
3. Apply concepts of decision trees, Bayesian learning, instance based learning and computational learning theory for identifying all relevant Constraints and requirements to formulate an accurate description of the problem while designing the machine learning based systems.
4. Apply cluster and kernel dimensionality reduction concept to categorize unsupervised data to design learning system.
5. Explain learning task for designing a system using Q-learning, non-deterministic rewards and actions.
6. Explain neural network from the available knowledge in the form of information and to select the most relevant among them with the help of Multiplayer perceptron.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: **Machine learning and ROS**	Semester: 5
Course Code: **18EARC301**	Year: 2021-2022

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1.Explain robotic operating system concepts like publisher, subscriber and messages.		**H**												
2.Use the perspective of machine learning and also to apply computer programming skills to solve the problems.		**H**	**M**	**M**										
3.Apply concepts of decision trees, Bayesian learning, instance based learning and computational learning theory for identifying all relevant Constraints and requirements to formulate an accurate description of the problem while designing the machine learning based systems.	**H**	**H**	**H**	**M**	**M**									
4.Apply cluster and kernel dimensionality reduction concept to categorize unsupervised data to design learning system.	**H**	**M**	**H**	**M**	**H**									
5.Explain learning task for designing a system using Q-learning, non-deterministic rewards and actions.	**H**	**H**	**H**											
6.Explain neural network from the available knowledge in the form of information and to select the most relevant among them with the help of Multiplayer perceptron.	**H**	**H**	**H**	**H**	**H**									

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 -Demonstrate the competence in mathematical modeling.	1.1.1 - Apply mathematical techniques to solve problems
	1.1.2-Apply discipline specific advanced mathematical techniques to modelling and problem solving.
1.3-Demonstrate competence in engineering problem	1.3.3- Apply computer programming skills to solve problems by building algorithm, flowchart and debugging.
2.1-Demonstrate an ability to identify and characterize an engineering problem	2.1.3-Identifies all relevant constraints and requirements and formulate an accurate descriptions of the problem.
	2.1.4-Gathers engineering knowledge from the available literature and selects the most relevant
2.2- Demonstrate an ability to formulate a solution plan and methology for an engineering problem	2.2.2-Partitions the problem, processes or systems into manageable elements for the purposes of analysis modeling or design.
2.3-Demostrate an ability to formulate and interpret the model	2.3.1-Evaluates the analysis for accuracy and validity of assumptions made.
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.3 Identify the suitable criteria for evaluation of alternate design solutions
4.3 Demonstrate an ability to critically analyze data to reach a valid conclusion	4.3.1 Use appropriate procedures, tools and techniques to collect and analyze data
5.2Demonstrate an ability to select and apply discipline specific tools, techniques and resources	5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) Monitoring system performance, and (iv) creating engineering designs.

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code:18EARC301	Course Title: **Machine learning and ROS**	
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration : 3 hours

Content	Hours
UNIT – 1	
Chapter 1:Introduction to Robot operating system ROS concepts, creating ROS packages writing a minimal ROS publisher, compiling ROS nodes, running ROS nodes, examining running minimal publisher node, scheduling node timing, writing a minimal ROS subscriber compiling and running minimal subscriber, minimal subscriber and publisher node summary writing ROS nodes more ROS tools: catkin simple, ROSlaunch, simplifying cmakelists.txt with catkin simple automating starting multiple nodes viewing output in a ROS console recording and playing back data with ROSbag.	5 hrs
Chapter 2:Messages, Classes and Servers in ROS Defining custom messages, ROS services- service messages, ROS service nodes, manual interaction with ROS services, example ROS service client, running, example service and client, using C++ classes in ROS creating library modules in ROS, introduction to action servers and action clients- creating an action server package, defining custom action-server messages, designing an action client running the example code, introduction to parameter server.	5 hrs
Chapter 3: **Introduction to machine learning** Introduction Machine Learning ,Well posed learning problem, Types of learning, supervised learning ,unsupervised learning and reinforcement learning, Learning Associations, Designing of learning system, perspectives & issues in machine learning, Concept learning task, concept learning search, Find-S: Finding a maximally specific hypotheses, version spaces & candidate elimination algorithm, Remarks - version spaces & candidate elimination algorithm, inductive bias.	5 hrs
UNIT – 2	
Chapter 4: Computational learning theory and decision tree learning Motivation, Estimating hypotheses accuracy, Basics of sampling theory, general approach for deriving confidence intervals, comparing learning algorithm. Probably learning an approximately correct hypothesis, sample complexity for finite hypnosis spaces, sample complexity for infinite hypothesis spaces, instance based learning-K nearest neighbor learning, locally weighted regression, Representation, decision tree algorithm, hypotheses space search in decision tree algorithm inductive bias in decision tree algorithm, issues in DTL, Bayesian decision theory classification.	8 hrs

Chapter 5:Kernel methods and Graphical models Embedding's into feature spaces, the kernel trick, Multiple kernel learning, Kernel dimensionality reduction Canonical Cases for Conditional Independence, Example Graphical Models, Naive Bayes' Classifier, Hidden Markov Model, Linear Regression, d-Separation Belief Propagation, Linkage–Based clustering algorithms-means and other cost minimization clustering.	7 hrs
UNIT – 3	
Chapter 6:Reinforcement Learning The learning task,Q-learning,Nondeterministic rewards & actions, temporal difference learning, generalizing from examples, relationship to dynamic programming.	5 hrs
Chapter 7: Artificial neural network Biological motivation, neural network representations, and appropriate problems for neural network learning, perceptron's, multilayer networks and the back propagation, algorithm, an illustrative example: face recognition	5 hrs

Text Book (List of books as mentioned in the approved syllabus)

1. Wyatt S. Newman " A Systematic Approach to Learning Robot Programming with ROS" CRC Press Taylor & Francis Group, 2018
2. Tom Mitchell "Machine Learning" McGraw-Hill Science/Engineering/Math (March 1, 1997).

References

1. Shai shalev-scwartz and Shai Ben David "Understanding Machine Learning" First Edition, Cambridge Press, USA, 2014.
2. Anis Koubaa "Robot Operating System" The Complete Reference (Volume 1), Springer publications,2016

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
Minor Exam-1	15
Minor Exam- 2	15
Course project	20
Total	50

Course Unitization for Minor Exams and Semester End Examination

Topics / Chapters	Teaching hours	No. of Questions in Minor Exam-1	No. of Questions in Minor Exam -2	No. of Questions in ESA
UNIT I				
Chapter 1:Introduction to Robot operating system	5	1	--	1
Chapter 2:Messages, Classes and Servers in ROS	5	1	--	1
Chapter 3: Introduction to machine learning	5	1	--	1
UNIT II				
Chapter 4: Computational learning theory and decision tree learning	8		1.5	1.5
Chapter 5:Kernel methods and Graphical models	7		1.5	1.5
UNIT III				
Chapter 6:Reinforcement Learning	5			1
Chapter 7: Artificial neural network	5			1

Note

1. Each question carries 20 marks and may consist of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA I, II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date:22/09/2020 **Head of Department**

Course Assessment Plan

<table>
<tr><td colspan="6">Course Title: Machine learning and ROS Course Code:18EARC301</td></tr>
<tr><td rowspan="2">Course outcomes (COs)</td><td rowspan="2">Weightage in assessment</td><td colspan="4">Assessment Methods</td></tr>
<tr><td>Minor Exam-1</td><td>Minor Exam-2</td><td>Course project</td><td>End semester assement</td></tr>
<tr><td>1.Explain robotic operating system concepts like publisher, subscriber and messages.</td><td>25%</td><td>✔</td><td></td><td>✔</td><td>✔</td></tr>
<tr><td>2.Use the perspective of machine learning and also to apply computer programming skills to solve the problems.</td><td>13%</td><td>✔</td><td></td><td>✔</td><td>✔</td></tr>
<tr><td>3.Apply concepts of decision trees, Bayesian learning, instance based learning and computational learning theory for identifying all relevant Constraints and requirements to formulate an accurate description of the problem while designing the machine learning based systems.</td><td>20%</td><td>✔</td><td></td><td>✔</td><td>✔</td></tr>
<tr><td>4.Apply cluster and kernel dimensionality reduction concept to categorize unsupervised data to design learning system.</td><td>17%</td><td></td><td>✔</td><td>✔</td><td>✔</td></tr>
<tr><td>5.Explain learning task for designing a system using Q-learning, non-deterministic rewards and actions.</td><td>13%</td><td></td><td>✔</td><td>✔</td><td>✔</td></tr>
<tr><td>6.Explain neural network from the available knowledge in the form of information and to select the most relevant among them with the help of Multiplayer perceptron.</td><td>12%</td><td></td><td></td><td>✔</td><td>✔</td></tr>
<tr><td colspan="2">Weightage</td><td>15%</td><td>15%</td><td>20%</td><td>50%</td></tr>
</table>

Chapter-wise plan

Course Code and Title:**18EARC301 Machine learning and ROS**	
Chapter Number and Title:**1:Introduction to Robot operating system**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. ROS concepts, creating ROS packages writing a minimal ROS publisher, compiling ROS nodes, running ROS nodes, examining running minimal publisher node, scheduling node timing, writing a minimal ROS subscriber compiling and running minimal subscriber	CO1	L2	1.1
2. minimal subscriber and publisher node summary writing ROS nodes more ROS tools: catkin simple, ROSlaunch, simplifying cmakelists.txt with catkin simple automating starting multiple nodes viewing output in a ROS console recording and playing back data with ROSbag	CO1	L2	1.1

Lesson Schedule Class No. - Portion covered per hour
1. ROS concepts, creating ROS packages writing a minimal ROS publisher, compiling ROS nodes, running ROS nodes
2. running ROS nodes, examining running minimal publisher node, scheduling node timing
3. writing a minimal ROS subscriber compiling and running minimal subscriber
4. minimal subscriber and publisher node summary writing ROS nodes more ROS tools: catkin simple
5. ROSlaunch, simplifying cmakelists.txt with catkin simple automating starting multiple nodes, viewing output in a ROS console recording and playing back data with ROSbag

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain the procedure for creating ROS packages with an example.	TLO1	L2	1.1.2
2. How to examine the running minimal publisher node? Write the procedure for the same.	TLO3	L2	1.1.2

Course Code and Title:**18EARC301 Machine learning and ROS**	
Chapter Number and Title:**2:Messages,classes and servers in ROS**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Defining custom messages, ROS services- service messages, ROS service nodes, manual interaction with ROS services, example ROS service client	CO1	L2	1.1
2. Running, example service and client, using C++ classes in ROS creating library modules in ROS,	CO1	L3	1.3
3. Introduction to action servers and action clients- creating an action server package, defining custom action-server messages, designing an action client running the example code, introduction to parameter server	CO1	L2	1.1

Lesson Schedule Class No. - Portion covered per hour
1. Defining custom messages, ROS services
2. service messages, ROS service nodes, manual interaction with ROS services,
3. example ROS service client, running, example service and client, using C++ classes in ROS creating library modules in ROS,
4. introduction to action servers and action clients- creating an action server package, defining custom action-server messages
5. designing an action client running the example code, introduction to parameter server

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain the ROS services.	TLO1	L2	1.1.2
2.Explain the method of defining C++ classes in ROS with an example program	TLO3	L3	1.3.3
3. How to create library modules in ROS? Write an example for the same.	TLO3	L3	1.3.3

Course Code and Title:**18EARC301 Machine learning and ROS**	
Chapter Number and Title**: 3. Introduction to machine learning**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the course student should be able to:

TLO's	CO's	BL	CA Code
1. Introduction Machine Learning ,Well posed learning problem, Types of learning, supervised learning ,unsupervised learning and reinforcement learning, Learning Associations	CO2	L2	1.1
2. Designing of learning system, perspectives & issues in machine learning, Concept learning task, concept learning search, Find-S: Finding a maximally specific hypotheses	CO2	L3	1.3
3. Apply Version spaces & candidate elimination algorithm, Remarks - version spaces & candidate elimination algorithm, inductive bias.	CO2	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction Machine Learning ,Well posed learning problem, Types of learning,
2. supervised learning ,unsupervised learning and reinforcement learning, Learning Associations
3. Designing of learning system, perspectives & issues in machine learning, Concept learning task
4. concept learning search, Find-S: Finding a maximally specific hypotheses, Version spaces & candidate elimination algorithm, Remarks - version spaces
5. Candidate elimination algorithm, inductive bias.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1.Discuss the perspectives & issues in machine learning	TLO1	L2	1.1.2
2.Write an algorithm for Find-S: Finding maximally specific	TLO4	L3	1.3.3

<table>
<tr><td>hypotheses.</td><td></td><td></td><td></td></tr>
<tr><td>3. Write candidate elimination algorithm.</td><td>TLO5</td><td>L3</td><td>1.3.3</td></tr>
<tr><td>4.Consider the problem of marketting agent who is trying to infer which books or articles the user reads based on keywords supplied in the article. Suppose the learning agent has the following data:
article Crime Academic Local Music Reads
a1 T F F T T
a2 T F F F T
a3 F T F F F
a4 F F T F F
a5 T T F F T
The aim of the given problem is to learn which articles the user reads.
Apply candidate elimination algorithm to achieve the specified aim.</td><td>TLO5</td><td>L3</td><td>2.2.2</td></tr>
<tr><td>5.Apply Find-S algorithm for the following problem.

Target Concept: Learning the concept of "Japanese Economy Car" ,Features: (Country of Origin, Manufacturer, Color, Decade, Type)

<table>
<tr><th>Origin</th><th>Manufacturer</th><th>Color</th><th>Decade</th><th>Type</th><th>Example Type</th></tr>
<tr><td>Japan</td><td>Honda</td><td>Blue</td><td>1980</td><td>Economy</td><td>Positive</td></tr>
<tr><td>Japan</td><td>Toyota</td><td>Green</td><td>1970</td><td>Sports</td><td>Negative</td></tr>
<tr><td>Japan</td><td>Toyota</td><td>Blue</td><td>1990</td><td>Economy</td><td>Positive</td></tr>
<tr><td>USA</td><td>Chrysler</td><td>Red</td><td>1980</td><td>Economy</td><td>Negative</td></tr>
<tr><td>Japan</td><td>Honda</td><td>White</td><td>1980</td><td>Economy</td><td>Positive</td></tr>
</table></td><td>TLO4</td><td>L3</td><td>2.2.2</td></tr>
</table>

KLE Technological University
Creating Value
Leveraging Knowledge

Department of Automation and Robotics

<table>
<tr><th colspan="2">Model Question Paper for Minor Examination – I (ISA)</th></tr>
<tr><td>Course Code: 18EARC301</td><td>Course Title: : Machine learning and ROS</td></tr>
<tr><td>Duration(H:M): 1:15</td><td>Max. Marks:40</td></tr>
<tr><td colspan="2">Note: Answer any two questions.</td></tr>
</table>

<table>
<tr><th>Q.No.</th><th>Questions</th><th>Marks</th><th>CO</th><th>BL</th><th>PO</th><th>PI Code</th></tr>
<tr><td>1a</td><td>How to examine the running minimal publisher node? Write the procedure for the same.</td><td>8</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>1b</td><td>Explain the method of defining C++ classes in ROS with an example program</td><td>8</td><td>CO2</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>1c</td><td>List the application of ROS .</td><td>4</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>2a</td><td>Explain the procedure for creating ROS packages with an example.</td><td>8</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>2b</td><td>How to create library modules in ROS? Write an example for the same.</td><td>8</td><td>CO1</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>2c</td><td>Explain ROS services.</td><td>4</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>3a</td><td>Apply Find-S algorithm for the following problem.
Target Concept: Learning the concept of "Japanese Economy Car" ,Features: (Country of Origin, Manufacturer, Color, Decade, Type)
<table>
<tr><th>Origin</th><th>Manufacturer</th><th>Color</th><th>Decade</th><th>Type</th></tr>
<tr><td>Japan</td><td>Honda</td><td>Blue</td><td>1980</td><td>Economy</td></tr>
<tr><td>Japan</td><td>Toyota</td><td>Green</td><td>1970</td><td>Sports</td></tr>
<tr><td>Japan</td><td>Toyota</td><td>Blue</td><td>1990</td><td>Economy</td></tr>
<tr><td>USA</td><td>Chrysler</td><td>Red</td><td>1980</td><td>Economy</td></tr>
<tr><td>Japan</td><td>Honda</td><td>White</td><td>1980</td><td>Economy</td></tr>
</table></td><td>8</td><td>CO2</td><td>L3</td><td>2</td><td>2.2.2</td></tr>
<tr><td>3b</td><td>.Consider the problem of marketting agent who is trying to infer which books or articles the user reads based on keywords supplied in the article. Suppose the learning agent has the following data:
<table>
<tr><th>article</th><th>Crime</th><th>Academic</th><th>Local</th><th>Music</th><th>Reads</th></tr>
<tr><td>a1</td><td>T</td><td>F</td><td>F</td><td>T</td><td>T</td></tr>
<tr><td>a2</td><td>T</td><td>F</td><td>F</td><td>F</td><td>T</td></tr>
<tr><td>a3</td><td>F</td><td>T</td><td>F</td><td>F</td><td>F</td></tr>
<tr><td>a4</td><td>F</td><td>F</td><td>T</td><td>F</td><td>F</td></tr>
<tr><td>a5</td><td>T</td><td>T</td><td>F</td><td>F</td><td>T</td></tr>
</table>
The aim of the given problem is to learn which articles the user reads. Apply candidate elimination algorithm to achieve the specified aim.</td><td>8</td><td>CO2</td><td>L3</td><td>2</td><td>2.2.2</td></tr>
<tr><td>3c</td><td>What is machine learning?</td><td>4</td><td>CO2</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
</table>

Course Code and Title:**17EARC305 Machine learning and ROS**	
Chapter Number and Title: **4 : Computational learning theory and decision tree learning**	Planned Hours: **8 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Explain Estimating hypotheses accuracy, Basics of sampling theory, general approach for deriving confidence intervals	CO3	L2	2.2
2. Identify difference in error of two hypotheses, comparing learning algorithm. Probably learning an approximately correct hypothesis	CO3	L3	2.1
3. Interpret sample complexity for finite hypnosis spaces, sample complexity for infinite hypothesis spaces, Apply instance based learning-K nearest neighbor learning, locally weighted regression	CO3	L3	1.3
4. Apply decision tree algorithm, hypotheses space search in decision tree algorithm inductive bias in decision tree algorithm, Discuss issues in DTL, Bayesian decision theory classification.	C03	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Explain Estimating hypotheses accuracy, Basics of sampling theory, general approach for deriving confidence intervals
2. Identify difference in error of two hypotheses, comparing learning algorithm. Probably learning an approximately correct hypothesis
3. Understand sample complexity for finite hypnosis spaces, Identify sample complexity for infinite hypothesis spaces
4. Explain the mistake bound model of learning.

5.	Explain instance based learning-K nearest neighbor learning, locally weighted regression
6.	Problems for decision tree, Decision tree algorithm Analyze hypotheses space search in decision tree algorithm inductive bias in decision tree algorithm.
7.	Understand issues in DTL
8.	Understand Bayesian decision theory classification

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1.Discuss the general approaches for deriving confidence intervals	TLO1	L2	2.2.2
2.Explain Probably learning an approximately correct hypothesis	TLO2	L2	2.1.1
3. Write mistake bound for Halving algorithm.	TLO4	L3	1.3.3
4. Write ID3 algorithm for decision learning trees.	TLO6	L3	1.3.3
5. Explain capabilities & limitations of ID3 algorithm in terms of its search space & search strategy.	TLO6	L2	2.2.2
6. Discuss the issues of decision tree learning.	TLO7	L2	1.3.3
7. Train a decision tree using the following instances With the help of ID3 algorithm and also generate the final decision tree	TLO6	L3	1.3.3

Weekend (Example)	**Weather**	**Parents**	**Money**	**Decision (Category)**
W1	Sunny	Yes	Rich	Cinema
W2	Sunny	No	Rich	Tennis
W3	Windy	Yes	Rich	Cinema
W4	Rainy	Yes	Poor	Cinema
W5	Rainy	No	Rich	Stay in
W6	Rainy	Yes	Poor	Cinema
W7	Windy	No	Poor	Cinema

Course Code and Title:**18EARC301 Machine learning and ROS**	
Chapter Number and Title: **5:Kernel methods and Graphical models**	Planned Hours: **7 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Understand Embedding's into feature spaces, the kernel trick, Multiple kernel learning	CO4	L2	2.1
2. Apply Kernel dimensionality reduction,Implementating soft SVM with kernels, Canonical Cases for Conditional Independence, Example Graphical Models	CO4	L3	1.3
3. Apply Naive Bayes' Classifier, Hidden Markov Model, Linear Regression, d-Separation Belief Propagation, Linkage–Based clustering algorithms-means and other cost minimization clustering.	CO4	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Understand Embeddings into feature spaces, the kernel trick, Multiple kernel learning
2. Apply Kernel dimensionality reduction, Implementing soft SVM with kernels
3. Understand Canonical Cases for Conditional Independence
4. Example Graphical Models, Naive Bayes' Classifier, Hidden Markov Model
5. Linear Regression, d-Separation Belief Propagation
6. Linkage–Based clustering algorithms-means.
7. Cost minimization clustering

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Describe Multiple kernel learning.	TLO1	L2	2.1.3
2. How to apply Kernel dimensionality reduction?.	TLO2	L2	2.1.3
3. Write d-Separation Belief Propagation algorithm	TLO5	L3	1.3.3
4. Write Linkage–based clustering algorithm.	TLO6	L3	1.3.3
5. How to identify cost minimization method for other clustering's?	TLO7	L2	2.1.3

Department of Automation and Robotics

Model Question Paper for Minor Examination –II (ISA)	
Course Code: 18EARC301	Course Title: : Machine Learning and ROS
Duration(H:M): 1:15	Max. Marks:40
Note: Answer any two questions.	

<table>
<tr><th>Q.No</th><th>Questions</th><th>Marks</th><th>CO</th><th>BL</th><th>PO</th><th>PI Code</th></tr>
<tr><td>1a</td><td>Write WEIGHTED-MAJORITY algorithm.</td><td>8</td><td>CO3</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>1b</td><td>Explain the concept of k nearest neighbor learning algorithm with an example.</td><td>8</td><td>CO3</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>1c</td><td>How to find out the difference in error of two hypotheses?</td><td>4</td><td>CO3</td><td>L2</td><td>2</td><td>2.1.3</td></tr>
<tr><td>2a</td><td>Write mistake bound for Halving algorithm.</td><td>8</td><td>CO4</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>2b</td><td>Train a decision tree using the following instances With the help of ID3 algorithm and also generate the final decision tree
<table>
<tr><th>Weekend (Example)</th><th>Weather</th><th>Parents</th><th>Mone y</th><th>Decision (Category)</th></tr>
<tr><td>W1</td><td>Sunny</td><td>Yes</td><td>Rich</td><td>Cinema</td></tr>
<tr><td>W2</td><td>Sunny</td><td>No</td><td>Rich</td><td>Tennis</td></tr>
<tr><td>W3</td><td>Windy</td><td>Yes</td><td>Rich</td><td>Cinema</td></tr>
<tr><td>W4</td><td>Rainy</td><td>Yes</td><td>Poor</td><td>Cinema</td></tr>
<tr><td>W5</td><td>Rainy</td><td>No</td><td>Rich</td><td>Stay in</td></tr>
<tr><td>W6</td><td>Rainy</td><td>Yes</td><td>Poor</td><td>Cinema</td></tr>
<tr><td>W7</td><td>Windy</td><td>No</td><td>Poor</td><td>Cinema</td></tr>
</table>
</td><td>8</td><td>CO4</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>2c</td><td>Explain the following
1.Naive bayes classifier
2. Hidden Markova model.</td><td>4</td><td>CO4</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>3a</td><td>List and explain Canonical Cases for Conditional Independence.</td><td>8</td><td>CO4</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>3b</td><td>With two independent inputs in a classification problem, that is, $p(x1, x2|C) = p(x1|C)p(x2|C)$, how can we calculate $p(x1|x2)$? Derive the formula for $p(xj |Ci) \sim N(\mu ij ,\sigma^2 ij)$.</td><td>8</td><td>CO4</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>3c</td><td>How to setup clustering model?</td><td>4</td><td>CO4</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
</table>

Course Code and Title:**17EARC305 Machine learning and ROS**	
Chapter Number and Title: **6. Reinforcement Learning**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Understand learning task,Q-learning,Nondeterministic rewards & actions	CO5	L3	1.3
2. Understand temporal difference learning, generalizing from examples, and relationship to dynamic programming**.**	CO5	L2	2.3

Lesson Schedule Class No. - Portion covered per hour
1. Learning task
2. Q-learning
3. Nondeterministic rewards & actions
4. Temporal difference learning
5. Generalizing from examples, relationship to dynamic programming, Learning task

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Write Q-learning algorithm	TLO1	L3	1.3.3
2. What is reinforcement learning?	TLO1	L2	2.3.1
3. Explain temporal difference learning with an example.	TLO2	L2	2.3.1
4. Explain reinforcement learning scenario based on sensory perceptions where in the agent seeks to maximize cumulative reward by performing actions in the local scope.	Tlo2	L2	2.3.1

Course Code and Title:**17EARC305 Machine learning and ROS**	
Chapter Number and Title: **7 Artificial neural network**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Apply Feed forward neural networks, learning neural network.	CO6	L3	1.3.3
2. Understand expressive power of neural network, the sample complexity of neural networks	CO6	L3	1.3.3
3. Apply runtime of learning neural networks,SGD and backpropogation	CO6	L3	1.3.3

Lesson Schedule Class No. - Portion covered per hour
1. Define neural network
2. Apply Feed forward neural networks, learning neural network.
3. Understand expressive power of neural network, the sample complexity of neural networks.
4. Apply runtime of learning neural networks,SGD and backpropogation
5. Define neural network

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1, What is neural network? Explain Feed forward neural networks	TLO1	L1	1.1.2
2. Discuss of multilayer network & back propagation algorithm.	TLO4	L3	1.3.3

KLE TECH. KLE Technological University
Creating Value
Leveraging Knowledge

Department of Automation and Robotics

Model Question Paper for End Semester Assessment (ESA)	
Course Code :18EARC301	**Course : Machine Learning and ROS**
Duration :3 Hours	**Maximum Marks :100**
Note :Answer Five Questions: Any two full questions from each Unit I and Unit II and one full question from Unit III	

<table>
<tr><th colspan="7">UNIT-I</th></tr>
<tr><th>Q.No</th><th>Questions</th><th>Marks</th><th>CO</th><th>BL</th><th>PO</th><th>PI Code</th></tr>
<tr><td>1a</td><td>How to examine the running minimal publisher node? Write the procedure for the same.</td><td>8</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>1b</td><td>Explain the method of defining C++ classes in ROS with an example program</td><td>8</td><td>CO1</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>1c</td><td>List the application of ROS .</td><td>4</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>2a</td><td>Explain the procedure for creating ROS packages with an example.</td><td>8</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>2b</td><td>How to create library modules in ROS? Write an example for the same.</td><td>8</td><td>CO1</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>2c</td><td>Explain ROS services.</td><td>4</td><td>CO1</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>3a</td><td>Apply Find-S algorithm for the following problem. Target Concept: Learning the concept of "Japanese Economy Car" ,Features: (Country of Origin, Manufacturer, Color, Decade, Type)
<table>
<tr><th>Origin</th><th>Manufacturer</th><th>Color</th><th>Decade</th><th>Type</th></tr>
<tr><td>Japan</td><td>Honda</td><td>Blue</td><td>1980</td><td>Econom</td></tr>
<tr><td>Japan</td><td>Toyota</td><td>Green</td><td>1970</td><td>Sports</td></tr>
<tr><td>Japan</td><td>Toyota</td><td>Blue</td><td>1990</td><td>Econom</td></tr>
<tr><td>USA</td><td>Chrysler</td><td>Red</td><td>1980</td><td>Econom</td></tr>
<tr><td>Japan</td><td>Honda</td><td>White</td><td>1980</td><td>Econom</td></tr>
</table></td><td>8</td><td>CO2</td><td>L3</td><td>2</td><td>2.2.2</td></tr>
<tr><td>3b</td><td>.Consider the problem of marketing agent who is trying to infer which books or articles the user reads based on keywords supplied in the article. Suppose the learning agent has the following data:
article Crime Academic Local Music Reads
a1 T F F T T
a2 T F F F T</td><td>8</td><td>CO2</td><td>L3</td><td>2</td><td>2.2.2</td></tr>
</table>

<table>
<tr><td></td><td>a3 F T F F F
a4 F F T F F
a5 T T F F T
The aim of the given problem is to learn which articles the user reads. Apply candidate elimination algorithm to achieve the specified aim.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3c</td><td>What is machine learning?</td><td>4</td><td>CO2</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td colspan="7">UNIT-II</td></tr>
<tr><td>Q.No</td><td>Questions</td><td>Marks</td><td>CO</td><td>BL</td><td>PO</td><td>PI Code</td></tr>
<tr><td>4a</td><td>Write WEIGHTED-MAJORITY algorithm.</td><td>8</td><td>CO3</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>4b</td><td>Explain the concept of k nearest neighbor learning algorithm with an example.</td><td>8</td><td>CO3</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>4c</td><td>How to find out the difference in error of two hypotheses?</td><td>4</td><td>CO3</td><td>L2</td><td>2</td><td>2.1.3</td></tr>
<tr><td>5a</td><td>Write mistake bound for Halving algorithm.</td><td>8</td><td>CO3</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>5b</td><td>Train a decision tree using the following instances With the help of ID3 algorithm and also generate the final decision tree
<table>
<tr><td>Weekend (Example)</td><td>Weather</td><td>Parents</td><td>Money</td><td>Decision (Category)</td></tr>
<tr><td>W1</td><td>Sunny</td><td>Yes</td><td>Rich</td><td>Cinema</td></tr>
<tr><td>W2</td><td>Sunny</td><td>No</td><td>Rich</td><td>Tennis</td></tr>
<tr><td>W3</td><td>Windy</td><td>Yes</td><td>Rich</td><td>Cinema</td></tr>
<tr><td>W4</td><td>Rainy</td><td>Yes</td><td>Poor</td><td>Cinema</td></tr>
<tr><td>W5</td><td>Rainy</td><td>No</td><td>Rich</td><td>Stay in</td></tr>
<tr><td>W6</td><td>Rainy</td><td>Yes</td><td>Poor</td><td>Cinema</td></tr>
<tr><td>W7</td><td>Windy</td><td>No</td><td>Poor</td><td>Cinema</td></tr>
</table></td><td>8</td><td>CO4</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
<tr><td>5c</td><td>Explain the following
1.Naive bayes classifier
2. Hidden Markova model.</td><td>4</td><td>CO4</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>6a</td><td>List and explain Canonical Cases for Conditional Independence.</td><td>8</td><td>CO4</td><td>L2</td><td>1</td><td>1.1.2</td></tr>
<tr><td>6b</td><td>With two independent inputs in a classification problem, that is, p(x1, x2|C) = p(x1|C)p(x2|C), how</td><td>8</td><td>CO4</td><td>L3</td><td>1</td><td>1.3.3</td></tr>
</table>

	can we calculate p(x1|x2)? Derive the formula for p(xj |Ci) ~N(μij ,$\sigma^2 ij$).					
6c	How to setup clustering model?	4	CO4	L2	1	1.1.2
UNIT-III						
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
7a	Write Q learning algorithm.	8	CO5	L3	1	1.3.3
7b	Explain the learning task.	8	CO5	L2	1	1.1.2
7c	What is reinforcement learning?	4	CO5	L2	1	1.1.2
8a	Explain feed forward neural network.	8	CO6	L2	2	2.3.1
8b	Write backpropogation algorithm.	8	CO6	L3	1	1.3.3
8c	What is artificial neural network?	4	CO6	L2	1	1.1.2

FMTH0301/Rev.5.3

Course Plan

Semester: III Year: 2021-22

Course Title: Analog and Digital Electronic Circuits	Course Code: 18EARC201
Total Contact Hours: 50	Duration of ESA: 3 Hours
ISA Marks: 50	ESA Marks: 50
Lesson Plan Author: Mrs. C B Kolanur	Date: 01-09-2021
Checked By: Prof. Rakesh Tapaskar	Date: 04-09-2021

Course Outcomes (COs):

At the end of the course the student should be able to:

i. Apply knowledge of analog abstraction applied to electric circuits, perform network analysis and their problems like transients.

ii. Develop the concepts of transistors and operational amplifiers along with ability to solve complex circuits involving active and passive elements. viz. Ohms law, KCL, KVL, Thevenin's, Norton's, Superposition theorems etc.

iii. Apply the knowledge of digital abstraction applied to logic gates, digital integrated circuits and their operations.

iv. Construct digital sequential and combinational logic circuits using theorems and reduction techniques of Boolean expressions like and DE Morgan's theorem and K-Maps.

v. Identify the application of the analog and digital electronics in the robotic subsystems with the help of case studies.

vi. Demonstrate conceptual and practical skill in modelling and solving real world intricate problems with design, simulate and development of analog, digital or combinational logic subsystem for assigned course project.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: Analog and Digital Electronic Circuits	Semester: 3
Course Code: 18EARC201	Year: 2021-2022

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
i. Apply knowledge of analog abstraction applied to electric circuits, perform network analysis and their problems like transients.	**H**													
ii. Develop the concepts of transistors and operational amplifiers along with ability to solve complex circuits involving active and passive elements. viz. Ohms law, KCL, KVL, Thevenin's, Norton's, Superposition theorems etc.	**M**													
iii. Apply the knowledge of digital abstraction applied to logic gates, digital integrated circuits and their operations.	**H**	**H**												
iv.Construct digital sequential and combinational logic circuits using theorems and reduction techniques of Boolean expressions like and DE Morgan's theorem and K-Maps.	**M**	**H**												
v. Identify the application of the analog and digital electronics in the robotic subsystems with the help of case studies.	**M**	**H**												
vi. Demonstrate conceptual and practical skill in modelling and solving real world intricate problems with design, simulate and development of analog, digital or combinational logic subsystem for assigned course project.	**M**	**M**	H	H	H			H	H	H				

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 Demonstrate the competence in mathematical modeling.	1.1.2 - Apply discipline specific advanced mathematical techniques to modeling and problem solving
1.3 Demonstrate competence in engineering fundamentals	1.3.2 - Apply basic electrical and electronics engineering principles and laws to solve problems
2.1 Demonstrate an ability to identify and characterize an engineering problem	2.1.3 - Identifies all relevant constraints and requirements and formulate an accurate description of the problem
	2.1.4 - Gathers engineering knowledge from the available literature and selects the most relevant
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 - Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions
	2.2.2 - Partitions problems, processes or systems into manageable elements for the purposes of analysis, modeling or design
3.1 - Demonstrate an ability to define a complex open-ended problem in engineering terms	3.1.6 - Determines design objectives, functional requirements and arrives at specifications
4.2 - Demonstrate their ability to design experiments to solve open ended problems	4.2.1 - Develop and design experimental approach, specify appropriate equipment and procedures, implement these procedures, and interpret the resulting data to characterize an engineering material, component, or system.
5.1 - Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1 - Identify modern engineering tools, techniques and resources for engineering activities
10.1 - Demonstrate an ability to comprehend technical literature and document project work.	10.1.1 - Read, understand and interpret technical and non-technical information

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: **18EARC201**	Course Title: **Analog and Digital Electronic Circuits**	
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Duration of ESA: 3 hrs

Content	**Hrs**
Unit - 1	
1.0 Introduction of PN junctions and analog electronics Diode theory, forward and reverse biased junctions, reverse- bias breakdown, load line analysis, diode applications – limiters, clippers, clampers, voltage multipliers, half wave and full wave rectification, voltage regulators, voltage dividers, pull up, pull down, optocoupler, special purpose diodes – Zener diode, varactor, light emitting diodes, photodiodes. Network theorems and applications: KVL, KCL, Node Method, Loop Method, Superposition, Thevenin's Theorem and Norton's Theorem.	7
2.0 Transistors Bipolar Junction Transistors and introduction to MOSFET: Operating point, Fixed bias circuits, Emitter stabilized biased circuits, Voltage divider biased, Bias stabilization, BJT transistor modeling, , Emitter follower, CB configuration, Collector feedback configuration, analysis of CE configuration using h- parameter model; Relationship between h-parameter model of CE,CC and CB configuration, Introduction to MOSFETs, MOSFET as a switch.	7
3.0 Operational Amplifiers Op-Amp Basics, practical Op-Amp circuits, differential and Common mode operation, Inverting & Non-Inverting Amplifier, differential and cascade amplifier, Op-Amp applications: Voltage follower, Comparator, summing, integrator, differentiator, instrumentation amplifiers, Schmitt trigger, Op-amp based oscillators.	6
Unit - 2	
4.0 Number system and digital logic gates Decimal, binary, octal, hexadecimal number system and conversion, binary weighted codes, signed numbers, 1s and 2s complement codes, Binary arithmetic. Logical Operators, Logic Gates-Basic Gates, Other gates, Active high and Active low concepts, Universal Gates and realization of other gates using universal gates, Gate Performance Characteristics and Parameters.	6
5.0 Boolean algebra and combinational logic circuits Binary logic functions, Boolean laws, truth tables, half adder, full adder, subtractor, associative and distributive properties, DE Morgan's theorems, realization of switching functions using logic gates. Switching equations, canonical logic forms, sum of product & product of sums, Karnaugh maps, two, three and four variable Karnaugh maps, simplification of expressions.	7
6.0 Design of combinational logic circuits and sequential logic Introduction to combinational circuits, code conversions, decoder, encoder, priority encoder, multiplexers as function generators, binary adder, subtractor, BCD adder, Binary comparator, arithmetic logic units. Sequential circuits, flip-flops, clocked and edge triggered flipflops, timing specifications, asynchronous and synchronous counters, counter design with state equations, Registers, serial in serial out shift registers, tristate register, timing considerations.	7
Unit - 3	
7.0 Data conversions Introduction to data conversions, $R/2^nR$ DAC, R/2R, Flash, Digital ramp ADC, Successive approximation ADC, Slope (integrating) ADC, Delta-Sigma ($\Delta\Sigma$) ADC, Practical considerations of ADC circuits.	5
8.0 Digital integrated circuits Logic levels, propagation delay time, power dissipation fan-out and fan-in, noise margin, logic families and their characteristics TTL, LSTTL CMOS and ECL integrated circuits and their performance comparison, open collector and tristate gates and buffers.	5

Text Books:
1. Anant Agarwal, Foundations of Analog and Digital Electronic Circuits, 1, Morgan Kau, 2005
2. Thomas L. Floyd, Digital fundamentals, 9, Pearson Ed, 2006
3. Robert L. Boylestad, Electronic Devices and Circuit Theory, 10, Pearson Ed, 2008

Evaluation Scheme for ISA

Assessment	Weightage in Marks
ISA-1	20
ISA-2	20
Activity	10
Total	50

Course Unitization for ISA Exams and ESA

Topics / Chapters	Teaching hours	No. of Questions in ISA-1	No. of Questions in ISA-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
1.0 Introduction of PN junctions and analog electronics	7	1.00	--	0	1
2.0 Transistors	7	1.00	--	0	1
3.0 Operational Amplifiers	6	1.00	--	0	1
Unit II					
4.0 Number system and digital logic gates	7	--	1.00	0	1
5.0 Boolean algebra and combinational logic circuits	7	--	1.00	0	1
6.0 Design of combinational logic circuits and sequential logic	6	--	1.00	0	1
Unit III					
7.0 Data conversions	5	--	--	0	1
8.0 Digital integrated circuits	5	--	--	0	1

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA-1, II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full question from Unit III) out of 8 questions in ESA.

Date: 04/09/2021 **Head of Department**

Course Assessment Plan

Course Title:		Code:			
Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		ISA-1	ISA-2	ACTIVITY	ESA
i. Identify, analyze and design basics of the electronics circuits with network theorems.	5	✓			✓
ii. Analyze the various biasing methods of BJTs using CB, CE and CC configurations and modeling parameters of each configuration using h parameter model.	5	✓			✓
iii. Design Op-Amp circuits to perform operations such as integration, differentiation and filtering on electronic signals.	15	✓			✓
iv. Discuss the number systems and their conversions also understand the operations of logic gates.	15	✓	✓		✓
v. Identify, analyze various combinational, synchronous and asynchronous sequential circuits from simple to complex form with their truth tables using Boolean algebra and K-map techniques.	15		✓		✓
vi. Design combinational and sequential logic circuits and analyze their practical applications.	15		✓		✓
vii. Design and analyze signal conversion circuits – Analog to digital vice versa.	10				✓
viii. Discuss the critical parameters associated with the digital integrated circuits determining their performance.	10				✓
ix. Solve in a team of four students, the assignment problems on each of the chapter with regular interaction with team leaders and Course instructor and students to undergo assessment of their performance based on surprise tests planned on assignments	10				✓
Weightage		20	20	10	50

UNIT I
Chapter-wise Plan

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **01.** Introduction of PN junctions and analog electronics	Planned Hrs: **7hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Explain the concept of PN Junction and biasing.	CO1	L2	1.1
2. Discuss the various wave shaping circuits, voltage regulators and diodes.	CO1	L3	1.1
3. Apply Kirchhoff's current and voltage laws to solve for branch current and voltage in the circuit.	CO1	L3	1.1
4. Discuss and understand the concepts of pull down, pull up and special purpose diodes.	CO1	L2	1.1
5. Apply network theorems to simplify circuit analysis, and provide substantial insight about how circuits behave.	CO1	L3	1.1

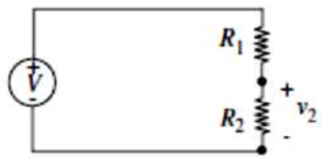
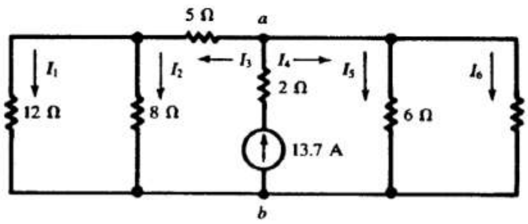
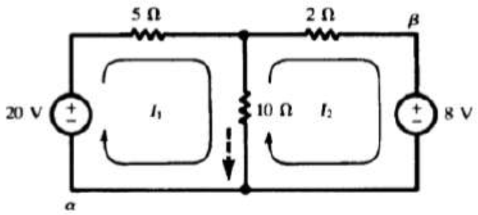
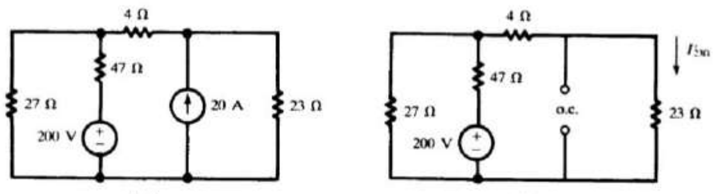
Lesson Schedule

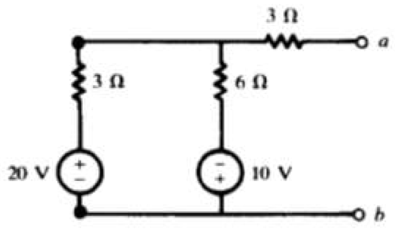
Class No. Portion covered per hour

1. PN Junction and diode theory – biasing, diode characteristics.
2. Wave shaping networks – clippers, clampers, voltage regulators, voltage divider.
3. Special purpose diodes – Zenner diode, Photodiodes.
4. Discussions on Voltage dividers, KVL and KCL and their applications.
5. Network theorems: Node Method, Loop Method.
6. Superposition theorem.
7. Thevenin's Theorem and Norton's Theorem.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What is biasing? Briefly explain forward and reverse biasing of PN junction.	1	L2	1.1.2
2	Briefly explain the difference between ideal and practical diode characteristics.	1,2	L3	1.1.2
3	Explain clippers and clampers and their applications.	3	L3	1.1.2
4	What are voltage multipliers explain with suitable circuit diagram?	4	L3	1.1.2
5	What is the significance of pull-up and pull-down resistors in electronic circuits	4	L3	1.1.2

6	Explain Node and Mesh method of solving electronic networks?	4	L3	1.1.2
7	State and explain Thevenin's theorem and Norton's theorem??	4	L3	1.1.2
8	State and explain Superposition theorem?	5	L3	1.1.2
9	Explain Zenner diode with its applications as voltage regulator.	4,5	L3	1.1.2
10	Explain KVL and KCL.	4,5	L3	1.1.2
11	A voltage divider circuit shown in Fig. below has V = 10 V and $R2$ = 1 kΩ. Choose $R1$ such that $v2$ is 10% of V. 	4,5	L3	1.1.2
12	Find all branch currents in the network shown in Fig. below 	5	L3	1.1.2
13	Obtain the current in each branch of the network shown in Fig. using the mesh current method. 	5	L3	1.1.2
14	Compute the current in the 23ohm resistor of Fig. (a) by applying the superposition principle. With the 200-V source acting alone, the 20-A current source is replaced by an open circuit, Fig. (b).  (a) (b)	5	L3	1.1.2
15	Obtain the Thevenin and Norton equivalent circuits for the active network in Fig. (a).	5	L3	1.1.2

	 (a)			

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **02. Transistors**	Planned Hours: **7 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Describe the need for biasing and obtain the operating point from AC and DC Load lines.	CO4	L2	2.1
2. Analyze the biasing stability of Fixed bias, collector to base bias and voltage divider bias circuits.	CO4	L3	2.1
3. Describe the h-parameter model and analyze the transistor amplifier using h-parameters.	CO4	L2	2.1
4. Analyze Small signal BJT Amplifiers at low & high frequency.	CO4	L3	2.1

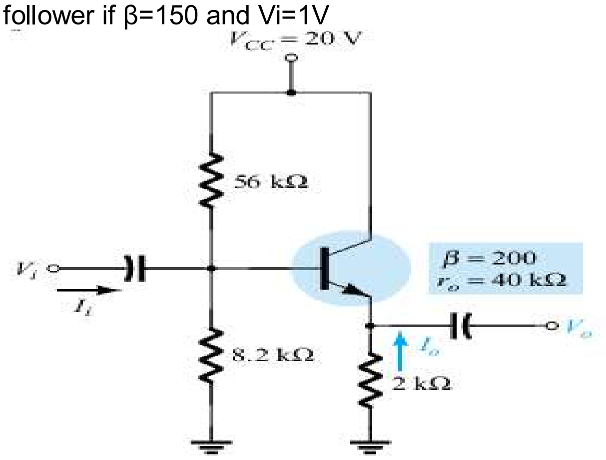
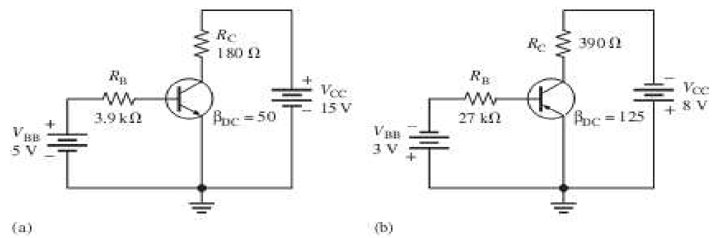
Lesson Schedule

Class No. Portion covered per hour

1. Operating point, Fixed bias circuits,
2. Emitter stabilized biased circuits, Voltage divider biased,
3. Bias stabilization, BJT transistor modeling, Emitter follower, CB configuration,
4. Collector feedback configuration,
5. analysis of CE configuration using h- parameter mode
6. Relationship between h-parameter model of CE, CC and CB configuration.
7. MOSFETS introduction, fundamentals and importance.
8. MOSFET as switch.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Explain the purpose of dc bias. Do the following Define Q-point and describe how it affects the output of an amplifier Describe and draw a dc load line State the conditions for linear operation	1	L3	2.1.4

	Explain what causes waveform distortion			
2	Explain the working of a voltage divider biased amplifier, highlighting on bias stabilization. With its circuit diagram.	2	L3	2.1.4
.3	Sketch the typical i/p and o/p characteristics of an NPN transistor and explain the three regions of operation	1	L3	2.1.4
4	Calculate α_{dc} and β_{dc} for the transistor if Ic is measured as 1mA and I_B is 25µA. Also determine the new base current to give Ic=5mA	1	L3	2.1.4
5	Calculate the voltage gain and the ac voltage of the following emitter follower if β=150 and Vi=1V 	4	L3	2.1.4
6	What is the value of IC for IE =5.34 mA and IB =475 mA? Find VCE, VBE, and VCB in both circuits. 	2	L3	2.1.4
7	Derive the expression for voltage gain of single stage CE voltage-divider bias amplifier using h-model	3	L3	2.1.4
8	Explain the operation of MOSFET as switch?	3	L3	2.1.4

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **03. Operational amplifiers**	Planned Hours: **6 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

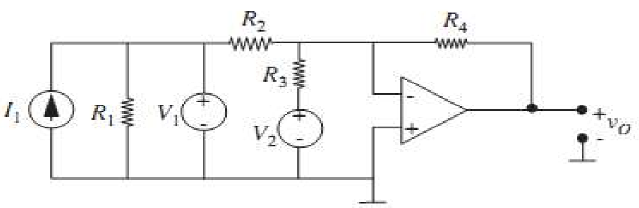
TLO's	CO's	BL	CA Code
1. Understand Operational amplifiers – fundamentals and importance.	CO4	L2	2.1
2. Discuss practical applications of Op-amps.	CO4	L3	2.1
2. Build Inverting, Non inverting, differential and cascade amplifier.	CO4	L2	2.1
3. Discuss and apply concept of Op-amp applications- Summing, Integrator	CO4	L3	2.1
4. Understand importance of Schmitt trigger, instrumentation amplifiers.	CO4	L3	2.1
6. Discuss the importance of Op-amp based oscillators	CO4	L3	2.1

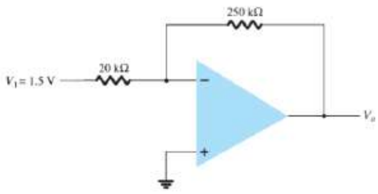
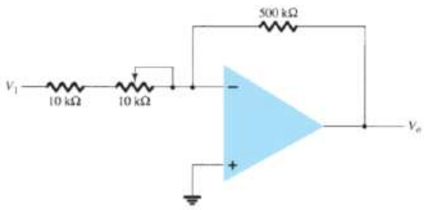
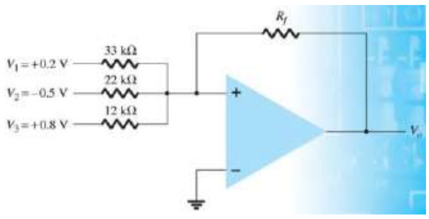
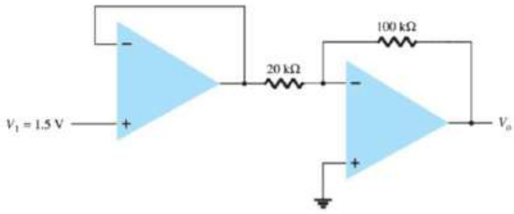
Lesson Schedule

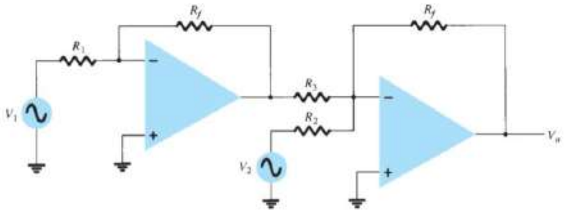
Class No. Portion covered per hour

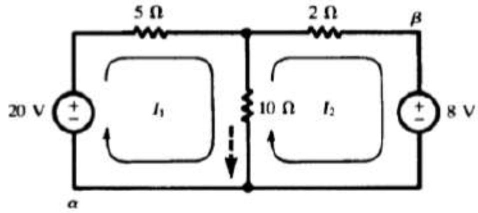
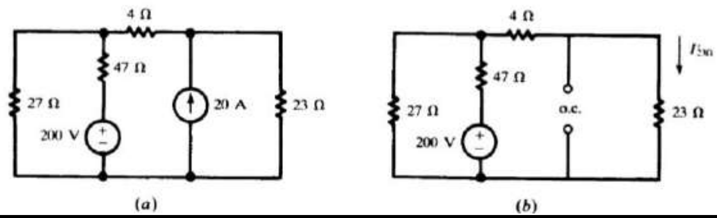
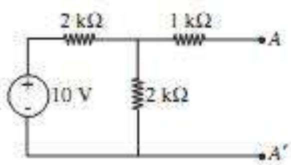
1. Operational amplifiers – fundamentals and importance.
2. Applications of Op-amps - Inverting, Non inverting, differential and cascade amplifier
2. Problems on Inverting, Non inverting, differential and cascade amplifier.
3. Discuss and design of Op-amp applications- Voltage follower, Summing, Integrator.
4. Discuss Schmitt trigger, instrumentation amplifiers.
6. Discussions on Op-amp based oscillators

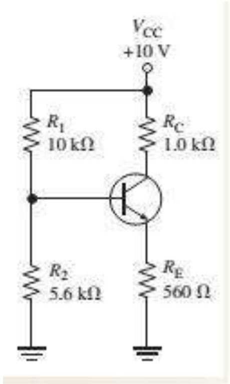
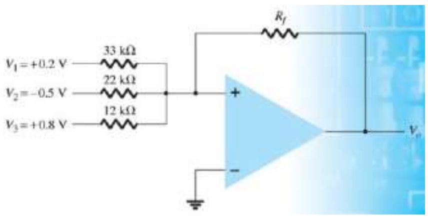
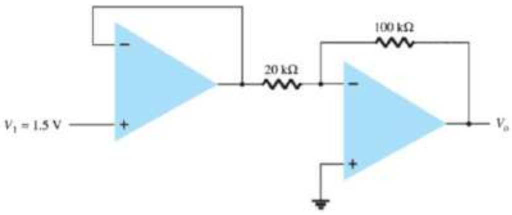
Review Questions

Sr.No	Questions	TLO	BL	PI Code
1	Describe following electrical parameters of an op-amp: CMRR, open-loop voltage gain, maximum output voltage swing, input offset voltage, input bias current, input impedance, input offset current, output impedance, slew rate.	2, 3	L2	2.2.1
2	Draw and explain the circuit model that approximates the Op Amp behavior.	1	L2	2.2.1
3	Calculate V_O in terms of I_1, V_1, and V_2 in Figure. You may assume the operational amplifier has ideal characteristics. 	4	L3	2.2.1
4	Draw the circuits of inverting amplifier and non- inverting amplifiers. Obtain the expression for voltage gain, input and output resistances	5	L3	2.2.1

5	Explain the following with their applications: Voltage follower, Summing, Integrator.	6	L3	2.2.1
6	Draw the circuit diagram and output wave form of Schmitt trigger for a sine wave input and also give the expressions for UTP and LTP.	2	L3	2.1.4
7	What are instrumentation amplifiers? How do you use Operational amplifier as an instrumentation amplifier?	3	L3	2.1.4
8	Calculate the output voltage of an op-amp summing amplifier for the following sets of voltages and resistors. Use Rf = 1Mohm in all cases. a. V_1 = +1V, V_2 = +2V, V_3 = +3V, R_1 = 500kohm, R_2 = 1Mohm, R_3 = 1Mohm. b.V_1 = -2V, V_2 = +3V, V_3 = +1V, R_1 = 200kohm, R_2 = 500kohm, R_3 = 1Mphm.	3	L3	2.1.4
9	For an op-amp having a slew rate of SR = 2 V>ms, what is the maximum closed-loop voltage gain that can be used when the input signal varies by 0.5 V in 10ms?	4	L3	2.1.4
10	What is the output voltage in the circuit of Fig. below? 	5	L3	2.1.4
11	What is the range of the voltage-gain adjustment in the circuit of Fig. below? 	3	L3	2.1.4
12	Calculate the output voltage developed by the circuit of Fig. below for R_f = 330kohm. 	5	L3	2.1.4
13	Calculate the output voltage for the circuit of Fig. below 	3	L3	2.1.4
14	Determine the output for the circuit of Fig. below with components: Rf = 1Mohm, R1 = 100kohm, R2 = 50kohm and R3 = 500kohm.	4	L3	2.1.4

Model Question Paper for In-Semester Assessment (ISA-1)						
Total Duration (H:M):1.15	**Course: Analog and Digital Electronic Circuits (18EARC201)**	**Maximum Marks :60**				
Note: Answer any two full questions						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Obtain the current in each branch of the network shown in Fig. using the mesh current method. 	5	CO1	L3	1	1.1.2
1b	Compute the current in the 23ohm resistor of Fig. (a) by applying the superposition principle. With the 200-V source acting alone, the 20-A current source is replaced by an open circuit, Fig. (b). 	10	CO1	L3	1	1.1.2
1c	Find the Thevenin's equivalent for the circuit in Fig. below, at the terminals AA' 	5	CO1	L3	1	1.1.2
2a	With neat graphs, show, what is the effect of variation in position of BJT DC operating point affects the output waveform of an amplifier.	5	CO4	L2	2	2.1.4
2b	Derive the expression for Zi, Zo and voltage gain (Av) for an Emitter follower circuit (Common collector) using h-parameter model.	10	CO4	L3	2	2.1.4
2c	Determine V_{CE} and I_C in the voltage-divider biased transistor circuit	5	CO4	L3	2	2.1.4

	in Fig.3.b), if β_{DC} =100.  					
3a	Explain the following with their applications: Voltage follower, Summing, Integrator and Schmitt trigger?	5	CO4	L2	2	2.1.4
3b	Calculate the output voltage developed by the circuit of Fig. below for R_f = 330kohm.  	10	CO4	L3	2	2.1.4
3c	Calculate the output voltage for the circuit of Fig. below  	5	CO4	L3	2	2.1.4

UNIT II

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **04 Number systems and logic gates**	Planned Hours: **6 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Understand the various number systems and conversions	CO5	L1	2.2
2. Describe ones and twos compliment with their importance	CO5	L2	2.2
3. Apply arithmetic operations on binary and hexadecimal numbers.	CO5	L2	2.2
4. Learn the basic of digital logic **-** logic gates, symbols and truth table.	CO5	L2	2.2
5. Understand the realization of universal gate with basic gates	CO5	L3	2.2
6. Describe the terminologies – Gate performance, Characteristics and Parameters.	CO5	L3	2.2

Lesson Schedule

Class No. Portion covered per hour

1. Introduction to various number systems and conversions
2. Ones and twos compliment with their importance
3. Binary arithmetic operations
4. Logic gates, truth table and Boolean laws.
5. Understand the realization of universal gate with basic gates
6. Describe the terminologies – Gate performance, Characteristics and Parameters.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Describe the following number systems such as binary, octal, hexadecimal and decimal number systems.	2, 3	L2	2.2.1
2	Explain how one’s and two’s compliment can be found for a given number.	1	L2	2.2.1
3	List and explain various binary operations that can be carried out given inputs.	4	L3	2.2.1
4	Write the basic logic gates with their respective symbols and truth tables.	5	L3	2.2.1
5	Realize the universal logic gates with the help on basic gates.	6	L3	2.2.1
6	Explain the term gate performance with respect to logic gates.	6	L3	2.2.1

.

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **05. Boolean Algebra and Combinational logic circuits**	Planned Hrs: **7 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Write Boolean logic for a given problem statement.	CO5	L1	2.2
2. Realization of half and full adders using logic gates	CO5	L2	2.2
3. Understand the associative & distributive properties applied to digital logic	CO5	L2	2.2
4. Realization of switching functions using logic gates	CO5	L2	2.2
5. Construct combinational circuits from truth tables using basic gates and only NAND/NOR gates.	CO5	L3	2.2
6. Understand the canonical forms, SoP, PoS	CO5	L3	2.2
7. Construct the K Map for simplification of logical expressions	CO5	L3	2.2

Lesson Schedule

Class No. Portion covered per hour

1. Boolean logic for modelling a given problem statement.
2. Half and full adders using logic gates
3. Associative & distributive properties applied to digital logic
4. Realization of switching functions using logic gates
5. Combinational circuits from truth tables using basic gates and only NAND/NOR gates.
6. Canonical forms, Sun of Products, Product of Sum
7. Construct the K Map for simplification of logical expressions

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Write the symbol and truth tables for the below mentioned gates: a.AND b.OR c.NOR d.EXOR	1	L2	2.2.2
2	Develop a half adder using universal logic gates	1	L2	2.2.2
3	Develop a full adder using universal logic gates	2	L2	2.2.2
4	Demonstrate associative and distributive properties applied to a digital logical expression.	2	L2	2.2.2
5	Explain the following terms with an example: a. Canonical Form b. Sum of Products c. Product of Sum	2	L2	2.2.2
6	What is K-Map and how do you simplify the given logical expression using K-Map?	2	L2	2.2.2

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **6.0 Design of Combinational logic circuits and sequential logic**	Planned Hrs: **6 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Understand the concepts of combinational circuits	CO7	L2	2.2
2. Demonstrate use and importance of code conversion, decoder and encoders	CO7	L3	2.2
3. Understand the use of multiplexer and using them to construct function generators	CO7	L2	2.2
4. Understand concepts of BCD adders, binary comparators & Arithmetic logic units	CO7	L2	2.2
5. Describe the sequential circuits, flip flops, edge triggering, timing specifications	CO7	L2	2.2
6. Design of Asynchronous and Synchronous counters with sate equations	CO7	L2	2.2
7. Illustrate the use of registers, serial in serial out, tristate register and timing considerations	CO7	L2	2.2

Lesson Schedule

Class No.   Portion covered per hour

1. Introduction to combinational circuits
2. Demonstrate code conversions, decoder and encoders
3. Multiplexer and function generators using multiplexers
4. BCD adders, Binary comparators & Arithmetic logic units
5. Introduction to sequential circuits, flip flops, edge triggering, timing specifications
6. Explanation of Asynchronous and Synchronous counters with sate equations
7. Registers, serial in serial out, tristate register and timing considerations

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1.	What are combinational circuits? Explain with an example.	1	L3	2.2.2
2.	What are decoders and encoders and where do you use them?	2	L3	2.2.2
3.	Explain multiplexer and its application.	2	L3	2.2.2
4	What are sequential circuits? Explain with an example.	2	L3	2.2.2
5	What are flipflops? Also explain edge triggering?	2	L3	2.2.2
6	What is the difference between Asynchronous and Synchronous counters?	2	L3	2.2.2
7	Convert the binary whole number 1101101 to decimal also find 2's complement of 10110010.	2	L3	2.2.2
8	Convert the following binary numbers to hexadecimal: (a) 1100101001010111 (b) 111111000101101001	2	L3	2.2.2

Model Question Paper for In-Semester Assessment (ISA-2)							
Total Duration (H:M):1.15	**Course: Analog and Digital Electronic Circuits (18EARC201)**			**Maximum Marks :60**			
Note: Answer any two full questions							
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**	
1a	Describe the following number systems such as binary, octal, hexadecimal and decimal number systems.	5	CO5	L2	2	2.2.1	
1b	Explain how one's and two's compliment can be found for a given number.	5	CO5	L3	2	2.2.1	
1c	Realize the universal logic gates with the help on basic gates.	10	CO5	L3	2	2.2.1	
2a	Develop a full adder using universal logic gates	5	CO4	L3	2	2.1.4	
2b	Explain the following terms with an example: a. Canonical Form b. Sum of Products c. Product of Sum	5	CO4	L2	2	2.1.4	
2c	What is K-Map and how do you simplify the given logical expression using K-Map?	10	CO4	L3	2	2.1.4	
3a	What are combinational circuits? Explain with an example.	5	CO6	L3	1	1.1.2	
3b	Convert the binary whole number 1101101 to decimal also find 2's complement of 10110010.	5	CO6	L3	1	1.1.2	
3c	Convert the following binary numbers to hexadecimal: (a) 1100101001010111 (b) 1111110001011101001	10	CO6	L3	1	1.1.2	

UNIT III

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **7.0 Data Conversions**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Illustrate the use of data conversion and its importance	CO6	L2	1.1
2. Design of Analog to digital conversion circuits – ADC	CO6	L2	1.1
3. Analyze and understand the concepts of R/2Rn, Digital Ramp ADC.	CO6	L3	1.1
4. Analyze and understand the concepts of Successive approximation ADC.	CO6	L3	1.1
5. Demonstrate the practical consideration of ADC for a specific application	CO6	L2	1.1

Course Code and Title: **18EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **8.0 Digital Integrated circuits**	Planned Hours: **5 hrs**

Lesson Schedule

Class No. Portion covered per hour

1. Data conversion and its importance
2. Analog to digital conversion circuits – ADC example
3. Design and understand R/2R^n, Digital Ramp ADC.
4. Design and understand Successive approximation ADC.
5. Discussion of the practical consideration of ADC for a specific application

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	How do you convert data/signal from analog to digital and vice versa? Explain the various schemes in which the data/signal can be converted.	1	L3	1.1.2
2	Explain with an example the working of ADC?	2	L2	1.1.2
3	What is Successive approximation ADC?	3	L3	1.1.2
4	Explain ADC and DAC with a practical example modelling a real-world problem.	4	L3	1.1.2
5	Explain the principle of operation of R/2R^n and digital ramp ADC.	5	L3	1.1.2

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Understand the critical logic circuit parameters – propagation delay, power dissipation, fan in, fan out.	CO7	L3	2.2
2. Understand the logic families and characteristics – TTL, LSTTL, CMOS	CO7	L3	2.2
3. Explain the underlying concepts of performance comparison, open collector and buffers.	CO7	L3	2.2

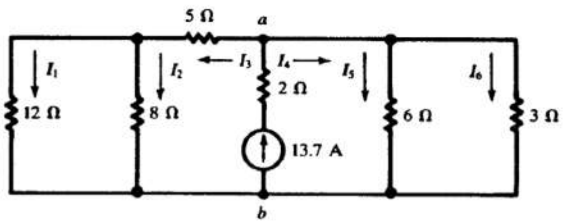
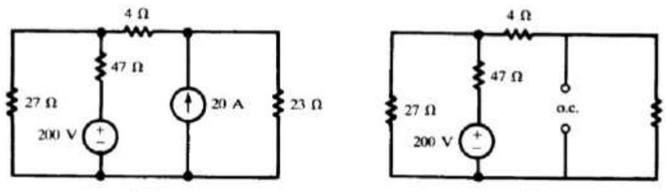
Lesson Schedule

Class No. Portion covered per hour

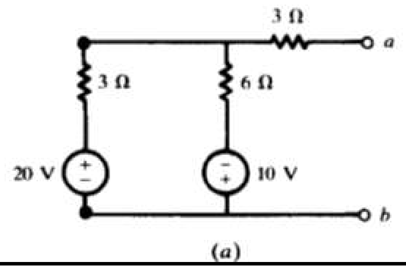
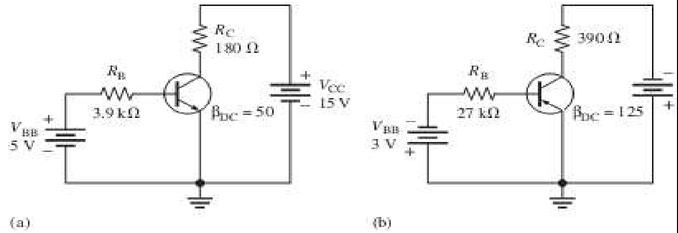
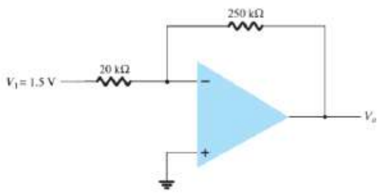
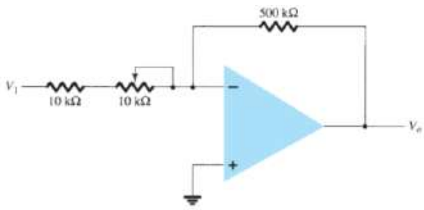
1. Introduction to digital integrated circuits and its importance
2. Discuss logic circuit parameters – propagation delay, power dissipation,
3. Discuss the concepts of fan in, fan out, noise margin
4. Discuss logic families and characteristics – TTL, LSTTL, CMOS
5. Explain the underlying concepts of performance comparison, open collector and buffers.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What is propagation delay in context of digital integrated circuits?	1	L3	2.2.2
2	Explain the following terms: a. Fan in b.Fan out c. Noise margin	2	L3	2.2.2
3	Explain briefly various logic families and their respective characteristics.	2	L3	2.2.2
4	Explain the below mentioned terms in context of digital integrated circuits: a. Performance comparison b. Open Collector c. Buffer	2	L3	2.2.2

<table>
<tr><th colspan="7">Model Question Paper for End Semester Examination (ESA)</th></tr>
<tr><td colspan="2">Total Duration (H:M): 3:0</td><td colspan="2">Course: Analog and Digital Electronic Circuits (18EARC201)</td><td colspan="3">Maximum Marks :100</td></tr>
<tr><td colspan="7">Note: Answer five questions; any two full questions from each unit-I and unit-II and one full question from unit-III</td></tr>
<tr><td colspan="7">PART- A</td></tr>
<tr><td>Q.No.</td><td>Questions</td><td>Marks</td><td>CO</td><td>BL</td><td>PO</td><td>PI Code</td></tr>
<tr><td>1a</td><td>Find all branch currents in the network shown in Fig. below

</td><td>5</td><td>CO1</td><td>L3</td><td>1</td><td>1.1.2</td></tr>
<tr><td>1b</td><td>Compute the current in the 23ohm resistor of Fig. (a) by applying the superposition principle. With the 200-V source acting alone, the 20-A current source is replaced by an open circuit, Fig. (b).


(a) (b)</td><td>10</td><td>CO1</td><td>L3</td><td>1</td><td>1.1.2</td></tr>
<tr><td>1c</td><td>Obtain the Thevenin and Norton equivalent circuits for the active network in Fig. (a).</td><td>5</td><td>CO1</td><td>L3</td><td>1</td><td>1.1.2</td></tr>
</table>

						
2a	What is the value of IC for IE =5.34 mA and IB =475 mA? Find VCE, VBE, and VCB in both circuits. 	5	CO2	L3	1	1.3.2
2b	Derive the expression for voltage gain of single stage CE voltage-divider bias amplifier using h-model	10	CO3	L3	2	2.1.3
2c	Explain the operation of MOSFET as switch?	5	CO3	L3	2	2.1.3
3a	For an op-amp having a slew rate of SR = 2 V>ms, what is the maximum closed-loop voltage gain that can be used when the input signal varies by 0.5 V in 10ms?	5	CO4	L2	2	2.1.4
3b	What is the output voltage in the circuit of Fig. below? 	10	CO4	L3	2	2.1.4
3c	What is the range of the voltage-gain adjustment in the circuit of Fig. below? 	5	CO4	L2	2	2.1.4

PART- B

Q.No.	Questions	Marks	CO	BL	PO	PI Code
4a	Describe the following number systems such as binary, octal, hexadecimal and decimal number systems.	5	CO5	L2	2	2.2.1
4b	Realize the universal logic gates with the help on basic gates.	5	CO5	L3	2	2.2.1
4c	Explain the term gate performance with respect to logic gates.	10	CO5	L3	2	2.2.1

5a	Develop a full adder using universal logic gates	5	CO4	L3	2	2.1.4
5b	Demonstrate associative and distributive properties applied to a digital logical expression.	5	CO4	L2	2	2.1.4
5c	What is K-Map and how do you simplify the given logical expression using K-Map?	10	CO4	L3	2	2.1.4
6a	Explain multiplexer and its application.	5	CO6	L3	1	1.1.2
6b	What are sequential circuits? Explain with an example.	10	CO6	L3	1	1.1.2
6c	Convert the following binary numbers to hexadecimal: (a) 1100101001010111 (b) 1111111000101101001	5	CO6	L3	1	1.1.2

PART- C

Q.No.	**Questions**	Marks	CO	BL	PO	PI Code
7a	What is Successive approximation ADC?	10	7	L3	1	1.1.2
7b	Explain the principle of operation of $R/2R^n$ and digital ramp ADC.	10	7	L3	1	1.1.2
8a	Explain the following terms: a. Fan in b.Fan out c. Noise margin	10	8	L3	2	2.2.1
8b	Explain the below mentioned terms in context of digital integrated circuits: a. Performance comparison b. Open Collector c. Buffer	10	8	L3	2	2.2.2

FMTH0301/Rev.5.3

Course Plan

Semester: **III** Year: 2021-2022

Course Title: **Mechanics of Materials**	Course Code: **18EARC204**
Total Contact Hours: **40**	Duration of ESA Hours : 3
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mrs Shilpa V Tanvashi	Date: 5/10/21
Checked By: Mr.Amit Talli	Date: 7/10/21

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Determine the mechanical behavior of structural members subjected to different types of loads such as tension, compression, torsion, bending and combined loads by using fundamental concepts of stress, strain, elastic and inelastic behavior.
2. Determine the mechanical properties of materials by using stress versus strain curves for different classes of homogenous, isotropic materials.
3. Evaluate the allowable loads and associated allowable stresses for a particular structure type before mechanical failure by using the method of allowable stress design.
4. Calculate the stresses and strains in axially-loaded members, circular torsion members, and members subject to flexural loadings.
5. Analyze the behaviour of slender members subjected to transverse loads by determining the stress distribution in, and the deflection of beams.
6. Demonstrate the skill of interpreting the behaviour of an engineering structural member for a given application as a course project by analyzing stresses, strains and deflections in structural members under load.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Mechanics of Materials	Semester: III
Course Code: 18EARC204	Year: 2021-2022

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Determine the mechanical behavior of structural members subjected to different types of loads such as tension, compression, torsion, bending and combined loads by using fundamental concepts of stress, strain, elastic and inelastic behavior.	M													
Determine the mechanical properties of materials by using stress versus strain curves for different classes of homogenous, isotropic materials	H				H									
Evaluate the allowable loads and associated allowable stresses for a particular structure type before mechanical failure by using the method of allowable stress design	M				H									
Calculate the stresses and strains in axially-loaded members, circular torsion members, and members subject to flexural loadings.	H				H									
Analyze the behaviour of slender members subjected to transverse loads by determining the stress distribution in, and the deflection of beams.	M				H									
Demonstrate the skill of interpreting the behaviour of an engineering structural member for a given application as a course project by analyzing stresses, strains and deflections in structural members under load.	M				M									

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply elements of mechanical engineering principles and laws to solve problems
5.1 Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1dentify modern engineering tools such as computer aided drafting, modelling and analysis; techniques and resources for engineering activities.

Course Assessment Plan

Course Title: Mechanics of Materials **Code:** 18EARC204					
Course outcomes (COs)	**Weightage in Assessment**	**Assessment Methods**			
		ISA1	**ISA2**	**Activity**	**ESA**
Determine the mechanical behavior of structural members subjected to different types of loads such as tension, compression, torsion, bending and combined loads by using fundamental concepts of stress, strain, elastic and inelastic behavior.	13%	✓	✓	✓	✓
Determine the mechanical properties of materials by using stress versus strain curves for different classes of homogenous, isotropic materials	6%	✓		✓	✓
Evaluate the allowable loads and associated allowable stresses for a particular structure type before mechanical failure by using the method of allowable stress design	5%	✓		✓	✓
Calculate the stresses and strains in axially-loaded members, circular torsion members, and members subject to flexural loadings.	38%	✓	✓	✓	✓
Analyze the behaviour of slender members subjected to transverse loads by determining the stress distribution in, and the deflection of beams.	38%		✓	✓	✓
Demonstrate the skill of interpreting the behaviour of an engineering structural member for a given application as a course project by analyzing stresses, strains and deflections in structural members under load.				✓	
Weightage		20%	20%	10%	50%

Course Content

Course Code: 18EARC204	Course Title: Mechanics of Materials	
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Content	Hrs
Unit - 1	
Chapter No. 1.Stress & Strain Introduction, Normal Stress Under Axial Loading, Direct Shear Stress, BearingStress, Stresses on Inclined Sections, Equality of Shear Stresses on Perpendicular Planes,Strain,Displacement, Deformation, and the Concept of Strain,Normal Strain,Shear Strain	5 hrs
Chapter No. 2.Mechanical Properties of Materials The Tension Test,The Stress–Strain Diagram,Hooke's Law,Poisson's Ratio,Design Concepts,Types of Loads,Safety,Allowable Stress Design,Load and Resistance Factor Design	5 hrs
Chapter No. 3.Axial Deformation Introduction,Saint-Venant's Principle,Deformations in Axially Loaded Bars,Deformations in a System of Axially Loaded Bars,Statically Indeterminate Axially Loaded Members	5 hrs
Unit - 2	
Chapter No. 4.Torsion Introduction, Torsional Shear Strain, Torsional Shear Stress, Stresses on Oblique Planes, Torsional Deformations, Torsion Sign Conventions, Power Transmission, Statically Indeterminate Torsion Members.	5 hrs
Chapter No. 5. Equilibrium of Beams Introduction, Shear and Moment in Beams, Graphical Method for Constructing Shear and Moment Diagrams, Discontinuity Functions to Represent Load, Shear, and Moment	5 hrs
Chapter No. 6.Bending Introduction, Flexural Strains, Normal Stresses in Beams, Analysis of Bending Stresses in Beams, Introductory Beam Design for Strength, Flexural Stresses in Beams of Two Materials, Bending Due to Eccentric Axial Load, Unsymmetrical Bending	5 hrs
Unit - 3	
Chapter No. 7. Shear Stress in Beams Introduction, Resultant Forces Produced by Bending Stresses, The Shear Stress Formula, The First Moment of Area Q, Shear Stresses in Beams of Rectangular Cross Section, Shear Stresses in Beams of Circular Cross Section.	5 hrs
Chapter No. 8. Beam Deflections Introduction, Moment-Curvature Relationship, The Differential Equation of the Elastic Curve, Deflections by Integration of a Moment Equation, Deflections by Integration of Shear-Force or Load Equations, Deflections Using Discontinuity Functions	5 hrs

Text Books (List of books as mentioned in the approved syllabus)

Timothy .A. Philpot, Mechanics of Materials, An Integrated Learning System, 4th edition, Wiley.

References

Roy R., Craig, JR. Mechanics of Materials, Third edition, JOHN WILEY & SONS

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
ISA- 1	20
ISA- 2	20
Activity	10
Total	**50**

Course Unitization for Minor Exams and End Semester Assessment

Topics / Chapters	Teaching Credits	No. of Questions in ISA- 1	No. of Questions in ISA- 2	No. of Questions in ESA
Unit I				
1.Stress & Strain	5	1.00	--	1.00
2.Mechanical Properties of Materials	5	1.00	--	1.00
3.Axial Deformation	5	1.00	--	1.00
Unit II				
4.Torsion	5	--	1.00	1.00
5. Equilibrium of Beams	5	--	1.00	1.00
6.Bending	5	--	1.00	1.00
Unit III				
7. Shear Stress in Beams	5	0	0	1.00
8. Beam Deflections	5	0	0	1.00

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in Minor I, II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date: 7/10/21 **HOD**

Course Code and Title: **18EARC204 / Mechanics of Materials**	
Chapter Number and Title: **1.Stress & Strain**	Planned Hours: **5 hrs**

Learning Outcomes:-

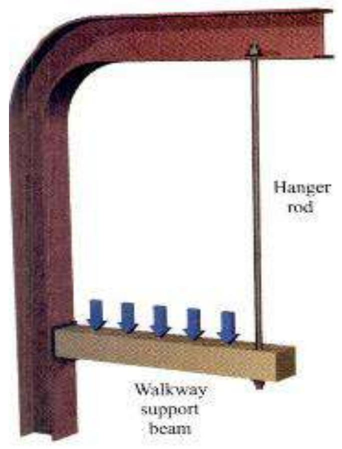
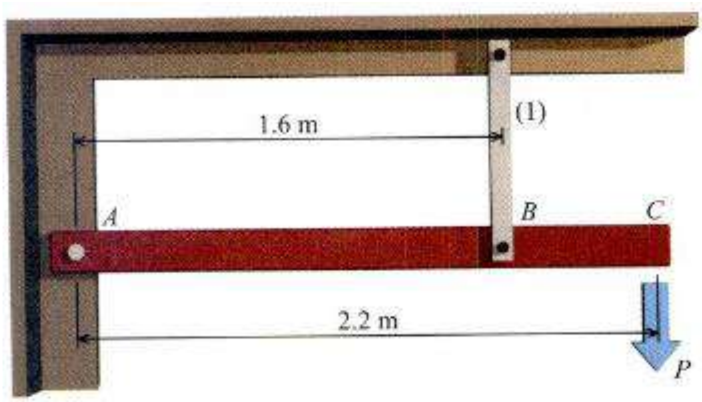
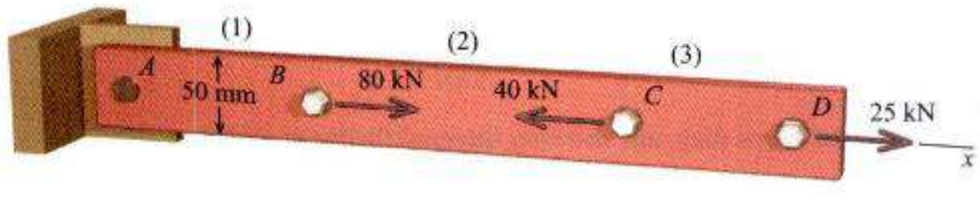
At the end of the topic the student should be able to:

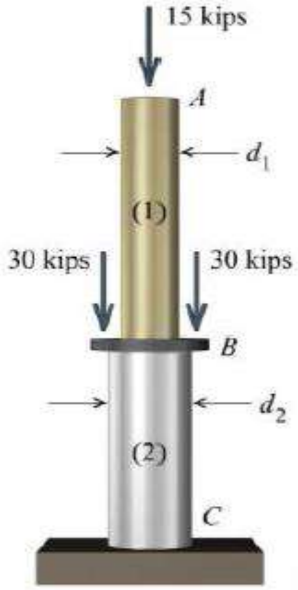
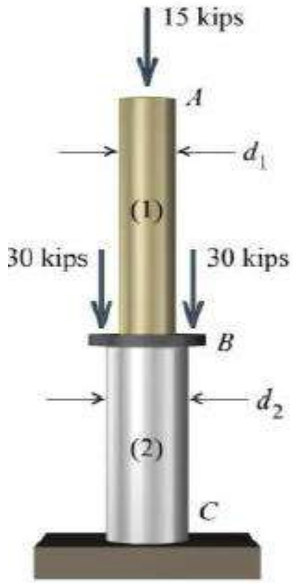
Topic Learning Outcomes	COs	BL	CA Code
Interpret, analyse and evaluate types of loads that exist in any components or engineering system	CO1	L2	1.3
Apply the basic principles of engineering mechanics to translate engineering problems to free body diagrams	CO1	L3	1.3
Explain the concept of normal stress , shear stress and bearing stress under axial loading .	CO1	L2	1.3
Explain the concept of normal strain and shear strain under axial loading.	CO1	L2	1.3
Determine the internal effect caused by external loads acting on real bodies and compute the deformations experienced by the real body as a result of internal stress.	CO1	L3	1.3

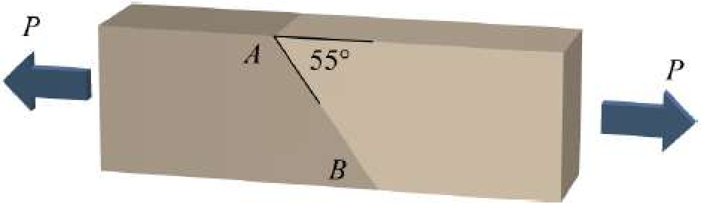
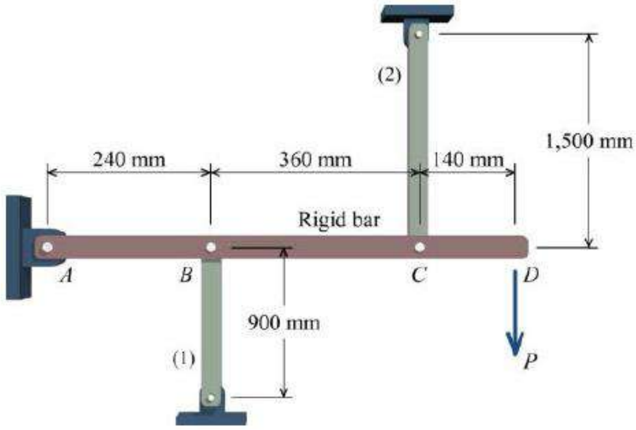
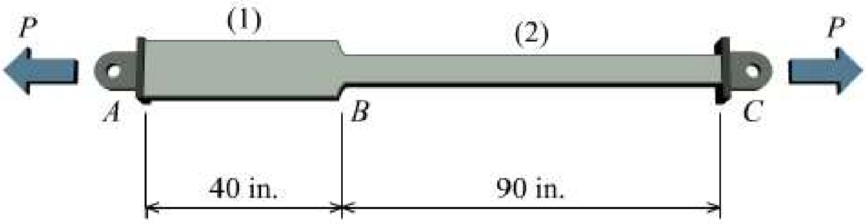
Lesson Schedule Class No. - Portion covered per hour / per Class
1. Introduction, Normal Stress Under Axial Loading
2. Direct Shear Stress, BearingStress, Stresses on Inclined Sections
3. Equality of Shear Stresses on Perpendicular Planes
4. ,Displacement, Deformation, and the Concept of Strain
5. Normal Strain, Shear Strain

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. A solid 0.5-in.diameter steel hanger rod is used to hold up one end of a walkway support beam. The force carried by the rod is 5,000 lb. Determine the normal stress in the rod. (Dis-regard the weight of the rod.)	TLO1	L3	1.3.1

			
2. Rigid bar ABC is supported by a pin at A and axial member (I), which has a cross-sectional area of 540 mm^2. The weight ofrigid bar ABC can be neglected. (Note: I kN = 1,000 N).Determine the normal stress in member (I) if a load of P = 8 kN is applied at C. If the maximum normal stress in member (I) must be limitedto 50 MPa, what is the maximum load magnitude P that may be applied to the rigid bar at C? 	TLO1	L3	1.3.1
3. A 50-mm-wide steel bar has axial loads ap-plied at points B, C, and D. If the normal stress magnitude in the bar must not exceed60 MPa, determine the minimum thickness that can be used for the bar. 	TLO1	L3	1.3.1
4. Two solid cylindrical rods (1) and (2)are joined together at flange B and loaded, asshown in Figure P1.3/4. If the normal stressin each rod must be limited to 40 ksi,determine the minimum diameter requiredfor each rod.	TLO1	L3	1.3.1

 FIGURE P1.3/4			
5. Two solid cylindrical rods (1) and (2) are joined together at flange B and loaded, as shown in Figure P1.3/4. The diameter of rod (1) is 1.75 inland the diameter of rod (2) is 2.50 in. Determine the normal stresses in rods (1) and (2).  FIGURE P1.3/4	TLO1	L3	1.3.1
6. An axial load *P* is applied to the rectangular bar shown in Figure P1.36. The cross-sectional area of the bar is 400 mm2. Determine the normal stress perpendicular to plane *AB* and the shear stress parallel to plane *AB* if the bar is subjected to an axial load of *P* = 70 kN	TLO2	L3	1.3.1

 FIGURE P1.36			
7. A rigid bar ABCD is supported by two bars as shown in Figure . There is no strain in the vertical bars before load P is applied. After load P is applied, the normal strain in rod (1) is -570µm/m. Determine:(a) the normal strain in rod (2), (b) the normal strain in rod (2) if there is a 1mm gap in the connection at pin C before the load is applied, (c) the normal strain in rod (2) if there is a 1mm gap in the connection at pin B before the load is applied.  	TLO2	L3	1.3.1
8. When an axial load is applied to the ends of the bar shown in Figure, the total elongation of the bar between joints *A* and *C* is 0.15 in. In segment (2), the normal strain is measured as 1,300µin./in. Determine: (a) the elongation of segment (2). (b) the normal strain in segment (1) of the bar.  	TLO2	L3	1.3.1

Course Code and Title: **18EARC204/ Mechanics of Materials**	
Chapter Number and Title: **2.Mechanical Properties of Materials**	Planned Hours: **5 hrs**

Learning Outcomes:-

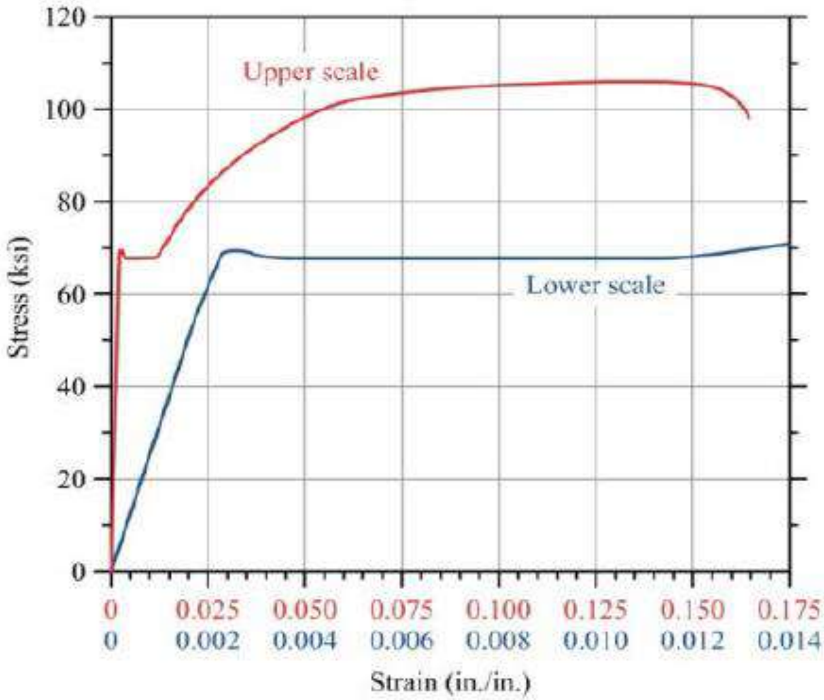
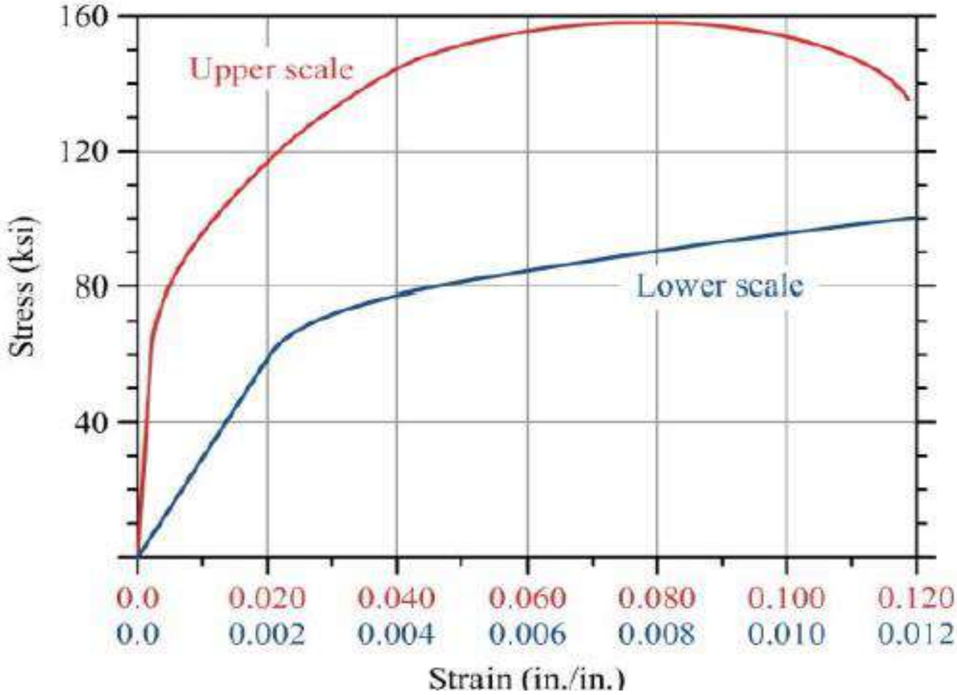
At the end of the topic the student should be able to:

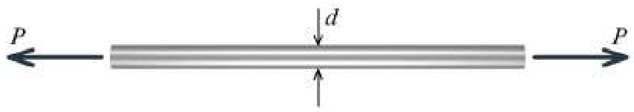
Topic Learning Outcomes	COs	BL	CA Code
Discuss the experimental methods to determine the stress–strain diagram for a specific material	CO1	L2	1.3
Determine the mechanical properties and discuss the tests that are related to the development of mechanics of materials.	CO2	L3	1.3

Lesson Schedule Class No. - Portion covered per hour / per Class
1. The Tension Test
2. The Stress–Strain Diagram
3. Hooke's Law, Poisson's Ratio
4. Design Concepts, Types of Loads
5. Safety, Allowable Stress Design, Load and Resistance Factor Design

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. A tensile test specimen of 1045 hot-rolled steel having a diameter of 0.505 in. and a gage length of 2.00 in. was tested to fracture. Stress and strain data obtained during the test are shown in Figure .Determine(a) the modulus of elasticity.(b) the proportional limit.(c) the ultimate strength.(d) the yield strength (0.20% offset).(e) the fracture stress.(f) the true fracture stress if the final diameter of the specimen at the location of the fracture was0.392 in.	TLO2	L3	1.3.1

<table>
<tr><td>
</td><td></td><td></td><td></td></tr>
<tr><td>2. A tensile test specimen of stainless steel alloy having a diameter of 0.495 in.and a gage length of 2.00 in. was tested to fracture. Stress and strain data obtainedduring the test are shown in Figure .Determine:(a) the modulus of elasticity.(b) the proportional limit.(c) the ultimate strength.(d) the yield strength (0.20% offset).(e) the fracture stress.(f) the true fracture stress if the final diameter of the specimen at the location of the fracture was 0.350 in.

</td><td>TLO2</td><td>L3</td><td>1.3.1</td></tr>
<tr><td>3. At the proportional limit, a 2-inch gage length of a 0.375-in.-diameter alloy bar has</td><td>TLO2</td><td>L3</td><td>1.3.1</td></tr>
</table>

elongated0.0083 in. and the diameter has been reduced 0.0005 in. The total tension force on the bar was 4.75 kips. Determine the following properties of the material:(a) the modulus of elasticity.(b) Poisson's ratio.(c) the proportional limit.			
4. A solid circular rod with a diameter of d = 16 mmis shown in Figure P3.2. The rod is made of an aluminium alloy that has an elastic modulus of E = 72GPa and Poisson's ratio of 0.33. When subjected tothe axial load P, the diameter of the rod decreases by0.024 mm. Determine the magnitude of load P.  FIGURE P3.2	TLO2	L3	1.3.1
5. At an axial load of 22 kN, a 45-mm-wide × 15-mm-thick polyimide polymer bar elongates 3.0 mmwhile the bar width contracts 0.25 mm. The bar is 200 mm long. At the 22-kN load, the stress in thepolymer bar is less than its proportional limit. Determine:(a) the modulus of elasticity.(b) Poisson's ratio.(c) the change in the bar thickness.	TLO2	L3	1.3.1
6. Draw the Stress-strain curve for Mild Steel and explain the properties associated with it.	TLO1	L2	1.3.1
7. Explain Hooke\'s Law & Poisson's ratio.	TLO1	L2	1.3.1
8. Explain Stress - strain test with neat sketch.	TLO1	L2	1.3.1

Course Code and Title: **18EARC204/ Mechanics of Materials**	
Chapter Number and Title: **3.Axial Deformation**	Planned Hours: **5 hrs**

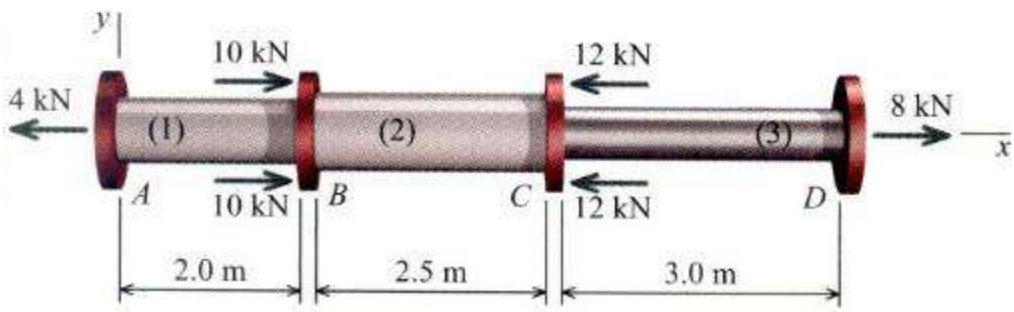
Learning Outcomes:-

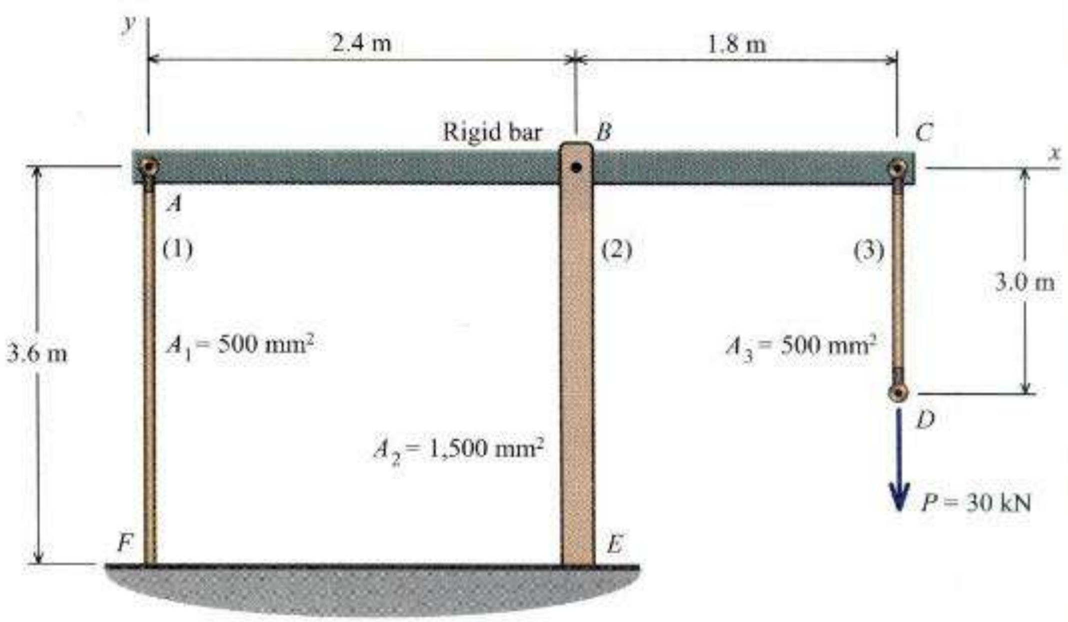
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
Determine the deformation of axially loaded members.	CO3	L3	1.3

Lesson Schedule Class No. - Portion covered per hour / per Class
1. Introduction
2. Deformations in Axially Loaded Bars
3. Deformations in a System of Axially Loaded Bars
4. Saint-Venant's Principle
5. Statically Indeterminate Axially Loaded Members

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. The compound axial member shown consists of a20-mm-diameter solid aluminium [E = 70 GPa] segment (l), a 24-mm-diameter solid aluminium segment (2), and a l6-mm-diameter solid steel [E = 200 GPa]segment (3). Determine the displacements of pointsB, C, and D relative to end A. 	TLO1	L3	1.3.1
2. The assembly shown consists ofrigid bar ABC, two fibre-reinforced plastic (FRP) rods (1) and (3), andFRP post (2). The modulus of elasticity for the FRP is E = 18 GPa. Determine the vertical deflection ofjoint D relative to its initial position after the 30-kN load is applied.	TLO1	L3	1.3.1

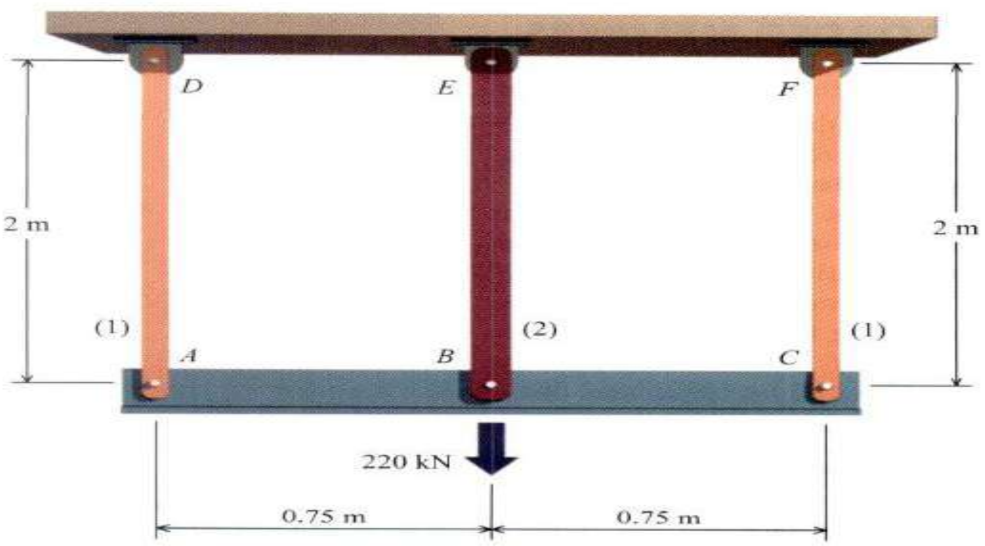
<table>
<tr>
<td>


</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>
3.

A 1.5-m-long rigid beam *ABC* is supported by three axial members. A concentrated load of 220 kN is applied to the rigid bar directly under *B*.

The axial members (1) connected at *A* and at *C* are identical aluminum alloy [E = 70 GPa] bars each having a cross-sectional area of $A_1 = 550$ mm^2 and a length of L_1 = 2 m. Member (2) is a steel [E = 200 GPa] bar with a cross-sectional area of $A_2 = 900$ mm^2 and a length of L_2 = 2 m. All members are connected with simple pins.

If all three bars are initially unstressed, determine (a) the normal stresses in the aluminum and steel bars and (b) the deflection of the rigid beam after application of the 220-kN load.



</td>
<td>TLO1</td>
<td>L3</td>
<td>1.3.1</td>
</tr>
<tr>
<td>4. An axial member consisting of twopolymer bars is supported at C as shown inFigure P5.5. Bar</td>
<td>TLO1</td>
<td>L3</td>
<td>1.3.1</td>
</tr>
</table>

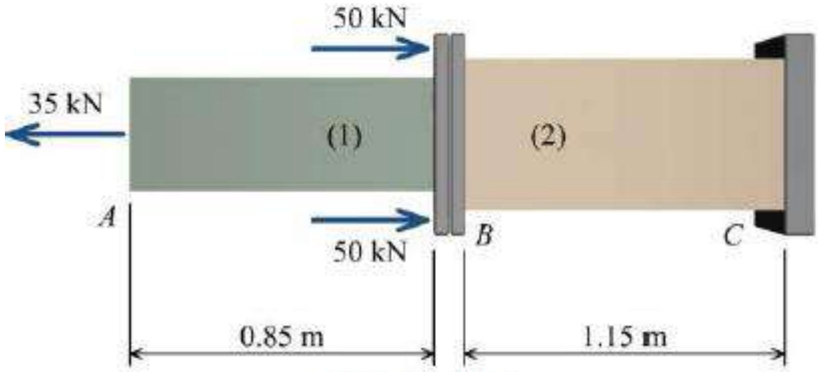
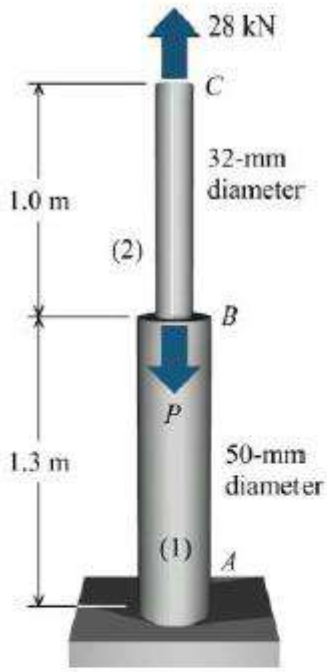
<table>
<tr>
<td>(1) has a cross-sectional area of540 mm2 and an elastic modulus of 28 GPa. Bar(2) has a cross-sectional area of 880 mm2 and elastic modulus of 16.5 GPa. Determine thedeflection of point A relative to support C.


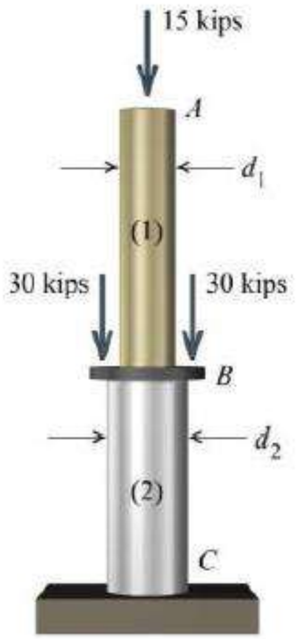
FIGURE P5.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.AnAluminum [E = 70 GPa] member ABC supports aload of 28 kN, as shown in Figure P5.7. Determine:(a) the value of load P such that the deflection of joint Cis zero.(b) the corresponding deflection of joint B.

</td>
<td>TLO1</td>
<td>L3</td>
<td>1.3.1</td>
</tr>
</table>

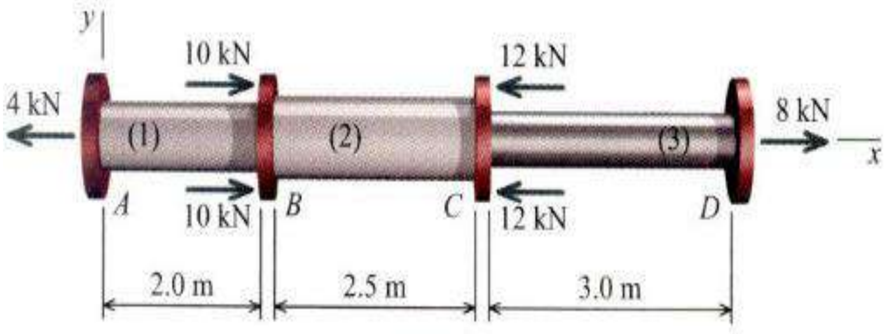
KLE Technological University
Creating Value Leveraging Knowledge

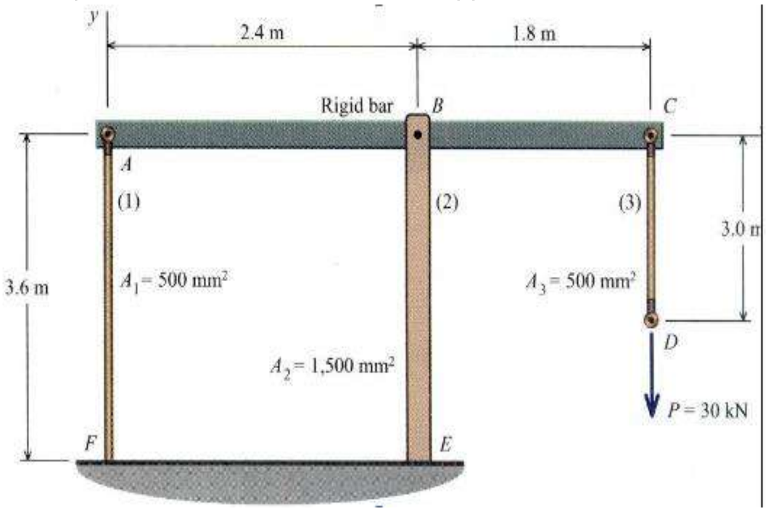
DEPARTMENT OF AUTOMATION & ROBOTICS

<table>
<tr><td colspan="3">Question Paper Title: Minor Exam - 1</td></tr>
<tr><td>Total Duration (H:M):1:15</td><td>Course :Mechanics of Materials (18EARC204)</td><td>Maximum Marks :40</td></tr>
<tr><td colspan="3">Note : Answer any two full questions</td></tr>
</table>

<table>
<tr><th>Q.No</th><th>Questions</th><th>Marks</th><th>CO</th><th>BL</th><th>PI Code</th></tr>
<tr><td>1a</td><td>Two solid cylindrical rods (1) and (2) are joined together at flange B and loaded, as shown in Figure . If the normal stressin each rod must be limited to 40 ksi,determine the minimum diameter required for each rod.

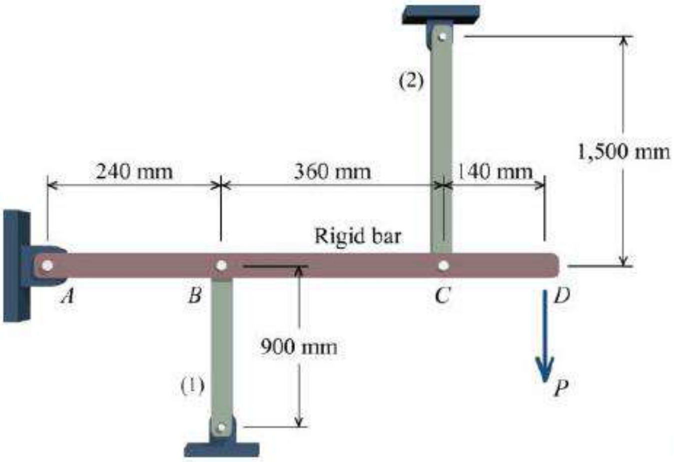

</td><td>10</td><td>CO1</td><td>L3</td><td>1.3.1</td></tr>
<tr><td>1b</td><td>The compound axial member shown consists of a20-mm-diameter solid aluminium [E = 70 GPa] seg-ment (l), a 24-mm-diameter solid aluminium segment (2), and a l 6-mm-diameter solid steel [E = 200 GPa]segment (3). Determine the displacements of point C, and D relative to end A.


</td><td>10</td><td>CO3</td><td>L3</td><td>1.3.1</td></tr>
<tr><td>2a</td><td>Explain material properties associated with stress-strain diagram.</td><td>10</td><td>CO2</td><td>L2</td><td>1.3.1</td></tr>
<tr><td>2b</td><td>The assembly shown consists of rigid bar ABC, two fibre-reinforced plastic</td><td>10</td><td>CO3</td><td>L3</td><td>1.3.1</td></tr>
</table>

<table>
<tr><td></td><td>(FRP) rods (1) and (3), and FRP post (2). The modulus of elas-ticity for the FRP is E = 18 GPa. Determine the vertical deflection of joint D relative to its initial position after the 30-kN load is applied.
</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3a</td><td>A 1035 hot-rolled steel specimen with adiameter of 0.500 in. and a 2.0-in. gage length wastested to fracture. Load and deformation dataobtained during the test are given. Determine:(a) the modulus of elasticity.(b) the proportional limit.(c) the ultimate strength.(d) the yield strength (0.05% offset).(e) the yield strength (0.20% offset).(f) the fracture stress.(g) the true fracture stress if the final diameter ofthe specimen at the location of the fracture was0.387 in.</td><td>10</td><td>CO2</td><td>L3</td><td>1.3.1</td></tr>
</table>

Load (lb)	Change in Length (in.)	Load (lb)	Change in Length (in.)
0	0	12,540	0.0209
2,690	0.0009	12,540	0.0255
5,670	0.0018	14,930	0.0487
8,360	0.0028	17,020	0.0835
11,050	0.0037	18,220	0.1252
12,540	0.0042	18,820	0.1809
13,150	0.0046	19,110	0.2551
13,140	0.0060	19,110	0.2968
12,530	0.0079	18,520	0.3107
12,540	0.0098	17,620	0.3246
12,840	0.0121	16,730	0.3339
12,840	0.0139	16,130	0.3385
		15,900	fracture

<table>
<tr><td>3b</td><td>A rigid bar ABCD is supported by two bars as shown in Figure P2.4. There is no strain in the vertical bars before load P is applied. After load P is applied, the normal strain in rod (1) is −570m/m. Determine:(a) the normal strain in rod (2).(b) the normal strain in rod (2) if there is a 1-mm gap in the</td><td>10</td><td>CO1</td><td>L3</td><td>1.3.1</td></tr>
</table>

	connection at pin C before the load is applied.(c) the normal strain in rod (2) if there is a 1-mmgap in the connection at pin B before the load is applied. 				

Chapterwise Plan

Course Code and Title: **18EARC204 / Mechanics of Materials**	
Chapter Number and Title: **4.Torsion**	Planned Hours: **5 hrs**

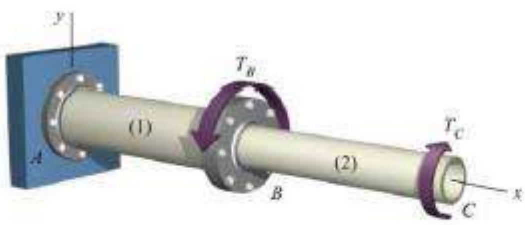
Learning Outcomes:-

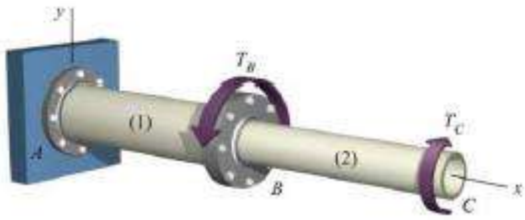
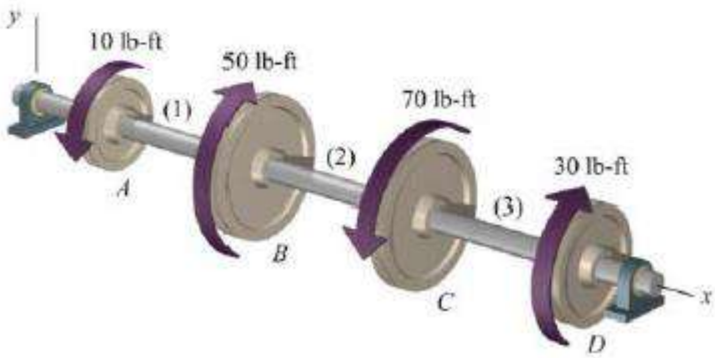
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
Determine both the stress distribution within the member and the angle of twist when the material behaves in a linear elastic manner and also when it is inelastic	CO5	L3	1.3

Lesson Schedule Class No. - Portion covered per hour / per Class
1. Introduction, Torsional Shear Strain
2. Torsional Shear Stress, Stresses on Oblique Planes
3. Torsional Deformations
4. Torsion Sign Conventions
5. Power Transmission, Statically Indeterminate Torsion Members.

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. A compound shaft consists of two pipe segments. Segment (1) has an outside diameter of200 mm and a wall thickness of 10 mm. Segment(2) has an outside diameter of 150 mm and a wall thickness of 10 mm. The shaft is subjected to torques TB = 42 kN-m and TC = 18 kN-m, which acting the directions shown in Figure P6.4/5. Determine the maximum shear stress magnitude in each shaft segment. 	TLO1	L3	1.3.1
2. A compound shaft consists of two pipe segments. Segment (1) has an outside diameter of10.75 in. and a wall thickness of 0.365 in. Segment(2) has an outside diameter of 6.625 in. and a wall thickness of 0.280 in. The shaft is subjected to torques TB = 60 kip-ft and TC = 24 kip-ft, which acting the directions shown in Figure P6.4/5. Determine the maximum shear stress magnitude in each shaft segment.	TLO1	L3	1.3.1

			
3. A compound shaft (Figure P6.6/7) consists of brass segment (1) and aluminium segment (2). Segment (1) is a solid brass shaft with an outside diameter of 0.625 in. and an allowable shear stress of 6,000 psi. Segment(2) is a solid aluminium shaft with an outside diameter of 0.50 in. and an allowable shear stress of 9,000 psi. Determine the magnitude of the largest torque TC that may be applied at C. 	TLO1	L3	1.3.1
4. A solid 0.75-in.-diameter shaft is subjected to the torques shown in Figure P6.8. The bearings shown allow the shaft to turn freely.(a) Plot a torque diagram showing the internal torque in segments (1), (2), and (3) of the shaft. Use the sign convention presented in Section 6-6.(b) Determine the maximum shear stress magnitude in the shaft. 	TLO1	L3	1.3.1

Course Code and Title: **18EARC204 / Mechanics of Materials**	
Chapter Number and Title: **5. Equilibrium of Beams**	Planned Hours: **5 hrs**

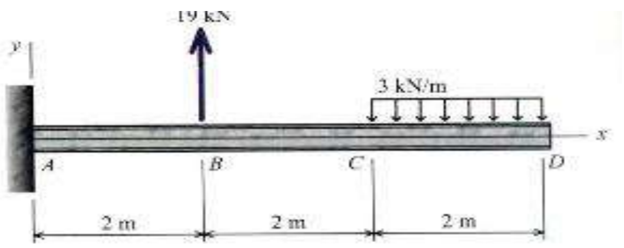
Learning Outcomes:-

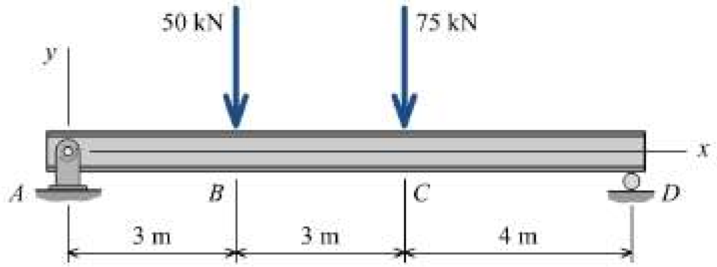
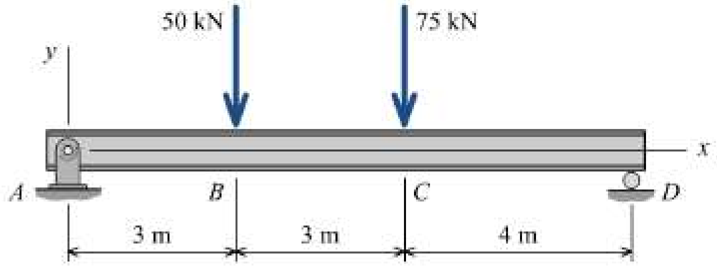
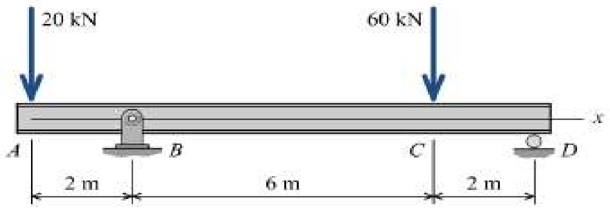
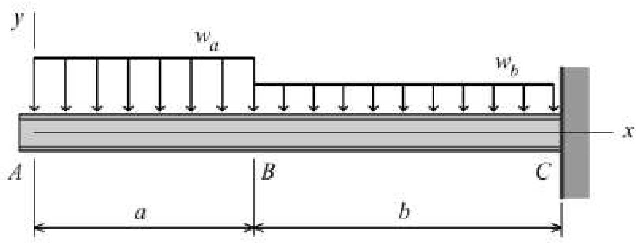
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
Calculate the shear and moment in different types of beams.	CO5	L3	1.3
Plot shear and moment diagrams for beams.	CO5	L3	1.3

Lesson Schedule Class No. - Portion covered per hour / per Class
1. Introduction
2. Shear and Moment in Beams
3. Shear and Moment diagrams
4. Discontinuity Functions to Represent Load
5. Examples

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Draw the shear-force and bending-moment diagrams forthe cantilever beam shown.  	TLO2	L3	1.3.1
2. For the simply supported beam subjected to the loading shown,(a) Derive equations for the shear force V and the bending moment M for any location in the beam.(Place the origin at point A.)	TLO2	L3	1.3.1

			
3. Plot the shear-force and bending-momentdiagrams for the beam using the derived functions. 	TLO1	L3	1.3.1
4. For the simply supported beam subjected to the loading shown,(a) Derive equations for the shear force V and the bending moment M for any location in the beam.(Place the origin at point A.)(b) Plot the shear-force and bending-moment diagrams for the beam using the derived functions.(c) Report the maximum positive bending moment, the maximum negative bending moment, and their respective locations. 	TLO1	L3	1.3.1
5. For the cantilever beam and loading shown, (a) Derive equations for the shear force *V* and the bending moment *M* for any location in the beam. (Place the origin at point *A*.) (b) Plot the shear-force and bending-moment diagrams for the beam using the derived functions. 			

Course Code and Title: **18EARC204 / Mechanics of Materials**	
Chapter Number and Title: **6.Bending**	Planned Hours: **5 hrs**

Learning Outcomes:-

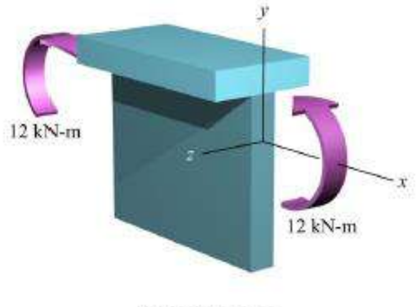
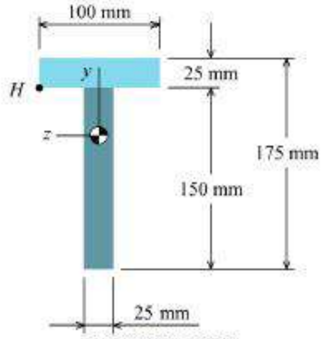
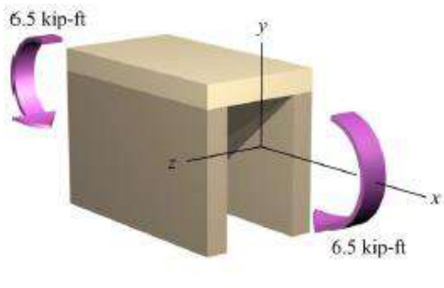
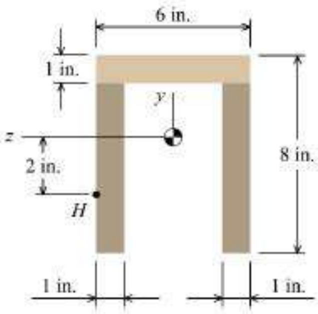
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
Once the internal moment at a section is determined, the bending stress can thenbe calculated. First we will consider members that are straight, have a symmetric cross section, and are made of homogeneous linear elastic material.	CO6	L3	1.3

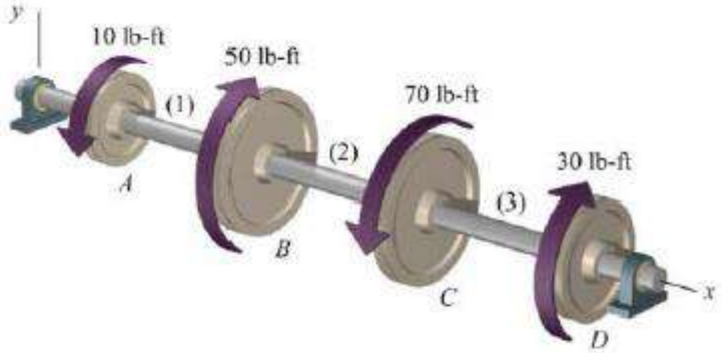
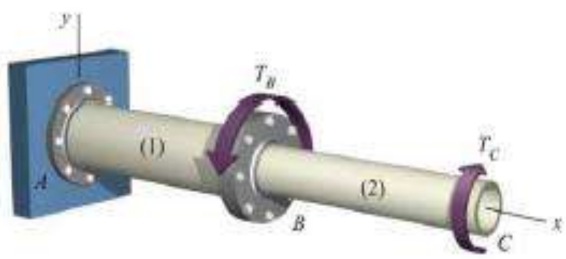
Lesson Schedule Class No. - Portion covered per hour / per Class
1. Introduction, Flexural Strains
2. Normal Stresses in Beams, Analysis of Bending Stresses in Beams
3. Introductory Beam Design for Strength
4. Flexural Stresses in Beams of Two Materials
5. Bending Due to Eccentric Axial Load, Unsymmetric Bending

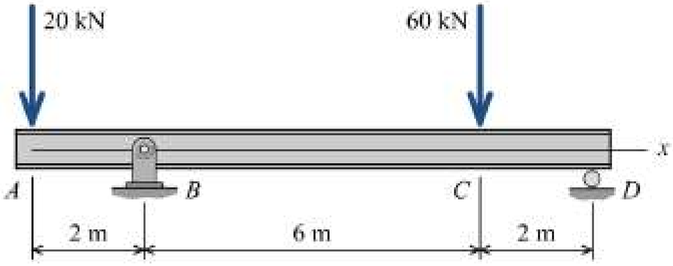
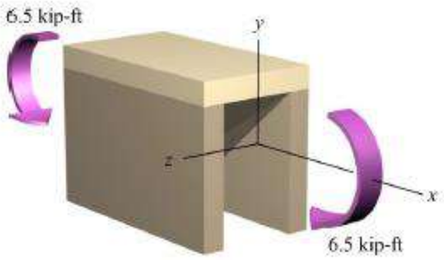
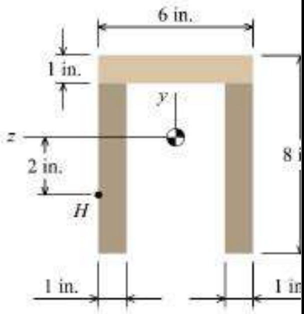
Review Questions

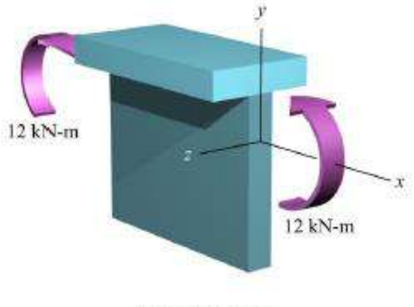
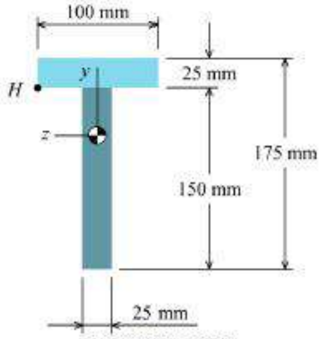
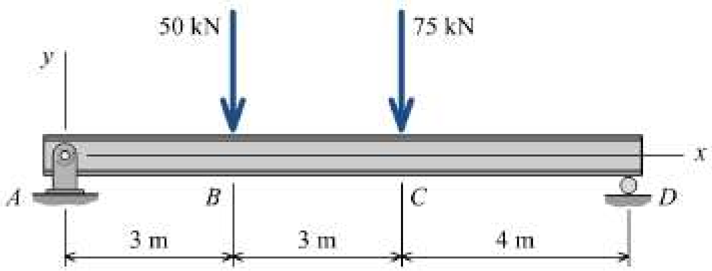
Sl.No. - Questions	TLOs	BL	PI Code
1. During fabrication of a laminated timber arch, one of the 10 in. wide by 1 in. thick Douglas fir [E =1,900 ksi] planks is bent to a radius of curvature of 40 ft. Determine the maximum bending stressdeveloped in the plank.	TLO1	L3	1.3.1
2. A high-strength steel [E = 200 GPa] tube having an outside diameter of 80 mm and a wallthickness of 3 mm is bent into a circular curve having a 52-m radius of curvature. Determine themaximum bending stress developed in the tube.	TLO1	L3	1.3.1
3. A high-strength steel [E = 200 GPa] band saw blade wraps around a pulley that has a diameter of450 mm. Determine the maximum bending stress developed in the blade. The blade is 12-mm wide and1-mm thick.	TLO1	L3	1.3.1
4. A beam having a tee-shaped cross section is subjected to equal 12 kN-m bending moments, asshown in Figure P8.5a. The cross-sectional dimensions of the beam are shown in Figure P8.5b.Determine:(a) the centroid location, the moment of inertia about the z axis, and the controlling section modulusabout the z axis.(b) the bending stress at point H. State whether the normal stress at H is tension or compression.(c) the maximum bending stress produced in the cross section. State whether the stress is tension orcompression.	TLO1	L3	1.3.1

 FIGURE P8.5a  FIGURE P8.5b			
5. A beam is subjected to equal 6.5 kip-ft bending moments, as shown in Figure P8.6a. The cross sectional dimensions of the beam are shown in Figure P8.6b. Determine:(a) the centroid location, the moment of inertia about the z axis, and the controlling section modulus about the z axis.(b) the bending stress at point H, which is located 2 in. below the z centroidal axis. State whether the normal stress at H is tension or compression.(c) the maximum bending stress produced in the cross section. State whether the stress is tension or compression.  FIGURE P8.6a  FIGURE P8.6b	TLO1	L3	1.3.1

Question Paper Title: MINOR EXAM - 2		
Total Duration (H:M):01:15	Course : Mechanics of Materials (18EARC204)	Maximum Marks :40
Note : Answer any two full questions		

Q.No.	Questions	Marks	CO	BL	PI Code
1	A solid 0.75-in.-diameter shaft is subjected to the torques shown in Figure P6.8. The bearings shown allow the shaft to turn freely.(a) Plot a torque diagram showing the internal torque in segments (1), (2), and (3) of the shaft. Use the sign convention presented in Section 6-6.(b) Determine the maximum shear stress magnitude in the shaft. 	10	CO4	L3	1.3.1
2	A compound shaft consists of two pipe segments. Segment (1) has an outside diameter of 10.75 in. and a wall thickness of 0.365 in. Segment(2) has an outside diameter of 6.625 in. and a wall thickness of 0.280 in. The shaft is subjected to torques TB = 60 kip-ft and TC = 24 kip-ft, which act in the directions shown in Figure P6.4/5. Determine the maximum shear stress magnitude in each shaft segment. 	10	CO4	L3	1.3.1
3	For the simply supported beam subjected to the loading shown,(a) Derive	10	CO5	L3	1.3.1

	equations for the shear force V and the bending moment M for any location in the beam.(Place the origin at point A.)(b) Plot the shear-force and bending-moment diagrams for the beam using the derived functions.(c) Report the maximum positive bending moment, the maximum negative bending moment, and their respective locations. 				
4	A beam is subjected to equal 6.5 kip-ft bending moments, as shown in Figure P8.6a. The cross sectional dimensions of the beam are shown in Figure P8.6b. Determine:(a) the centroid location, the moment of inertia about the z axis, and the controlling section modulus about the z axis.(b) the bending stress at point H, which is located 2 in. below the z centroidal axis. State whether the normal stress at H is tension or compression.(c) the maximum bending stress produced in the cross section. State whether the stress is tension or compression.  FIGURE P8.6a  FIGURE P8.6b	10	CO6	L3	1.3.1
5	A beam having a tee-shaped cross section is subjected to equal 12 kN-m bending moments, as shown in Figure P8.5a. The cross-sectional dimensions of the beam are shown in Figure P8.5b.Determine:(a) the centroid location, the moment of inertia about the z axis, and the controlling section modulus about the z axis.(b) the bending stress at point H. State whether the normal stress at H is tension or compression.(c) the maximum bending stress produced in the cross section. State whether the stress is tension or compression.	10	CO6	L3	1.3.1

	 FIGURE P8.5*a*  FIGURE P8.5*b*				
6	For the simply supported beam subjected to the loading shown,(a) Derive equations for the shear force V and the bending moment M for any location in the beam.(Place the origin at point .  	10	CO5	L3	1.3.1

Course Code and Title: **18EARC204 / Mechanics of Materials**	
Chapter Number and Title: **7. Shear Stress in Beams**	Planned Hours: **5 hrs**

Learning Outcomes:-

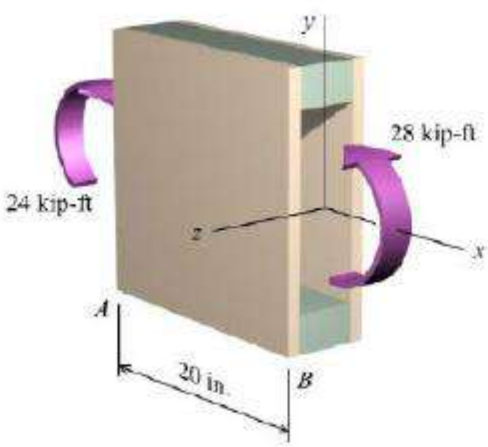
At the end of the topic the student should be able to:

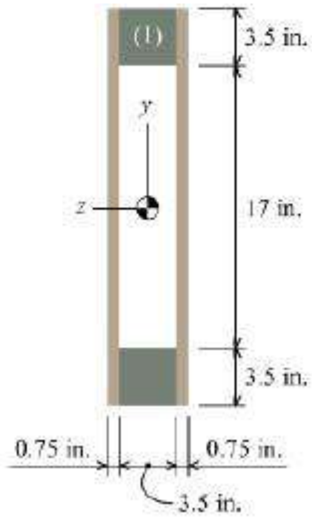
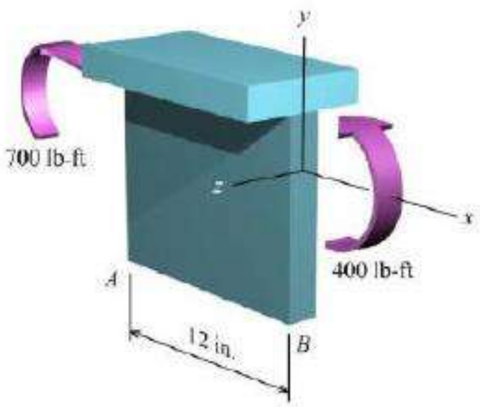
Topic Learning Outcomes	COs	BL	CA Code
Determine the shear stress in nonuniform bending.	CO7	L3	1.3

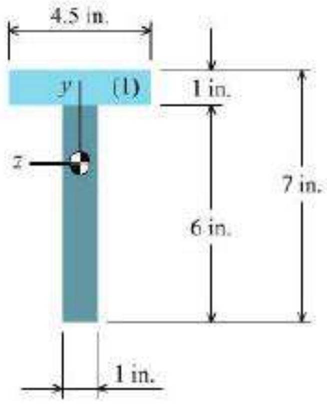
Lesson Schedule Class No. - Portion covered per hour / per Class
1. Introduction
2. Resultant Forces Produced by Bending Stresses
3. The Shear Stress Formula
4. The First Moment of Area Q, Shear Stresses in Beams of Rectangular Cross Section
5. Shear Stresses in Beams of Circular Cross Section.

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. For the following problems, a beam segment subjected to internal bending moments at sections Aand B is shown along with a sketch of the cross-sectional dimensions. For each problem: (a) Sketch a side view of the beam segment and plot the distribution of bending stresses acting atsections A and B. Indicate the magnitude of key bending stresses on the sketch.(b) Determine the resultant forces acting in the x direction on the specified area at sections A and B andshow these resultant forces on the sketch.(c) Is the specified area in equilibrium with respect to forces acting in the x direction? If not, determinethe horizontal force required to satisfy equilibrium for the specified area and show the location anddirection of this force on the sketch.	TLO1	L3	1.3.1

<table>
<tr>
<td>


</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. For the following problems, a beam segment subjected to internal bending moments at sections Aand B is shown along with a sketch of the cross-sectional dimensions. For each problem:(a) Sketch a side view of the beam segment and plot the distribution of bending stresses acting atsections A and B. Indicate the magnitude of key bending stresses on the sketch.(b) Determine the resultant forces acting in the x direction on the specified area at sections A and B andshow these resultant forces on the sketch.(c) Is the specified area in equilibrium with respect to forces acting in the x direction? If not, determinethe horizontal force required to satisfy equilibrium for the specified area and show the location anddirection of this force on the sketch



</td>
<td>TLO1</td>
<td>L3</td>
<td>1.3.1</td>
</tr>
</table>

Course Code and Title: **18EARC204 / Mechanics of Materials**	
Chapter Number and Title: **8. Beam Deflections**	Planned Hours: **5 hrs**

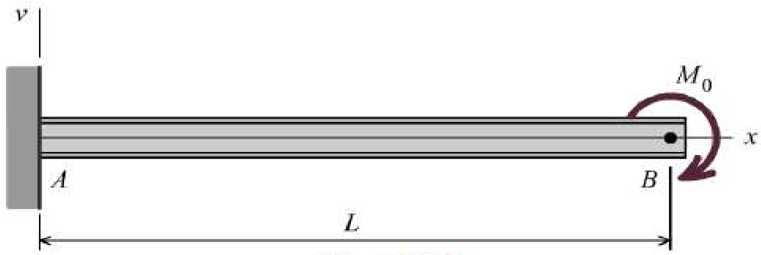
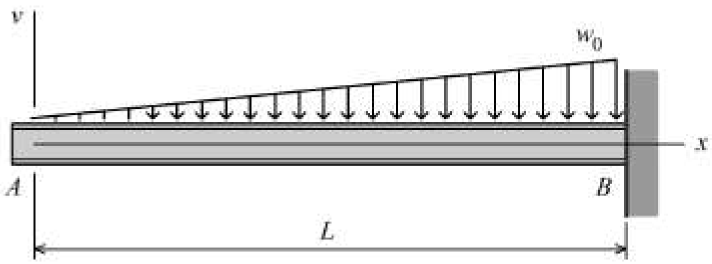
Learning Outcomes:-

At the end of the topic the student should be able to:

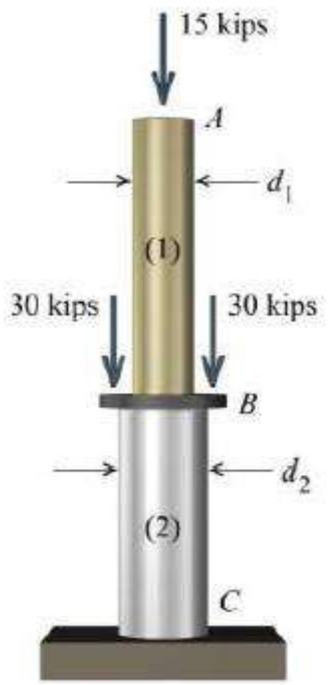
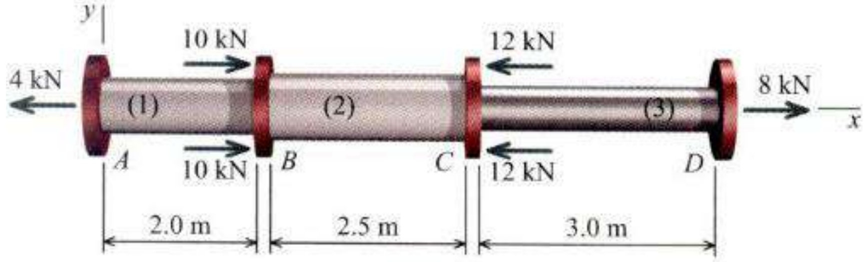
Topic Learning Outcomes	COs	BL	CA Code
Determine the deflection and slope for different types of beams.	CO7	L3	1.3

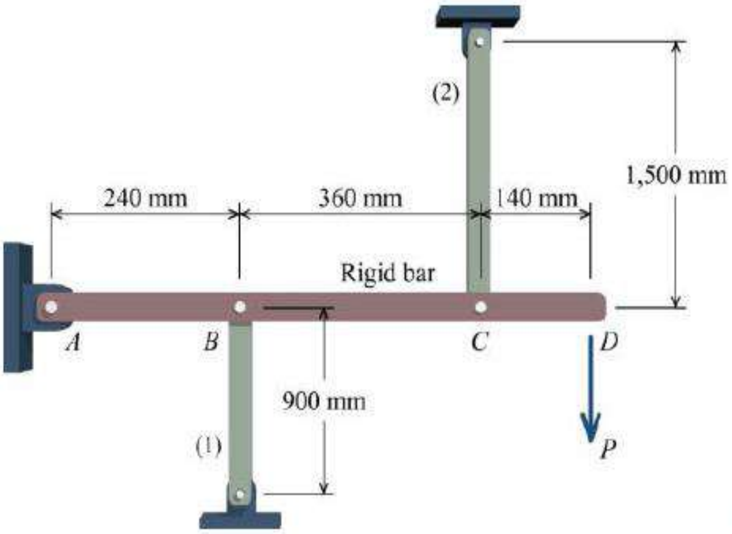
Lesson Schedule Class No. - Portion covered per hour / per Class
1. Introduction, Moment-Curvature Relationship
2. The Differential Equation of the Elastic Curve
3. Deflections by Integration of a Moment Equation
4. Deflections by Integration of Shear-Force or Load Equations
5. Deflections Using Discontinuity Functions

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. For the loading shown, use thedouble-integration method to determine (a)the equation of the elastic curve for thecantilever beam, (b) the deflection at the freeend, and (c) the slope at the free end.Assume that EI is constant for each beam.  Fig. P10.1	TLO1	L3	1.3.1
2. For the loading shown, use the doubleintegrationmethod to determine (a) theequation of the elastic curve for the cantileverbeam, (b) the deflection at the free end, and(c) the slope at the free end. Assume that EI isconstant for each beam. 	TLO1	L3	1.3.1

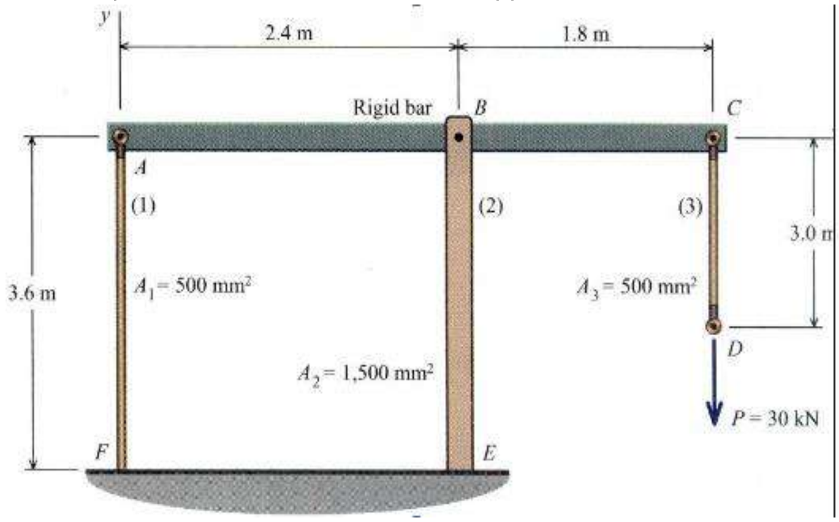
Question Paper Title: Model Question Paper for End Semester Assessment		
Total Duration (H:M):03:00	**Course :Mechanics of Materials (18EARC204)**	**Maximum Marks :100**
Note : These questions are just for reference purpose only. Actual questions will differ in content, pattern, difficulty level, etc.		

Q.No.	Questions	Marks	CO	BL	PI Code
1a	Two solid cylindrical rods (1) and (2) are joined together at flange B and loaded, asshown in Figure . If the normal stressin each rod must be limited to 40 ksi,determine the minimum diameter required for each rod. 	10	CO1	L3	1.3.1
1b	The compound axial member shown consists of a20-mm-diameter solid aluminium [E = 70 GPa] segment (I), a 24-mm-diameter solid aluminium segment (2), and a I 6-mm-diameter solid steel [E = 200 GPa]segment (3). Determine the displacements of point C, and D relative to end A. 	10	CO3	L3	1.3.1
2a	Explain material properties associated with stress-strain diagram.	10	CO2	L2	1.3.1

2b	A rigid bar ABCD is supported by two bars as shown in Figure P2.4. There is no strain in the vertical bars before load P is applied. After load P is applied, the normal strain in rod (1) is −570m/m. Determine:(a) the normal strain in rod (2).(b) the normal strain in rod (2) if there is a 1-mm gap in the connection at pin C before the load is applied.(c) the normal strain in rod (2) if there is a 1-mmgap in the connection at pin B before the load is applied.  	10	CO1	L3	1.3.1
3a	A 1035 hot-rolled steel specimen with a diameter of 0.500 in. and a 2.0-in. gage length was tested to fracture. Load and deformation data obtained during the test are given. Determine:(a) the modulus of elasticity.(b) the proportional limit.(c) the ultimate strength.(d) the yield strength (0.05% offset).(e) the yield strength (0.20% offset).(f) the fracture stress.(g) the true fracture stress if the final diameter of the specimen at the location of the fracture was0.387 in.	10	CO2	L3	1.3.1

Load (lb)	Change in Length (in.)	Load (lb)	Change in Length (in.)
0	0	12,540	0.0209
2,690	0.0009	12,540	0.0255
5,670	0.0018	14,930	0.0487
8,360	0.0028	17,020	0.0835
11,050	0.0037	18,220	0.1252
12,540	0.0042	18,820	0.1809
13,150	0.0046	19,110	0.2551
13,140	0.0060	19,110	0.2968
12,530	0.0079	18,520	0.3107
12,540	0.0098	17,620	0.3246
12,840	0.0121	16,730	0.3339
12,840	0.0139	16,130	0.3385
		15,900	fracture

3b	The assembly shown consists of rigid bar ABC, two fibre-reinforced plastic (FRP) rods (1) and (3), and FRP post (2). The modulus of elas-ticity for the FRP is E = 18 GPa. Determine the vertical deflection of joint D relative to its initial position after the 30-kN load is applied.	10	CO3	L3	1.3.1



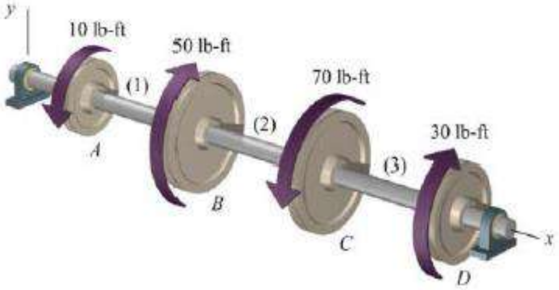
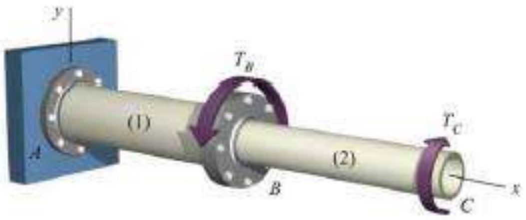
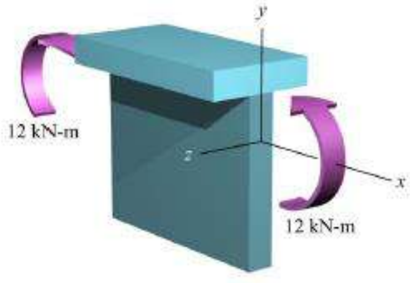
<table>
<tr><td>4a</td><td>A solid 0.75-in.-diameter shaft is subjected tithe torques shown in Figure P6.8. The bearings shown allow the shaft to turn freely.(a) Plot a torque diagram showing the internal torque in segments (1), (2), and (3) of the shaft. Use the sign convention presented in Section 6-6.(b) Determine the maximum shear stress magnitude in the shaft

</td><td>10</td><td>CO4</td><td>L3</td><td>1.3.1</td></tr>
<tr><td>4b</td><td>A compound shaft consists of two pipe segments. Segment (1) has an outside diameter of10.75 in. and a wall thickness of 0.365 in. Segment(2) has an outside diameter of 6.625 in. and a wall thickness of 0.280 in. The shaft is subjected to torques TB = 60 kip-ft and TC = 24 kip-ft, which acting the directions shown in Figure P6.4/5. Determine the maximum shear stress magnitude in each shaft segment.

</td><td>10</td><td>CO4</td><td>L3</td><td>1.3.1</td></tr>
<tr><td>5a</td><td>A beam having a tee-shaped cross section is subjected to equal 12 kN-m bending moments, as shown in Figure P8.5a. The cross-sectional dimensions of the beam are shown in Figure P8.5b.Determine:(a) the centred location, the moment of inertia about the z axis, and the controlling section modulus about the z axis.(b) the bending stress at point H. State whether the normal stress at H is tension or compression.(c) the maximum bending stress produced in the cross section. State whether the stress is tension or compression.


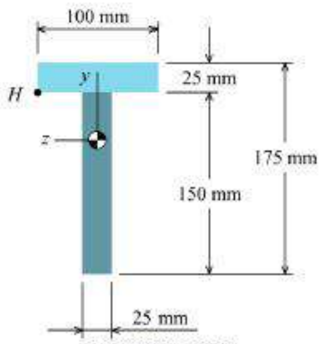
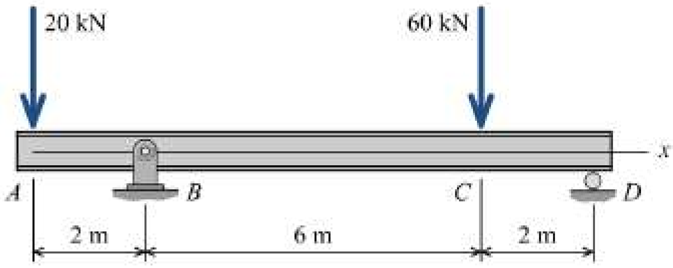
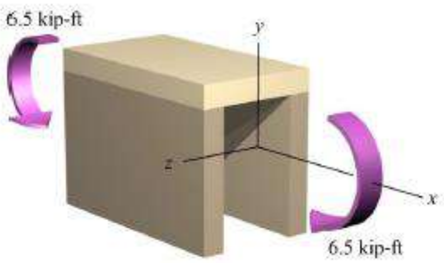
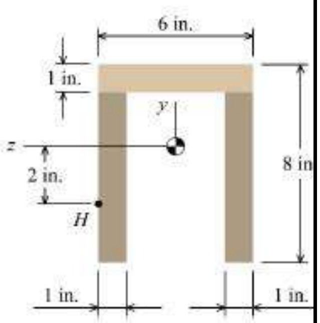
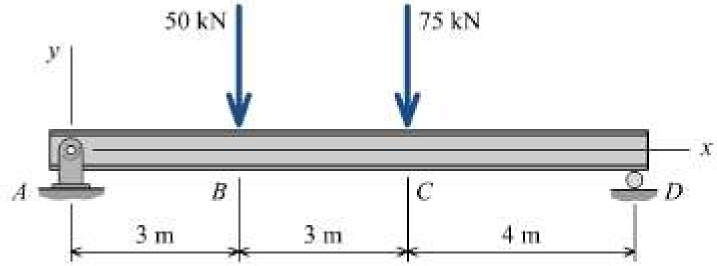
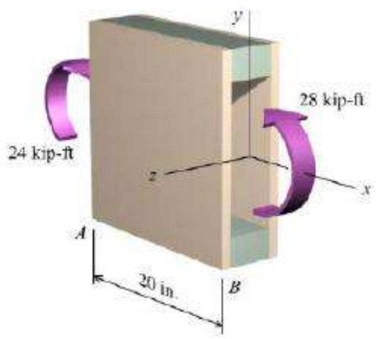
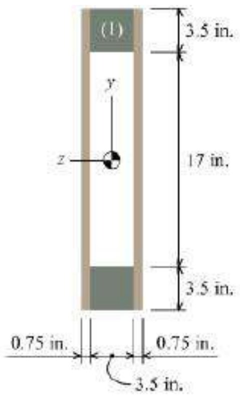
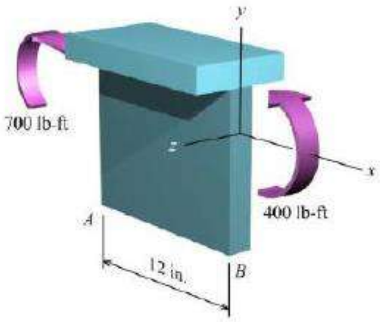
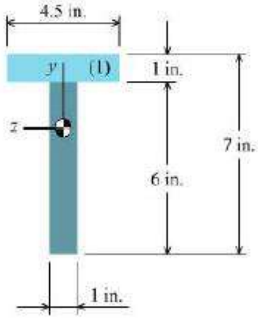
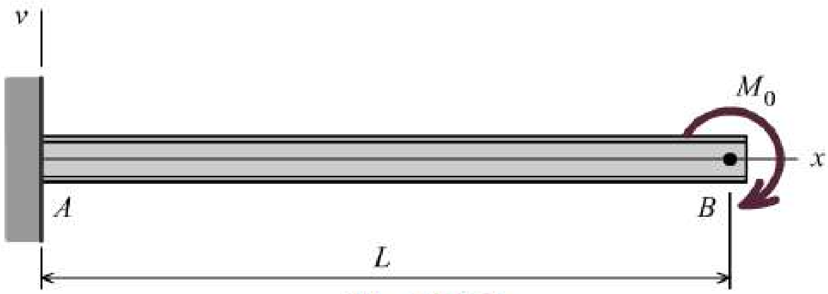
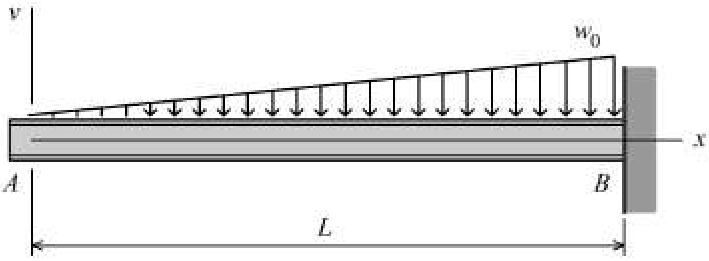
FIGURE P8.5a


FIGURE P8.5b</td><td>10</td><td>CO6</td><td>L3</td><td>1.3.1</td></tr>
</table>

5b	For the simply supported beam subjected to the loading shown,(a) Derive equations for the shear force V and the bending moment M for any location in the beam.(Place the origin at point A.) (b) Plot the shear-force and bending-moment diagrams for the beam using the derived functions. (c) Report the maximum positive bending moment, the maximum negative bending moment, and their respective locations  	10	CO5	L3	1.3.1
6a	A beam is subjected to equal 6.5 kip-ft bending moments, as shown in Figure P8.6a. The cross sectional dimensions of the beam are shown in Figure P8.6b. Determine:(a) the centroid location, the moment of inertia about the z axis, and the controlling section modulus about the z axis.(b) the bending stress at point H, which is located 2 in. below the z centroidal axis. State whether the normal stress at H is tension or compression.(c) the maximum bending stress produced in the cross section. State whether the stress is tension or compression  FIGURE P8.6*a*  FIGURE P8.6*b* .	10	CO6	L3	1.3.1
6b	For the simply supported beam subjected to the loading shown,(a) Derive equations for the shear force V and the bending moment M for any location in the beam.(Place the origin at point A) . (b) Plot the shear-force and bending-moment diagrams for the beam using the derived functions. (c) Report the maximum bending moment and its location	10	CO5	L3	1.3.1

<table>
<tr>
<td></td>
<td>
</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>1. For the following problems, a beam segment subjected to internal bending moments at sections A and B is shown along with a sketch of the cross-sectional dimensions. For each problem:(a) Sketch a side view of the beam segment and plot the distribution of bending stresses acting at sections A and B. Indicate the magnitude of key bending stresses on the sketch.(b) Determine the resultant forces acting in the x direction on the specified area at sections A and B and show these resultant forces on the sketch.(c) Is the specified area in equilibrium with respect to forces acting in the x direction? If not, determine the horizontal force required to satisfy equilibrium for the specified area and show the location and direction of this force on the sketch.



</td>
<td>10</td>
<td>CO7</td>
<td>L3</td>
<td>1.3.1</td>
</tr>
<tr>
<td>7b</td>
<td>2. For the following problems, a beam segment subjected to internal bending moments at sections A and B is shown along with a sketch of the cross-sectional dimensions. For each problem:(a) Sketch a side view of the beam segment and plot the distribution of bending stresses acting at sections A and B. Indicate the magnitude of key bending stresses on the sketch.(b) Determine the resultant forces acting in the x direction on the specified area at sections A and B and show these resultant forces on the sketch.(c) Is the specified area in equilibrium with respect to forces acting in the x direction? If not, determine the horizontal force required to satisfy equilibrium for the specified area and show the location and direction of this force on the sketch</td>
<td>10</td>
<td>CO7</td>
<td>L3</td>
<td>1.3.1</td>
</tr>
</table>

	 				
8a	1. For the loading shown, use the double-integration method to determine (a)the equation of the elastic curve for the cantilever beam, (b) the deflection at the friend, and (c) the slope at the free end. Assume that EI is constant for each beam.  Fig. P10.1	10	CO8	L3	1.3.1
8b	2. For the loading shown, use the double integration method to determine (a) the equation of the elastic curve for the cantilever beam, (b) the deflection at the free end, and(c) the slope at the free end. Assume that EI inconstant for each beam. 	10	CO8	L3	1.3.1

DEPARTMENT OF AUTOMATION AND ROBOTICS

FMTH0301/Rev.5.3

Course Plan

Semester: III Year: 2021-2022

Course Title: **Manufacturing Technology**	Course Code: **18EARC205**
Total Contact hrs: **40 hrs**	Duration of ESA: **3 hrs**
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr. Nagaraj Benakanahalli	Date: 02/08/2021
Checked By: Mrs. Shilpa Tanvashi	Date: 04/08/2021

Prerequisites:

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Explain the different types of manufacturing processes and machine tools used in the industries to manufacture the required components.
2. Select the machine tool and the required accessories and attachments for the given component and select the machining operations required and finally prepare the process sheet.
3. Explain the different non-traditional machining principles, computer aided numerically controlled machining principles, and given the component geometry create CNC programs to machine them on a CNC machine tool.
4. Explain the requirements of inspection and different instruments used, and apply GD and T to prepare inspection charts.
5. Explain the principles used for inspections and identify different machines such as Co-ordinate Measuring Machine (CMM) and Universal Measuring Machine (UMM) used for inspections.
6. Simulate a CNC program for the given component geometry by using modern CAM tools.
7. Explain the importance of health, safety and engineering roles in a manufacturing organization.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Manufacturing Technology	Semester: 3
Course Code: 18EARC205	Year: 2021-2022

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Explain the different types of manufacturing processes and machine tools used in the industries to manufacture the required components.	**M**													
2. Select the machine tool and the required accessories and attachments for the given component and select the machining operations required and finally prepare the process sheet.	**H**													
3. Explain the different non-traditional machining principles, Computer aided numerically controlled machining principles, and given the component geometry create CNC programs to machine them on a CNC machine tool.	**M**													
4. Explain the requirements of inspection and different instruments used, and apply GD and T to prepare inspection charts.	**M**													
5. Explain the principles used for inspections and identify different machines such as Co-ordinate Measuring Machine (CMM) and Universal Measuring Machine (UMM) used for inspections.	**M**													
6. Simulate a CNC program for the given component geometry by using modern CAM tools	**M**				**M**									

7. Explain the importance of health, safety and engineering roles in a manufacturing organization	**L**						**L**			**L**				

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3 Demonstrate competence in engineering fundamentals.	1.3.1 Apply elements of mechanical engineering principles and laws to solve problems.
	1.3.3 Apply computer programming skills to solve problems by building algorithms, flow charts & debugging
7.1 Demonstrate an understanding of the impact of engineering and industrial practice on social, environmental and economic contexts	7.1.2 Demonstrate an understanding of the relationship between the technical, socio economic and environmental dimensions of sustainability
5.2 Demonstrate an ability to select and apply discipline specific tools, techniques and resources	5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) Monitoring system performance, and (iv) creating engineering designs.
	5.2.2 Demonstrate proficiency in using discipline specific tools
10.2 Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others

Eg: 1.2.3: Represents Program Outcome '1', Competency '2' and Performance Indicators '3'.

Course Content

Course Code: 18EARC205	Course Title: Manufacturing Technology	
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Content	Hrs
Unit - 1	
Chapter No. 1. Turning, Shaping and Planing Machines Classification, constructional features of Lathe, Shaping Machine, Planing Machine. Driving mechanisms of Lathe, Shaping and Planing machines. Different operations on Lathe, Shaping Machine & Planing Machine. Cutting tools. Simple problems on machining time calculations.	5 hrs
Chapter No. 2. Milling Machines Classification, constructional features of milling machines. Types of milling cutters & milling cutter nomenclature. Milling processes, up milling and down milling concepts. Various milling operations. Indexing: Simple, compound, differential and angular indexing. Simple problems on simple and compound indexing	5 hrs
Chapter No. 3. Drilling & Grinding Machines Classification, constructional features of drilling machine & related operations. Types of drill & drill bit nomenclature, drill materials. Types of abrasives, Grain size, bonding process, grade and structure of grinding wheels, grinding wheel types. Classification, constructional features of grinding machines (Center less, cylindrical and surface grinding). Selection of grinding wheel, dressing and truing of grinding wheels. Analysis of the grinding process.	5 hrs
Unit - 2	
Chapter No. 4. CNC Machine Tools Introduction to CNC machines- Principles of operation. Axes of CNC machine-Coordinate systems. Elements of CNC machines, Basics of Manual part programming methods.	5 hrs
Chapter No. 5. Nontraditional Machining Need for nontraditional machining, principle, equipment & operation of Abrasive Jet Machining, Water Jet Machining, Electro-Chemical Machining, Electrical Discharge Machining, Wire EDM, Electron Beam Machining, Laser Beam Machining & Plasma Arc Machining	5 hrs
Chapter No. 6. Metrology and Inspection Definition, need of inspection, terminologies, methods of measurement. Standards of measurement-line standards, end standards & wavelength standards. Limits, fits & gauges-introduction, tolerances, limits of size, fit and tolerances, Limit gauges classification.	5 hrs
Unit - 3	
Chapter No. 7. Comparators and Angular Measurement Devices Characteristics of comparators, classification of comparators- Mechanical, Electrical &	5 hrs

Pneumatic comparators. Introduction to angular measurement - Vernier & optical Bevel Protractor, sine bar, sine centre, angle gauges.	
Chapter No. 8. Advanced Metrology Introduction & applications of: Co-ordinate Measuring Machine-important features of CMM, possible causes of errors in CMM, Performance, applications & advantages of CMM. Universal Measuring Machine- comparison of CMM & UMM, inspection on UMM. Precision instruments based on laser – principle- laser interferometer- application in linear, angular measurements	5 hrs

Text Books (List of books as mentioned in the approved syllabus)

1. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes and Systems, 4th Edition, John Wiley & Sons Inc, 2010.
2. R.K.Jain, Engineering Metrology, Khanna Publishers, 2009.

References

1. R.K.Jain, Production Technology, Khanna Publications, 2003.
2. HMT, Production Technology, Tata Mc Graw Hill, 2001.
3. S .K. Hajra & Choudhury, Elements of workshop technology, volume -II Machine Tools, 13th Edition, Media Promoters & Publishers Pvt Ltd.

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
ISA-1	20
ISA-2	20
Activity/Post Test	10
Total	**50**

Course Unitization for ISA and ESA

Topics / Chapters	Teaching Credits	No. of Questions in Minor ISA-1	No. of Questions in Minor ISA-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
1. Turning, Shaping and Planing Machines	5	1.00	--	--	1.00
2. Milling Machines	5	1.00	--	--	1.00
3. Drilling & Grinding Machines	5	1.00	--	--	1.00
Unit II					
4. CNC Machine Tools	5	--	1.00	1.0	1.00
5. Nontraditional Machining	5	--	1.00	--	1.00
6. Metrology and Inspection	5	--	1.00	1.0	1.00
Unit III					
7. Comparators and Angular Measurement Devices	5	--	--	--	1.00
8. Advanced Metrology:	5	--	--	--	1.00

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA-I, ISA-II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full question from Unit III) out of 8 questions in ESA.

Date: 08-08-2021 HOD

Course Assessment Plan

Course Title: Manufacturing Technology					Code: 18EARC205
Course outcomes (COs)	Weightage in Assessment	Assessment Methods			
		ISA-1	ISA-2	Activity	ESA
1. Explain the different types of manufacturing processes and machine tools used in the industries to manufacture the required components.	18%	✓			✓
2. Select the machine tool and the required accessories and attachments for the given component and select the machining operations required and finally prepare the process sheet.	18%	✓			✓
3. Explain the different non-traditional machining principles, Computer aided numerically controlled machining principles, and given the component geometry create CNC programs to machine them on a CNC machine tool.	18%		✓		✓
4. Explain the requirements of inspection and different instruments used, and apply GD and T to prepare inspection charts.	18%		✓		✓
5. Explain the principles used for inspections and identify different machines such as Co-ordinate Measuring Machine (CMM) and Universal Measuring Machine (UMM) used for inspections.	18%				✓
6. Simulate a CNC program for the given component geometry by using modern CAM tools.	5%			✓	
7. Explain the importance of health, safety and engineering roles in a manufacturing organization.	5%			✓	
Weightage		20%	20%	10%	50%

Chapter-wise Plan

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **1. Turning, Shaping and Planing Machines**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Define manufacturing and classify the manufacturing processes by giving the examples.	CO1	L2	1.3
2. Define machine tool and identify the function of a lathe, different types of lathes used in the industries, parts of a typical center lathe and their functions.	CO1	L2	1.3
3. Identify the various headstock drive mechanisms that are used to transfer motion to the spindle and explain the working principle of those mechanisms.	CO1	L2	1.3
4. Identify the different operations which can be performed on a center lathe.	CO2	L2	1.3
5. Explain working principle of a single point cutting tool, seven elements of a single point cutting tool by drawing the single point cutting tool geometry and identify the terminologies used in the single point cutting tool nomenclature.	CO1	L2	1.3
6. Identify the different types of single point cutting tools, tool holding devices and work holding devices.	CO1	L2	1.3
7. Define the following terms with respect to turning operation: Feed rate, depth of cut, spindle rotation speed, Material removal rate and machining time.	CO2	L3	1.3
8. Select proper machining parameters for the operations which are performed on a typical center lathe and prepare the process sheets to carry out the operations by calculating the machining time and material removal rate.	CO2	L3	1.3
9. Identify the function of a typical shaping machine and parts of a typical shaping machine and their functions.	CO1	L3	1.3
10. Explain cutting tool motion transmission mechanisms in a shaping machine by drawing the mechanism sketches.	CO1	L2	1.3
11. Identify the different operations which can be performed on a typical shaping and planing machines.	CO2	L2	1.3
12. Select proper machining parameters for the operations which are performed on a typical shaping machine and prepare the process sheets to carry out the operations by calculating the machining time.	CO2	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Classification manufacturing processes and constructional features of Lathe and Shaping Machine, Planing Machine.
2. Driving mechanisms of Lathe and Shaping machines.
3. Different operations on Lathe, Shaping Machine & Planing Machine
4. Different operations on Shaping Machine & Planing Machines
5. Cutting tools. Simple problems on machining time calculations

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Name the various ways in which a work-part can be held in a lathe.	TLO6	L2	1.3.1
2. What is the difference between a live center and a dead center, when these terms are used in the context of work holding in a lathe?	TLO2	L2	1.3.1
3. How does a turret lathe differ from an engine lathe?	TLO2	L2	1.3.1
4. Explain the taper turning operation by swiveling the compound rest by drawing a neat figure.	TLO4	L2	1.3.1
5. Discuss the crank and slotted link quick return mechanism with a neat figure.	TLO10	L2	1.3.1
6. Explain single point cutting tool geometry with a neat figure.	TLO5	L2	1.3.1
7. Explain all geared headstock mechanism with a neat figure	TLO3	L2	1.3.1
8. In a shaper the length of stroke is 300mm, number of double strokes is 40 & the ratio of return time cutting time is 1:2. Find the cutting speed.	TLO12	L3	1.3.1
9. Find the time required in Lathe for one complete cut on a piece of work 350mm long & 50 mm in diameter. The cutting speed is 35 meters per minute & feed is 0.5 mm per revolution	TLO8	L3	1.3.1
10. A 4.00-in-diameter work-piece that is 25 in long is to be turned down to a diameter of 3.50 in, using two passes on an engine lathe using a cutting speed = 300 ft/min, feed=0.015 in/rev, and depth of cut=0.125 in. The bar will be held in a chuck and supported on the opposite end in a live center. With this work holding setup, one end must be turned to diameter; then the bar must be reversed to turn the other end. Using an overhead crane available at the lathe, the time required to load and unload the bar is 5 min, and the time to reverse the bar is 3 min. For each turning cut an allowance must be added to the cut length for approach and over travel. The total allowance (approach plus over travel) =0.50 in. Determine the total cycle time to complete this turning operation.	TLO8	L3	1.3.1
11. A shaft of length 90 mm has a tapered portion of length 55 mm. The diameter of the taper is 80 mm at one end and 65 mm at the other. If the taper is made by tailstock set over method, determine the taper	TLO8	L3	1.3.1

angle and the set over.			
12. A steel bar 200 mm in diameter is turned at a feed of 0.25 mm/rev with a depth of cut of 4 mm. The rotational speed of the work piece is 160 rpm. Determine he material removal rate in mm 3/s.	TLO8	L3	1.3.1
13. Estimate the shortest machining time required in a shaper machine to machine a plate of 200X90 mm under the following conditions. Cutting speed=13.3m/min, feed=0.57 mm/double stroke, ratio of cutting speed to rapid return=0.83.	TLO12	L3	1.3.1
14. A mild steel plate 400 mm x 800 mm x 30 mm is to be shaped along its wider face. The ratio of return to cutting time is 2:3 and the feed per cycle is 2mm. Tool approach and the over travel respectively are 50 mm each. Select a suitable cutting speed and calculate the machining time required for machining the given plate with HSS tools.	TLO12	L3	1.3.1
15. Explain back geared headstock mechanism with a neat figure.	TLO3	L2	1.3.1
16. A facing operation is performed on an engine lathe. The diameter of the cylindrical part is 6 in and the length is 15 in. The spindle rotates at a speed of 180 rev/min. Depth of cut= 0.110 in, and feed=0.008 in / rev. Assume the cutting tool moves from the outer diameter of the work-piece to exactly the center at a constant velocity. Determine (a) the velocity of the tool as it moves from the outer diameter towards the center and (b) the cutting time.	TLO8	L3	1.3.1
17. A cylindrical work-part 200 mm in diameter and 700 mm long is to be turned in an engine lathe. Cutting speed = 2.30 m/s, feed = 0.32 mm/rev, and depth of cut = 1.80 mm. Determine cutting time, and metal removal rate.	TLO8	L3	1.3.1

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **2. Milling Machines**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Identify the function of a milling machine, different types of milling machines used in the industries, parts of a typical milling machine and their functions.	CO1	L2	1.3
2. Identify the different types of milling cutters used in the industries.	CO1	L2	1.3
3. Explain working principle of a multi-point cutting tool, elements of a multi-point cutting tool by drawing the tool geometry.	CO1	L2	1.3
4. Identify the different operations which can be performed on a typical milling machine.	CO2	L2	1.3
5. Select proper machining parameters for the operations which are performed on a typical milling machine and prepare the process sheets to carry out the operations by calculating the machining time and material removal rate.	CO2	L3	1.3
6. Explain the different types of indexing methods used to divide the periphery of a component and select the suitable indexing method to divide the periphery of the component, the given the number of divisions.	CO1	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Classification of milling machine & description of principal parts of milling machine
2. Types of milling cutters & milling cutter nomenclature
3. Peripheral milling & face milling processes, Milling machine operations
4. Selection of proper machining parameters and calculation of machining time for milling operations
5. Simple and compound Indexing

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. How does a universal milling machine differ from a conventional knee-and-column machine?	TLO1	L2	1.3.1
2. Compare up milling & down milling operations with the help of neat sketches.	TLO4	L2	1.3.1
3. List the different types of milling cutters.	TLO2	L2	1.3.1

4. Explain the face milling operations with neat sketches.	TLO4	L2	1.3.1
5. Explain the peripheral milling operations with neat sketches.	TLO4	L2	1.3.1
6. Explain the profile sharpened cutters with the help of neat sketches.	TLO2	L2	1.3.1
7. Explain the milling cutter nomenclature by drawing a neat sketch of the milling cutter.	TLO3	L2	1.3.1
8. Compare peripheral milling and face milling operations by drawing the neat sketches.	TLO3	L2	1.1.1
9. A face milling operation is used to machine 6.0 mm in a single pass from the top surface of a rectangular piece of aluminum 300 mm long by 125 mm wide. The cutter has four teeth & is 150 mm in diameter. The cutting speed is 2.8 m/s, & the chip load is 0.27 mm/tooth. Determine (a) time to make one pass across the surface & (b) the maximum metal removal rate during cutting.	TLO5	L3	1.3.1
10. A block of length 200mm is machined by a slab milling cutter 34mm in diameter. The depth of cut and table feed are set at 2mm and 18mm/minute, respectively. Considering the approach and the over travel of the cutter to be same, determine the minimum estimated machining time per pass in minutes.	TLO5	L3	1.3.1
11. In a slab milling operation the following data was observed Diameter of cutter=90mm, Number of teeth on cutter=10, cutting speed=30m/min, Table feed=180mm/min, Depth of cut=3mm, Calculate the maximum and average chip thickness in milling	TLO5	L3	1.3.1
12. Compute the indexing movement required to index the following divisions by compound indexing using Brown & Sharp index plate: (i) 69 divisions (ii) 87 divisions	TLO6	L3	1.3.1
13. The top surface of a rectangular work-part is machined using a peripheral milling operation. The work-part is 735 mm long by 50 mm wide by 95 mm thick. The milling cutter, which is 60 mm in diameter and has five teeth, overhangs the width of the part equally on both sides. Cutting speed =80 m/min, chip load = 0.30 mm/tooth, and depth of cut = 7.5 mm. (a) Determine the time required to make one pass across the surface, given that the setup and machine settings provide an approach distance of 5 mm before actual cutting begins and an over travel distance of 25 mm after actual cutting has finished. (b) What is the maximum material removal rate during the cut?	TLO5	L3	1.3.1
14. A face milling operation is performed on the top surface of a steel rectangular work-piece 12.0 in long by 2.5 in wide. The milling cutter follows a path that is centered over the work-piece. It has five teeth and a 3.0 in diameter. Cutting speed = 250 ft/min, feed = 0.006 in/tooth, and depth of cut = 0.150 in. Determine (a) the actual cutting time to make one pass across the surface and (b) the maximum metal removal rate during the cut. (c) If an additional approach distance of 0.5 in is provided at the beginning of the pass (before cutting begins), and an over travel distance is provided at the end of the pass equal to the cutter radius plus 0.5 in, what is the duration of the feed motion.	TLO5	L3	1.3.1

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **3. Drilling & Grinding Machines**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Identify the function of a drilling machine, different types of drilling machines used in the industries, parts of a typical drilling machine and their functions.	CO1	L2	1.3
2. Identify the different types of milling cutters used in the industries.	CO1	L2	1.3
3. Explain working principle of a drill bit, types of drill bits, and elements of a drill bit by drawing the drill bit geometry.	CO1	L2	1.3
4. Identify the different operations which can be performed on a typical drilling machine.	CO2	L2	1.3
5. Identify the function of a grinding machine, different types of grinding machines used in the industries, parts of a typical grinding machine and their functions.	CO1	L2	1.3
6. Identify the principal parameters of a grinding wheel and select the grinding wheel based on the grinding wheel specification as defined by American National Standards Institute (ANSI).	CO1	L2	1.3
7. Identify the different operations which can be performed on grinding machines.	CO2	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Types of drilling machines & twist drill nomenclature
2. Operations performed on drilling machine, Types of grinding machines & principal grinding operations
3. Types of grinding wheels & their selection
4. Marking system for grinding wheels, dressing & truing of the grinding wheel
5. Grinding wheel parameters

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain the five basic parameters of a grinding wheel.	TLO6	L2	1.3.1
2. Explain the different operations which can be performed on drilling	TLO4	L2	1.3.1

machine by drawing the neat sketches.			
3. Compare external cylindrical grinding and internal cylindrical grinding operations by drawing the neat sketches.	TLO7	L2	1.3.1
4. Explain twist drill nomenclature by drawing the drill bit geometry.	TLO3	L2	1.3.1
5. Explain the two types in center-less grinding operations by drawing the neat figures.	TLO7	L2	1.3.1
6. Discuss the four the types of surface grinding operations by drawing the neat sketches.	TLO7	L2	1.3.1
7. Explain the different bonding materials used in grinding wheels by indicating the type of grinding operation for which it is used.	TLO6	L2	1.3.1
8. Discuss the different types of abrasive materials used for grinding different work materials.	TLO6	L2	1.3.1

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **4. CNC Machine Tools**	Planned Hours: **5 hrs**

Learning Outcomes:-

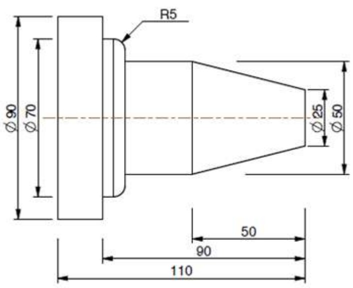
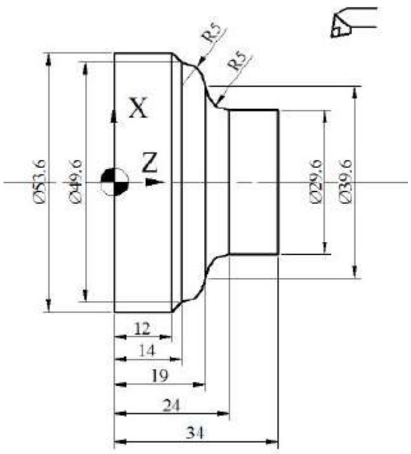
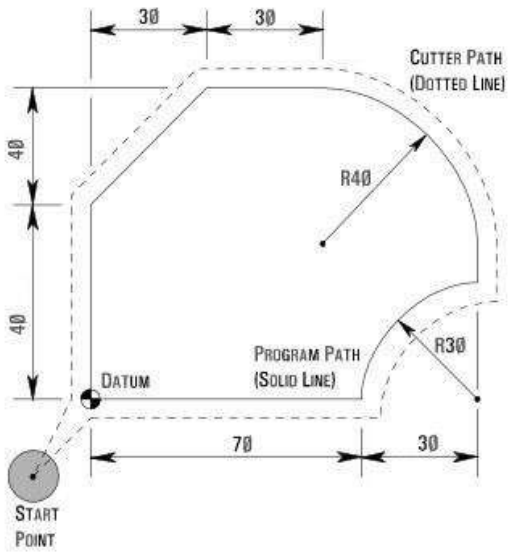
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Identify the function of a CNC machine, different types of typical CNC machines used in the industries, parts of a typical CNC machine and their functions.	CO3	L2	1.3
2. Identify different axes, machine zero, home position, systems and controls of CNC machines.	CO3	L2	1.3
3. Explain ISO G and M codes used in CNC turning and milling machines and write programs using ISO format for the given geometry of the component with and without use of MACRO, CANNED CYCLE and SUBROUTINE using ISO format.	CO3	L2	1.3
4. Simulate a CNC program for CNC lathe and CNC milling machines for a given geometry of the component on the modern CAM tools.	CO3	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction & principle of computer numerical control machine tool, NC, CNC & DNC systems
2. Constructional Features of CNC machine tools, Axes standards
3. Advantages & applications of CNC machines in manufacturing
4. Part programming fundamentals, G codes & M codes
5. Simple CNC part programming examples

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain the important elements of a CNC machine by drawing the block diagram.	TLO1	L2	1.3.1
2. Explain the terms preparatory functions & miscellaneous functions by stating where they are used in CNC program.	TLO3	L2	1.3.1
3. Write a CNC part program for the component shown in Figure 3 below.	TLO3	L3	1.3.1

 Figure 3 All dimensions are in mm			
4. Write a CNC part program for the component shown in Figure 4 below  Figure 4 All dimensions are in mm	TLO3	L3	1.3.1
5. Write a CNC program for the component shown in figure 5.  Figure 5 All dimensions are in mm	TLO3	L3	1.3.1

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **5. Nontraditional Machining**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Define the nontraditional machining.	CO3	L1	1.3
2. Discuss the importance of the nontraditional processes.	CO3	L1	1.3
3. List the four categories of nontraditional machining processes, based on principal energy form.	CO3	L1	1.3
4. Discuss the working principle of nontraditional processes, which use mechanical energy other than a sharp cutting tool by drawing the neat sketches of the processes.	CO3	L2	1.3
5. Discuss the working principle of electrochemical processes, which use electrical energy in combination with chemical reactions to accomplish material removal, by drawing the neat sketches of the processes.	CO3	L2	1.3
6. Discuss the working principle of material removal processes based on thermal energy by drawing the neat sketches of the processes.	CO3	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction & classification of non-traditional machining processes
2. Non- traditional machining processes using water & abrasive jets
3. Electro-Chemical Machining, Electric Discharge Machining
4. Wire EDM & Electron Beam Machining
5. Laser Beam Machining, Plasma Arc Machining

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Why are the nontraditional material removal processes important?	TLO2	L1	1.3.1
2. List the four categories of nontraditional machining processes, based on principal energy form.	TLO3	L1	1.3.1
3. Discuss the working principle of water jet cutting process by drawing the neat sketch of the process.	TLO4	L2	1.3.1
4. Compare the working principle of water jet cutting and abrasive water jet cutting by drawing the neat sketches of the processes.	TLO4	L2	1.3.1

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **6. Metrology and Inspection**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Discuss the need for inspection.	CO4	L1	1.3
2. List the different types of inspections.	CO4	L1	1.3
3. List the different standards of measurement.	CO4	L1	1.3
4. Discuss the material standards - yard and metre by explaining their contribution, and disadvantages, and appreciate the significance of wavelength standards.	CO4	L2	1.3
5. Compare the characteristics of line and end standards.	CO4	L2	1.3
6. List the subdivisions of standards.	CO4	L1	1.3
7. Appreciate the significance of different types of limits, fits, and tolerances in design and manufacturing fields, which are required for efficient and effective performance of components/products.	CO4	L2	1.3
8. Discuss the principle of limit gauging and its importance in inspection in industries.	CO4	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction, need of inspection
2. Standards of measurement, Methods of measurement
3. Tolerances, Limits of size, System of Limits & Fits
4 Geometric Dimensioning & Tolerancing
5. Limit gauges

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain the imperial standard yard by drawing the neat figure.	TLO4	L2	1.3.1
2. List the material standards and list their disadvantages.	TLO4	L2	1.3.1
3. Explain the International prototype of metre by drawing the neat figure.	TLO4	L2	1.3.1
4. Explain why a unilateral tolerance system is generally preferred over bilateral system.	TLO7	L2	1.3.1
5. A clearance fit is required between the mating parts with hole, specified	TLO7	L3	1.3.1

as $25^{+0.04}_{-0.00}$ mm and shaft $25^{-0.02}_{-0.04}$ mm. Find maximum and minimum permissible size of the hole and also for the shaft.			
6. Define the following terms: Limit and Fit. Fundamental deviation and Fundamental tolerance	TLO7	L1	1.3.1
7. Discuss the different types of fits by drawing the neat sketches.	TLO7	L2	1.3.1

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **7. Comparators and Angular Measurement Devices**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Define the comparator.	CO4	L1	1.3
2. Classify the comparators.	CO4	L1	1.3
3. Explain the functional requirements and characteristics of comparators.	CO4	L2	1.3
4. Explain the basic principles of construction and operations of various types of comparators such as mechanical, pneumatic and electrical comparators.	CO4	L2	1.3
5. Discuss the basic requirements of angular measurement in the industry.	CO4	L2	1.3
6. Discuss the basic principle of a protractor and its extension as the universal bevel protractor.	CO4	L2	1.3
7. Measure angles using the sine principle and explain the use of sine bar and sine center.	CO4	L2	1.3
8. Use angle gauges and slip gauges to set them accurately to the required angle.	CO4	L2	1.3
9. Explain the principles of the autocollimator and the angle dekkor.	CO4	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction, characteristics of comparators
2 Mechanical comparators
3. Electrical & Pneumatic comparators
4. Introduction to angular measurement - Vernier & optical Bevel Protractor
5. Sine bar, Sine centre and angle gauges.

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain the working principle of a sigma mechanical comparator by drawing the neat sketch.	TLO4	L2	1.3.1

2. Explain the working principle of solex pneumatic comparator by drawing neat sketch.	TLO4	L2	1.3.1
3. Explain working principle of mechanical optical comparator by drawing the neat sketch.	TLO4	L2	1.3.1
4. Explain how a sine bar may be employed to determine the inclined angle of a taper plug gauge.	TLO7	L2	1.3.1
5. 100 mm sine bar is to be set up to angle of 32.5^0. Determine the slip gauges needed and build the dimension of slip gauges using M87 set slip gauge.	TLO8	L3	1.3.1
6. Select the sizes of angle gauges required to build the following angles 22^0 11' 20", 29^0 54", 31^0 49' 24"	TLO8	L3	1.3.1
7. Which comparator is best suited for inspection of small gears and screws?	TLO4	L1	1.3.1

Course Code and Title: **18EARC205 / Manufacturing Technology**	
Chapter Number and Title: **8. Advanced Metrology**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explain the construction & operation of different types of measuring machines.	CO5	L2	1.3
2. Develop fundamental knowledge on measuring machines.	CO5	L2	1.3
3. Explain the working principle of measurement using laser & its applications in metrology.	CO5	L2	1.3
4. Discuss the working principle of advanced metrological devices & machine used in industrial environments.	CO5	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to CMM & types of CMMs
2. Causes of errors, error reduction & error compensation in CMM
3. Performance & applications of CMMs
4. Inspection on UMM
5. Laser in metrology (Scanning Laser system, Laser Triangulation)

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. What are the different types of CMM configurations (based on construction) available? Explain anyone with a neat diagram.	TLO1	L2	1.3.1
2. Discuss the working principle of a UMM & explain its applications.	TLO1	L2	1.3.1
3. Explain the major aspects to be considered in evaluating the performance of CMM.	TLO2	L2	1.3.1
4. Discuss the possible causes of errors in CMM.	TLO2	L2	1.3.1
5. Briefly explain with a neat sketch Scanning Laser system.	TLO3	L2	1.3.1
6. Compare inspection on CMM & UMM. Describe suitability of each measuring machine.	TLO4	L2	1.3.1

Model Question Paper for In-Semester Assessment (ISA-1)		
Course Code: 18EARC205		Course Title: Manufacturing Technology
Duration: 75 min		
Max. Marks: 40		
Note: Answer any two full questions		

Q.No	Questions	Marks	CO	BL	PO	PI Code
1a	i) In a production turning operation, the foreman has decreed that a single pass must be completed on the cylindrical work piece in 5.0 min. The piece is 400 mm long and 150 mm in diameter. Using a feed = 0.30 mm/rev and a depth of cut= 4.0 mm, what cutting speed must be used to meet this machining time requirement? ii) A plate measuring 300 mm x 100 mm x 40 mm is to be rough shaped along its wider face. Calculate the machining time taking approach =25 mm, over travel=25mm, cutting speed = 12m/min, return speed = 20m/min, allowance on either side of the plate width = 5 mm and feed per cycle = 2mm.	6	2	L3	1	1.3.1
1b	Explain all geared headstock mechanism with a neat figure.	7	2	L2	1	1.3.1
1c	Explain crank and slotted link quick return mechanism with a neat figure.	7	1	L2	1	1.3.1
2a	A slab milling operation is performed on the top surface of a steel rectangular work piece 12.0 in long by 2.5 in wide. The helical milling cutter, which has a 3.0 in diameter and ten teeth, is set up to overhang the width of the part on both sides. Cutting speed is 125 ft/min, feed is 0.006 in/tooth, and depth of cut = 0.300 in. Determine (a) the actual machining time to make one pass across the surface and (b) the maximum metal removal rate during the cut. (c) If an additional approach distance of 0.5 in is provided at the beginning of the pass (before cutting begins), and an over travel distance is provided at the end of the pass equal to the cutter radius plus 0.5 in, what is the duration of the feed motion.	6	2	L3	1	1.3.1
2b	Compute the indexing movement required to index *87* divisions by compound indexing using Brown & Sharp index plate. **Brown and Sharp Index plate:** Plate 1: 15, 16, 17, 18, 19 and 20. Plate 2: 21, 23, 27, 29, 31 and 33. Plate 3: 35, 37, 39, 41, 43, 47 and 49.	7	2	L2	1	1.3.1
2c	Explain the elements of a plain milling cutter with a neat figure.	7	1	L2	1	1.3.1
3a	Explain the different types of drill bits and drill bit materials.	6	1	L2	1	1.3.1

3b	With the help of neat sketches explain the operations related to drilling.	7	2	L3	1	1.3.1
3c	Explain the five basic parameters of a grinding wheel.	7	2	L3	1	1.3.1

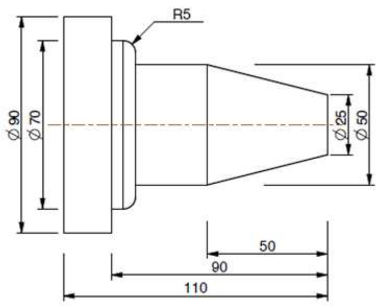
<table>
<tr><td colspan="7">Model Question Paper for In-Semester Assessment (ISA-2)</td></tr>
<tr><td>Course Code: 18EARC205</td><td></td><td colspan="5">Course Title: Manufacturing Technology</td></tr>
<tr><td>Duration: 75 min</td><td></td><td colspan="5"></td></tr>
<tr><td>Max. Marks: 40</td><td></td><td colspan="5"></td></tr>
<tr><td colspan="7">Note: Answer any two full questions</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>Q.No</td><td>Questions</td><td>Marks</td><td>CO</td><td>BL</td><td>PO</td><td>PI Code</td></tr>
<tr><td>1a</td><td>Explain the important elements of a CNC system with the help of a neat figure.</td><td>6</td><td>3</td><td>L2</td><td>1</td><td>1.3.1</td></tr>
<tr><td>1b</td><td>Write a complete CNC part program for the component shown in figure 1.b.


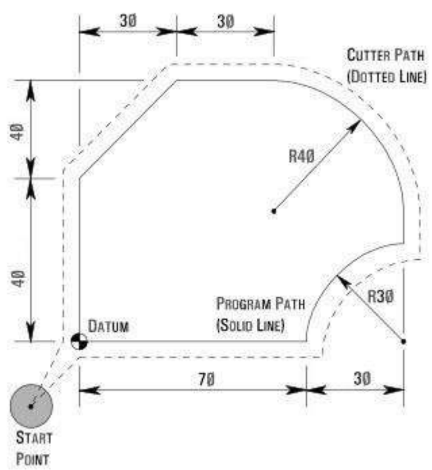
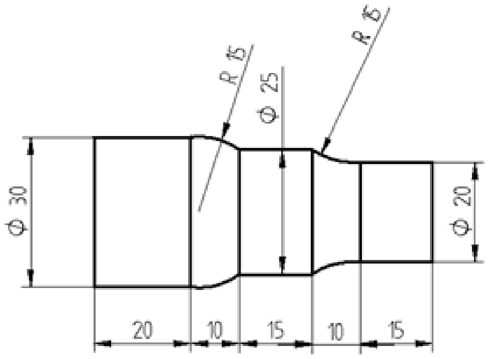
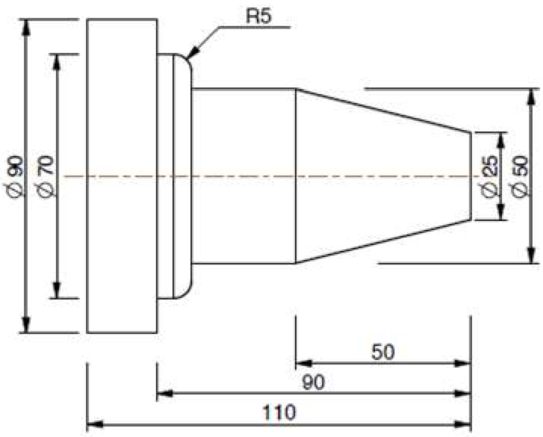
Figure 1.b
All dimensions are in mm</td><td>7</td><td>3</td><td>L2</td><td>1</td><td>1.3.1</td></tr>
<tr><td>1c</td><td>Write a complete CNC part program for the component shown in figure 1.c.

</td><td>7</td><td>4</td><td>L2</td><td>1</td><td>1.3.1</td></tr>
</table>

	Figure 1.c All dimensions are in mm					
2a	Explain plasma arc cutting with the help of a neat figure.	6	3	L2	1	1.3.1
2b	Explain electrical discharge machining with the help of a neat figure.	7	3	L2	1	1.3.1
2c	Explain laser beam machining with the help of a neat figure.	7	3	L2	1	1.3.1
3a	Explain different types of fits with neat sketches.	6	3	L3	1	1.3.1
3b	Explain imperial standard yard with a neat sketch.	7	4	L2	1	1.3.1
3c	i) A shaft of diameter $20^{+0.05\ -0.15}$ mm and a hole of diameter $20^{+0.20\ +0.10}$ mm, when assembled would give which type of fit? ii) Explain the unilateral and bilateral system of writing tolerances with suitable examples.	7	4	L3	1	1.3.1

Model Question Paper for End Semester Assessment (ESA)		
Course Code: 18EARC205		Course Title: Manufacturing Technology
Duration: 180 min		
Max. Marks: 100		
Note :Answer Five Questions: Any two full questions from each Unit I & Unit II and one full question from Unit III		

UNIT - I

Q.No	Questions	Marks	CO	BL	PO	PI Code
1a	Explain tumbler gear reversing mechanism with a neat figure.	6	1	L2	1	1.3.1
1b	Explain the taper turning by swiveling the compound rest with a neat figure.	7	1	L2	1	1.3.1
1c	A 4.00-in-diameter workpiece that is 25 in long is to be turned down to a diameter of 3.50 in, using two passes on an engine lathe using a cutting speed = 300 ft/min, feed=0.015 in/rev, and depth of cut=0.125 in. The bar will be held in a chuck and supported on the opposite end in a live center. With this work holding setup, one end must be turned to diameter; then the bar must be reversed to turn the other end. Using an overhead crane available at the lathe, the time required to load and unload the bar is 5 min, and the time to reverse the bar is 3 min. For each turning cut an allowance must be added to the cut length for approach and over travel. The total allowance (approach plus over travel) =0.50 in. Determine the total cycle time to complete this turning operation.	7	2	L3	1	1.3.1
2a	Explain any six milling operations with neat sketches.	6	2	L2	1	1.3.1
2b	Compute the indexing movement required to index 87 divisions by compound indexing using Brown & Sharp index plate.	7	2	L3	1	1.3.1
2c	A face milling operation is performed on the top surface of a steel rectangular work-piece 12.0 in long by 2.5 in wide. The milling cutter follows a path that is centered over the work-piece. It has five teeth and a 3.0 in diameter. Cutting speed = 250 ft/min, feed = 0.006 in/tooth, and depth of cut = 0.150 in. Determine (a) the actual cutting time to make one pass across the surface and (b) the maximum metal removal rate during the cut. (c) If an additional approach distance of 0.5 in is provided at the beginning of the pass (before cutting begins), and an over travel distance is provided at the end of the pass equal to the cutter radius plus 0.5 in, what is the duration of the feed motion.	7	2	L3	1	1.3.1
3a	Explain the two types in center-less grinding operations with figures.	6	1	L2	1	1.3.1

3b	Explain twist drill nomenclature with neat a figure.	7	2	L3	1	1.3.1
3c	Explain the operations related to drilling with the help of neat sketches.	7	1	L2	1	1.3.1
	UNIT – II					
4a	Explain the elements of a typical CNC machine with the help of a block diagram.	6	3	L2	1	1.3.1
4b	Write complete CNC part program for the component shown in figure 4.b.  Figure 4.b All dimensions are in mm	7	3	L3	2	1.3.3
4c	Write a complete CNC part program for the component shown in Figure 4.c.  Figure 4.c All dimensions are in mm	7	3	L3	2	1.3.3
5a	Explain with sketch principal of Electric Discharge Machining & also mention its applications.	6	3	L2	1	1.3.1
5b	Explain with sketch the principle of plasma generation & mechanism of metal removal in PAM	7	3	L2	1	1.3.1
5c	Distinguish between line standards and end standards. Why tolerances are specified	7	4	L2	1	1.3.1
6a	Explain with neat sketch principle of wire EDM process.	6	3	L2	1	1.3.1
6b	With a help of suitable examples explain three different types of fits. Support your answer with sketches for each fit.	7	4	L2	1	1.3.1

6c	Explain with suitable examples, Shaft basis & Hole basis system.	7	4	L2	1	1.3.1
UNIT - III						
7a	Describe mechanical comparator & explain the magnification method adopted in it.	6	4	L2	1	1.3.1
7b	Explain the difference between flow type & back pressure type pneumatic comparator.	7	4	L2	1	1.3.1
7c	100 mm sine bar is to be set up to angle of 32.5^0. Determine the slip gauges needed and build the dimension of slip gauges using M87 set slip gauge	7	4	L3	1	1.3.1
8a	Explain the possible causes of errors in CMM.	6	5	L2	1	1.3.1
8b	Explain with neat sketches the following measurements with Lasers i) Scanning Laser system ii) Laser Triangulation	7	5	L2	1	1.3.1
8c	What are the different types of CMM configurations (based on construction) available? Explain anyone with a neat diagram.	7	5	L2	1	1.3.1

FMTH0301/Rev.5.3

Course Plan

Semester: III Year: 2021-22

Course Title: Data structures ,Algorithm design and analysis	Course Code: 18EARC203
Total Contact Hours: 50	Duration of ESA : 3 Hours
ISA Marks: 50	ESA Marks:50
Lesson Plan Author: Mrs Ashwini G K	Date: 22/10/2021
Checked By: Mr Shridhar Doddamani	Date: 22/10/2021

Course Outcomes (COs):

At the end of the course the student should be able to:

1 Demonstrate the knowledge of the concept of problems and problem solving processes by being able to define a problem along with its typology and space.

2 Demonstrate knowledge of data patterns and data structures by being able to formulate the problem statement, given the need, in context of the domain to identify functional / operational requirements.

3 Demonstrate the knowledge / skill of the design of the algorithm for the formulated problem statement by applying prior knowledge/data, and analyzing constraints in terms of space and time complexity for selecting / designing algorithms.

4 Design and develop solutions to solve real world problems using data structures like dynamic arrays, stacks, queues, linked lists and graphs and also make use of key algorithmic design paradigms such as brute force, divide and conquer, dynamic programming and iterative improvement.

5 Apply knowledge of object-oriented solution to demonstrate the appropriate use of a range of data structures and algorithms

6. Demonstrate in pairs and team wise problem-solving techniques to formulate and communicate potential solutions to the problems with standard heuristic/algorithmic methodologies in course projects.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: **Data structures ,Algorithm design and analysis**	Semester: 3 - Semester
Course Code: 18EARC203	Year: 2021-22

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1 Demonstrate the knowledge of the concept of problems and problem solving processes by being able to define a problem along with its typology and space.	**H**	**H**												
2 Demonstrate knowledge of data patterns and data structures by being able to formulate the problem statement, given the need, in context of the domain to identify functional / operational requirements.		**H**	**M**	**H**										
3 Demonstrate the knowledge / skill of the design of the algorithm for the formulated problem statement by applying prior knowledge/data, and analyzing constraints in terms of space and time complexity for selecting / designing algorithms.		**H**	**H**											
4 Design and develop solutions to solve real world problems using data structures like dynamic arrays, stacks, queues, linked lists and graphs and also make use of key algorithmic design paradigms such as brute force, divide and conquer, dynamic programming and iterative improvement.		**H**	**H**											
5Apply knowledge of object-oriented solution to demonstrate the appropriate use of a range of data structures and algorithms		**H**	**H**											
6.Demonstrate in pairs and team wise problem-solving techniques to formulate and communicate potential solutions to the problems with standard heuristic/algorithmic methodologies in course projects.		**M**	**H**											

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 - Demonstrate the competence in mathematical modeling.	1.1.2 - Apply discipline specific advanced mathematical techniques to modeling and problem solving
1.3 - Demonstrate competence in engineering fundamentals	1.3.3 - Apply computer programming skills to solve problems by building algorithms ,flow charts and debugging
2.1 - Demonstrate an ability to identify and characterize an engineering problem	2.1.3 - Identifies all relevant constraints and requirements and formulate an accurate description of the problem
	2.1.4 - Gathers engineering knowledge from the available literature and selects the most relevant
2.2 - Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.2 - Partitions problems, processes or systems into manageable elements for the purposes of analysis, modeling or design
2.3 - Demonstrate an ability to formulate and interpret a model	2.3.1 - Evaluates the analysis for accuracy and validity of assumptions made
3.1. Demonstrate an ability to define a complex open ended problems in engineering terms	3.1.1-Recognizes that good problem definition assists in design process.
	3.1.5. Determine Design objectives, functional requirements and arrives at specifications.
4.1 Demonstrate their ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1 Define a problem for purposes of investigation, its scope and importance

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: 18EARC203	Course Title: **Data structures ,Algorithm design and analysis**	
L-T-P : 4-1-0	Credits: 4	Contact Hrs: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 03 hours

Content	Hrs
Unit - 1	
Chapter 1: GENERAL PROBLEM SOLVING CONCEPTS- Problem Solving in Everyday Life, Types of Problems, Problem Solving with Computers - Problem Definition, Solution Design & Refinement, Testing Strategy Development, Program Coding and Testing, Using the Problem Solving Method, Break-Out Diagrams**,** Difficulties with Problem Solving. How the Computer Stores Data, Functions-function prototypes, Operators, Expressions and Equations.	6 hrs
Chapter 2: DESIGN AND ANALYSIS OF ALGORITHMS-Algorithms and Their Representations, Modifying Algorithms, Review of Asymptotic Notations, Mathematical Analysis of Non-Recursive and Recursive Algorithms, Brute Force Approaches: Introduction, Selection Sort and Bubble Sort, Sequential Search and Brute Force String Matching , Divide and Conquer: General Method, Defective Chess Board, Binary Search, Merge Sort, Quick Sort and its performance.	7 hrs
Chapter 3: ARRAYS, STACKS & QUEUES: Arrays, Dynamically Allocated Arrays, , Polynomials, Sparse Matrices, Representation of Multidimensional Arrays, Structures and Unions, Stacks, Stacks Using Dynamic Arrays, Queues, Circular Queues, Evaluation of Expressions, Queues, Single- and Double-Ended Priority Queues.	7 hrs
Unit - 2	
Chapter 4: LINKED LISTS, TREES &GRAPHS: Singly Linked lists and Chains, Representing Chains in C, Linked Stacks and Queues, Polynomials, Additional List operations, Sparse Matrices, Doubly Linked Lists. Introduction, Binary Trees, Binary Tree Traversals, Graph representation, Adjacency matrix, Adjancey list, Application of graphs.	8 hrs
Chapter 5:DYNAMIC PROGRAMMING & GREEDY METHOD: Depth First Search and Breadth First Search, The General Method, Warshall's Algorithm, Floyd's Algorithm for the All-Pairs Shortest Paths Problem, Single-Source Shortest Paths, The Traveling Salesperson problem, Kruskal's algorithm, Huffman trees**.**	7 hrs

Unit - 3	
Chapter 6: INTRODUCTION TO C++: Overview of C++, Sample C++ program, Different data types, operators, expressions, and statements, arrays and strings, pointers & user defined types. Class Specification, Class Objects, Scope resolution operator, Access members, Defining member functions, Data hiding, Constructors, Destructors, Parameterized constructors,	8 hrs
Chapter 7:BASIC OOP CONCEPTS: Base Class, Inheritance and protected members, Protected base class inheritance, Inheriting multiple base classes, Virtual function, Calling a Virtual function through a base class reference, Virtual attribute is inherited, and Virtual functions are hierarchical, Pure virtual functions, Abstract classes, Using virtual functions.	7 hrs

Text Books (List of books as mentioned in the approved syllabus)

1. Maureen Sprankle, Jim Hubbard: “PROBLEM SOLVING & PROGRAMMING CONCEPTS”, Pearson Publications, 9th edition, 2012.
2. AnanyLevitin: Introduction to The Design & Analysis of Algorithms, 2nd Edition, Pearson Education, 2007.
3. Horowitz, Sahni, Anderson-Freed: Fundamentals of Data Structures in C, 2nd Edition, Universities Press, 2007.
4. Herbert Schildt: The Complete Reference C++, 4th Edition, Tata McGraw Hill, 2003.

References

1. Yedidyah, Rubenstein, Tannenbaum: Data Structures Using C and C++, 2nd Edition, Pearson Education, 2003.

2. Thomas H. Cormen, Charles E. Leiserson, Ronal L. Rivest, Cliffor Stein: Introduction to Algorithms, 3rd Edition, PHI, 2010.

Evaluation Scheme
ISA Scheme

Assessment	Weightage in Marks
ISA-1	15
ISA-2	15
Tutorial	20
Total	50

Course Unitization for Minor Exams and End Semester Assessment

Topics / Chapters	Teaching Credits	No. of Questions in ISA-1	No. of Questions in ISA-2	No. of Questions in ESA
Unit I				
Chapter1: General problem solving concepts	6	1		1
Chapter 2: Design and analysis of algorithms	7	1		1
Chapter 3: Arrays, stacks & queues	7	1		1
Unit II				
Chapter4: Linked lists, trees &graphs	8		1.5	1.5
Chapter5: Dynamic programming & greedy method	7		1.5	1.5
Unit III				
Chapter 6: Introduction to C++	8			1
Chapter 7: Basic oop concepts	7			1

Note

1. Each Question carries 20 marks and may consist of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA I, II and ESA
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full question from Unit III) out of 8 questions in ESA.

Date:22/11/2021 **Head of Department**

Course Assessment Plan

Course Title: Data structures ,Algorithm design and analysis Code: 118EARC203					
Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		Minor Exam-1	Minor Exam-2	Tutorial	End semester assessment
1 Demonstrate the knowledge of the concept of problems and problem solving processes by being able to define a problem along with its typology and space.	12%	✓		✓	✓
2 Demonstrate knowledge of data patterns and data structures by being able to formulate the problem statement, given the need, in context of the domain to identify functional / operational requirements.	14%	✓		✓	✓
3 Demonstrate the knowledge / skill of the design of the algorithm for the formulated problem statement by applying prior knowledge/data, and analyzing constraints in terms of space and time complexity for selecting / designing algorithms.	14%	✓		✓	✓
4 Design and develop solutions to solve real world problems using data structures like dynamic arrays, stacks, queues, linked lists and graphs and also make use of key algorithmic design paradigms such as brute force, divide and conquer, dynamic programming and iterative improvement.	30%		✓	✓	✓
5Apply knowledge of object-oriented solution to demonstrate the appropriate use of a range of data structures and algorithms	15%		✓	✓	✓
6.Demonstrate in pairs and team wise problem-solving techniques to formulate and communicate potential solutions to the problems with standard heuristic/algorithmic methodologies in course projects.	16%			✓	✓
Weightage		15%	15%	20%	50%

Chapter wise Plan

Course Code and Title: **18EARC203 Data structures ,Algorithm design and analysis**	
Chapter Number and Title: **1 General problem solving concepts.**	Planned Hours:6 **hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Identify types of Problems and provide solutions using problem solving methods.	CO1	L2	1.1.2
2. Demonstrate solution & refinement, Testing Strategy development and program coding and to do testing using break-out diagrams.	CO1	L2	1.1.2
3. Illustrate how the computer stores data and classify and to write functions-function prototypes, operators, expressions and equations	CO1	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Problem Solving in Everyday Life, Types of Problems, Problem Solving with Computers - Problem Definition.
2. Solution Design & Refinement, Testing Strategy Development, Program Coding and Testing.
3. Using the Problem Solving Method, Break-Out Diagrams, and Difficulties with Problem Solving.
4. Computer Data storage format
5. Functions-function prototypes. Operators
6. Expressions and Equations

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. What are the six steps of problem solving?	TLO1	L2	1.1.2
2. Name three problems that might arise at home, at school, or in a business that could be solved more efficiently with	TLO1	L2	1.1.2

computer assistance. Do these problems require an algorithmic or heuristic solution? Why?			
3. Set up a logical expression for the following conditions. A company gives a bonus at the end of each fiscal year. For an employee to get a bonus, the following must be true: **a.** The employee has been working at the company for more than six months with no negative reports. **b.** The employee has earned more than $5,000 during the fiscal year.	TLO5	L3	1.3.3
4. Explain function prototypes.	TLO4	L2	1.1.2
5. What is an algorithmic solution to a problem?	TLO1	L2	1.1.2
6. Name three current problems in your life that could be solved through an algorithmic process. Explain why each of these problems is algorithmic in nature.	TLO3	L2	1.1.2
7. What is a heuristic solution to a problem?	TLO1	L2	1.1.2
8. Eureka Lumber Company gives a 2% discount if the remaining balance is paid within 10 days of purchase. Write a logical expression to verify whether a customer qualifies for this discount. Use the following variable names: *Buying Date:* date the customer purchased the merchandise *Paid Date:* date the customer made the final payment	TLO5	L3	1.3.3
9. Sharon is traveling from city A to city B. The distance between the two cities is a variable because she would like to use the equation to use for other cities. She knows that 50% of the time she will be traveling 30 miles an hour and the remaining 50% she will be traveling 65 miles per hour. Write an equation that will calculate the time it will take to travel from one city to the next.	TLO5	L3	1.3.3

Course Code and Title: **18EARC203 Data structures ,Algorithm design and analysis**	
Chapter Number and Title**: 2. DESIGN AND ANALYSIS OF ALGORITHMS**	Planned Hours: **7 hrs**

Learning Outcomes:

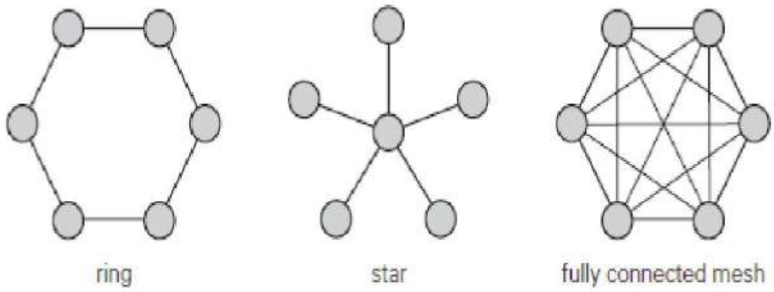
At the end of the course student should be able to:

TLO's	CO's	BL	CA Code
1. Write an algorithm and to analyze its performance using asymptotic notations and also to do the mathematical analysis of non-recursive and recursive algorithms	CO2	L2	4.1
2. Write brute force approaches for Selection Sort and Bubble Sort algorithms and sequential search and brute force string matching and divide & conquer: General Method	CO3	L3	1.3
3. Build programs defective chess board, Binary Search and merge sort, quick sort	CO3	L3	2.2

Lesson Schedule Class No. - Portion covered per hour
1. Algorithms and Their Representations, Modifying Algorithms, Alternative Algorithms.
2. Review of Asymptotic Notations-Ω,Ọ,Θ notations, Mathematical Analysis of Non-Recursive and Recursive Algorithms
3. Brute Force Approaches: Introduction, Selection Sort and Bubble Sort
4. Sequential Search and Brute Force String Matching ,
5. Divide and Conquer: General Method
6. Defective Chess Board, Binary Search, Merge Sort
7. Quick Sort and its performance.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Give the Mathematical Analysis of Non-Recursive and Recursive Algorithms	TLO2	L2	4.1.1
2. What is the time efficiency of the brute-force algorithm for computing and as a function of n? As a function of the number of bits in the binary representation of n?	TLO3	L3	4.1.1
3. Design a brute-force algorithm for computing the value of a	TLO3	L3	1.3.3

polynomial at a given point x0 and determine its worst-case efficiency class. $p(x) = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0$			
4. Sort the list E, X, A, M, P, L, E in alphabetical order by bubble sort.	TLO3	L3	1.3.3
5. A stack of fake coins there are n stacks of n identical-looking coins. All of the coins in one of these stacks are counterfeit, while all the coins in the other stacks are genuine. Every genuine coin weighs 10 grams; every fake weighs 11 grams. You have an analytical scale that can determine the exact weight of any number of coins. **a.** Devise a brute-force algorithm to identify the stack with the fake coins and determine its worst-case efficiency class. **b.** What is the minimum number of weighings needed to Identify the stack with the fake coins?	TLO3	L3	1.3.3
6 A network topology specifies how computers, printers, and other devic are connected over a network. The figure below illustrates three commo topologies of networks: the ring, the star, and the fully connected mesh.  You are given a boolean matrix $A[0..n-1, 0..n-1]$, where $n > 3$, which i supposed to be the adjacency matrix of a graph modeling a network with on of these topologies. Your task is to determine which of these three topologie if any, the matrix represents. Design a brute-force algorithm for this task an indicate its time efficiency class.	TLO3	L3	1.3.3
7.Write a C program to implement Binary search.	TLO6	L3	1.3.3
8. Write a C program to implement Merge Sort.	TLO6	L3	1.3.3

Course Code and Title: **18EARC203 Data structures ,Algorithm design and analysis**	
Chapter Number and Title: **3 ARRAYS, STACKS & QUEUES**	Planned Hours: **7 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Develop solutions to the problems based on arrays, Polynomials and Sparse Matrices programming methods	CO4	L3	1.3
2. Develop programs using Structures and Unions, Stacks, Queues, Circular Queues, and to perform Evaluation of expressions	CO4	L3	3.1
3. Develop programs using Multiple Stacks and Queues, Single- and Double-Ended Priority Queues	CO4	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Arrays, Dynamically Allocated Arrays
2. Polynomials, Sparse Matrices
3. Representation of Multidimensional Arrays
4. Structures and Unions,
5. Stacks, Stacks Using Dynamic Arrays
6. Queues, Circular Queues, Evaluation of Expressions,
7. Multiple Stacks and Queues, Single- and Double-Ended Priority Queues

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. List out the differences between structure and union.	TLO4	L2	3.1.5
2. Write a C program to implement a circular queue.	TLO6	L3	1.3.3
3. Write a C Program to implement stack operations.	TLO5	L3	1.3.3
4. Write a program to implement stack using queue concept.	TLO5	L3	1.3.3
5. Write a C program to implement double ended queue operations.	TLO7	L3	1.3.3

Model Question Paper for Minor Examination – I (ISA)	
Course Code: 18EARC203	Course Title: : Data structure, algorithm design and analysis
Duration(H:M): 1:15	Max. Marks:40
Note: Answer any two questions.	

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Write and explain the six general steps of problem solving.	8	CO1	L2	1	1.1.2
1b	Develop the logical expression for the given problem Problem: A large department store has its own charge card. The policy for a customer to charge an item is that the customer must have a valid charge card and either a balance of less than $5000 or a charge of less than $500.	8	CO2	L3	1	1.3.3
1c	What is a heuristic solution to a problem?	4	CO1	L2	1	1.1.2
2a	Write a C Program to implement the Quick Sort method.	8	CO3	L4	1	1.3.3
2b	Write a C Program to implement Defective Chess Board	8	CO3	L2	1	1.3.3
2c	Explain dynamic allocated arrays with an example.	4	CO3	L2	2	2.1.3
3a	Write a C program to implement stack operations.	8	CO4	L3	1	1.3.3
3b	A circular queue the size of which is 5 has 3 elements 20, 45, 56, where F=2 and R=4.After inserting 58, 65, what is the value of F and R? Trying to insert an element 100 at this stage what will happen? Delete 2 elements from the queue and insert 300 .Show the sequence of steps with necessary diagrams with the value of F and R.	8	CO3	L3	1	1.3.3
3c	Write a C Program to implement Selection sort and evaluate its performance	4	CO4	L3	1	1.3.3

Course Code and Title: **18EARC203 Data structures ,Algorithm design and analysis**	
Chapter Number and Title: **4. LINKED LISTS, TREES & GRAPHS**	Planned Hours: **8hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Develop solutions/algorithms based on Singly Linked lists, Linked Stacks and Queues, Polynomials and Sparse Matrices, Doubly Linked Lists	CO4	L3	1.3
2. Develop programs for binary trees and its types, Binary Tree traversals, threaded binary trees, Heaps,.	CO4	L2	1.3
3. Describe graph representation, adjacency matrix, adjacency list and application of graphs.	CO4	L3	1.1

Lesson Schedule Class No. - Portion covered per hour
1. Singly Linked lists and Chains
2. Representing Chains in C
3. Linked Stacks and Queues
4. Polynomials, Additional List operations
5. Sparse Matrices, Doubly Linked Lists
6. Introduction, Binary Trees
7. Binary Tree Traversals, Threaded Binary Trees, Heaps,
8. Graph representation, Adjacency matrix, Adjacency list, Application of graphs.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Write a C program to implement a linked list.	TLO1	L3	1.3.3
2.Discuss the additional list operations	TLO4	L2	1.1.2
3. Write a C program to implement a binary tree.	TLO6	L3	1.3.3
4.. Define a binary tree with an example.	TLO7	L2	1.1.2

Course Code and Title: **18EARC203 Data structures ,Algorithm design and analysis**	
Chapter Number and Title: **5. DYNAMIC PROGRAMMING**	Planned Hours: **7 hrs**

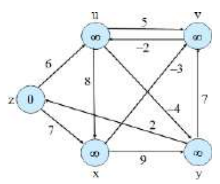
Learning Outcomes:

At the end of course student should be able to:

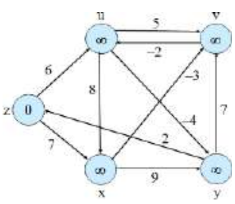
TLO's	CO's	BL	CA Code
1. Develop solutions for the problems using depth first search breadth first search, Warshall's algorithm and Floyd's Algorithm.	CO4	L3	3.1
2. Develop the solution for the problems using single-source shortest paths and traveling salesperson problem,Kruskal's algorithm, Huffman trees	CO4	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Depth First Search and Breadth First Search
2. General Method,
3. Warshall's Algorithm
4. Floyd's Algorithm for the All-Pairs Shortest Paths Problem
5. Single-Source Shortest Paths
6. The Traveling Salesperson problem,
7. Kruskal's algorithm, Huffman trees

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Write an algorithm for Breadth First Search.	TLO1	L3	1.3.3
2. Write a C program to implement All-Pairs Shortest Paths Problem	TLO4	L3	1.3.3
3.  solve it by using Single-Source Shortest Paths method	TLO5	L3	1.3.3

Model Question Paper for Minor Examination – II (ISA)	
Course Code: 18EARC203	Course Title: : Data structure, algorithm design and analysis
Duration(H:M): 1:15	Max. Marks:40
Note: Answer any two questions.	

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Write a C function which will perform an insertion to the immediate left of the K node in a singly linked list.	8	CO4	L3	1	1.3.3
1b	Write a C program to implement preorder, post order and in order traversals.	8	CO4	L3	1	1.3.3
1c	List out the differences between singly linked list and doubly linked list.	4	CO4	L2	1	1.3.3
2a	If we define an input restricted dqueue as a queue which performs the operations delete_front, delete_rear and insert front, how can we implement a stack and how can we implement a queue?	8	CO4	L4	2	2.1.4
2b	Write a C program to create a tree, traverse a tree and delete an item from the tree.	8	CO4	L3	1	1.3.3
2c	Define graphs. Write the applications of graph	4	CO4	L2	1	1.1.2
3a	Write an algorithm for Breadth First Search.	8	CO4	L3	1	1.3.3
3b	Write a C program to implement All-Pairs Shortest Paths Problem	8	CO4	L3	1	1.3.3
3c	 solve it by using Single-Source Shortest Paths method	4	CO4	L2	1	1.3.3

Course Code and Title: **18EARC203 Data structures ,Algorithm design and analysis**	
Chapter Number and Title:**6 INTRODUCTION TO C++**	Planned Hours: **8 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Demonstrate the knowledge of C++ basics - Different data types, operators, expressions, and statements, arrays and strings.	CO5	L2	2.1
2. Write programs using pointers user defined types. Class Specification and Class Objects, Scope resolution operator, Access members.	CO5	L3	1.3
3. Define member functions, Data hiding, Constructors, Destructors and parameterized constructors.	CO5	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Basics of C++ - Different data types,
2. Operators, expressions
3. Statements, arrays and strings.
4. Pointers and user defined types
5. Class Specification, Class Objects, Scope resolution operator, Access members.
6. Define member functions, Data hiding,
7. Constructors, Destructors
8. Parameterized constructors

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Assuming there are 7.481 gallons in a cubic foot, write a program that asks the user to enter a number of gallons, and then displays the equivalent in cubic feet.	TLO5	L3	1.3.3

2. Write a program that generates the following table: 1990 135 1991 7290 1992 11300 Use a single cout statement for all output	TLO5	L3	1.3.3
3. A queue is a data storage device much like a stack. The difference is that in a stack the last data item stored is the first one retrieved, while in a queue the first data item stored is the first one retrieved. That is, a stack uses a last-in-first-out (LIFO) approach, while a queue uses first-in-first-out (FIFO). A queue is like a line of customers in a bank: The first one to join the queue is the first one served. Rewrite the STAKARAY program from this chapter to incorporate a class called queue instead of a class called stack. Besides a constructor, it should have two functions: one called put() to put a data item on the queue, and one called get() to get data from the queue. These are equivalent to push() and pop() in the stack class.	TLO5	L3	1.3.3
4. Write a program that displays your favorite poem. Use an appropriate escape sequence for the line breaks. If you don't have a favorite poem, you can borrow this one by Ogden a. Nash: b. Candy is dandy, c. But liquor is quicker.	TLO6	L3	1.3.3

Course Code and Title: **18EARC203 Data structures ,Algorithm design and analysis**	
Chapter Number and Title:7 **BASIC OOP CONCEPTS**	Planned Hours: **7 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Understand Base Class, Inheritance and protected members, Protected base class inheritance, Inheriting multiple base classes	CO5	L2	2.1
2. Implement the Virtual function, Calling a Virtual function through a base class reference, Virtual attribute is inherited,	CO5	L3	1.3.3
3. Use Virtual functions are hierarchical, Pure virtual functions, Abstract classes, Using virtual functions.	CO5	L3	1.3.3

Lesson Schedule Class No. - Portion covered per hour
1. Base Class, Inheritance and protected members
2. Protected base class inheritance, Inheriting multiple base classes
3. Virtual function, Calling a Virtual function
4. base class reference, Virtual attribute is inherited
5. Virtual functions are hierarchical
6. Pure virtual functions
7. Abstract classes, Using virtual functions

Review Questions

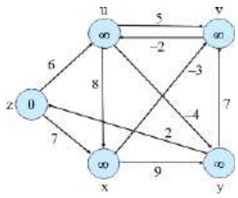
Sr.No. - Questions	TLO	BL	PI Code
1. Create a class that imitates part of the functionality of the basic data type int. Call the class Int (note different capitalization). The only data in this class is an int variable.Include member functions to initialize an Int to 0, to initialize it to an int value, to display it (it looks just like an int), and to add two Int values.Write a program that exercises this class by creating one uninitialized and two initialized Int values, adding the two initialized values and placing the response in the uninitialized value, and then displaying this result.	TLO1	L3	1.3.3

2. Create a class that includes a data member that holds a "serial number" for each object created from the class. That is, the first object created will be numbered 1, the second 2, and so on. To do this, you'll need another data member that records a count of how many objects have been created so far. (This member should apply to the class as a whole; not to individual objects. What keyword specifies this?) Then, as each object is created, its constructor can examine this count member variable to determine the appropriate serial number for the new object. Add a member function that permits an object to report its own serial number. Then write a main() program that creates three objects and queries each one about its serial number. They should respond that I am object number 2, and so on.	TLO2	L3	1.3.3
3. Imagine a publishing company that markets both book and audiocassette versions of its works. Create a class publication that stores the title (a string) and price (type float) of a publication. From this class derive two classes: book, which adds a page count (type int), and tape, which adds a playing time in minutes (type float). Each of these three classes should have a getdata() function to get its data from the user at the keyboard, and a putdata() function to display its data.Write a main() program to test the book and tape classes by creating instances of them,asking the user to fill in data with getdata(), and then displaying the data with putdata().	TLO3	L3	1.3.3

Model Question Paper for End Semester Assessment (ESA)	
Course Code :18EARC203	**Course:Data structure, algorithm design and analysis**
Total Duration : 3 Hours	**Maximum Marks :100**
Note :Answer Five Questions: Any two full questions from each Unit I & Unit II and one full question from Unit III	

UNIT-I						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Write and explain the six general steps of problem solving.	8	CO1	L2	1	1.1.2
1b	Develop the logical expression for the given problem		CO2			
1c	Problem: A large department store has its own charge card. The policy for a customer to charge an item is that the customer must have a valid charge card and either a balance of less than $5000 or a charge of less than $500.	8	CO1	L3	1	1.3.3
2a	What is a heuristic solution to a problem?	4	CO3	L2	1	1.1.2
2b	Write a C Program to implement the Quick Sort method.	8	CO3	L4	1	1.3.3
2c	Write a C Program to implement Defective Chess Board	8	CO3	L2	1	1.3.3
3a	Explain dynamic allocated arrays with an example.	4	CO4	L2	2	2.1.3
3b	Write a C program to implement stack operations.	8	CO3	L3	1	1.3.3
3c	A circular queue the size of which is 5 has 3 elements 20, 45, 56, where F=2 and R=4.After inserting 58, 65, what is the value of F and R? Trying to insert an element 100 at this stage what will happen? Delete 2 elements from the queue and insert 300 .Show the sequence of steps with necessary diagrams with the value of F and R.	8	CO4	L3	1	1.3.3

UNIT-II						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
4a	Write a C function which will perform an insertion to the immediate left of the K node in a singly linked list.	8	CO4	L3	1	1.3.3

4b	Write a C program to implement preorder, post order and in order traversals.	8	CO4	L3	1	1.3.3
4c	List out the differences between singly linked list and doubly linked list.	4	CO4	L2	1	1.3.3
5a	If we define an input restricted dqueue as a queue which performs the operations delete_front, delete_rear and insert front, how can we implement a stack and how can we implement a queue?	8	CO4	L4	2	2.1.4
5b	Write a C program to create a tree, traverse a tree and delete an item from the tree.	8	CO4	L3	1	1.3.3
5c	Define graphs. Write the applications of graph	4	CO4	L2	1	1.1.2
6a	Write an algorithm for Breadth First Search.	8	CO4	L3	1	1.3.3
6b	Write a C program to implement All-Pairs Shortest Paths Problem	8	CO4	L3	1	1.3.3
6c	 solve it by using Single-Source Shortest Paths method	4	CO4	L2	1	1.3.3

UNIT-III

Q.No.	Questions	Marks	CO	BL	PO	PI Code
7a	Write a C++ program to add ,subtract two complex numbers of the form a+ib	8	CO5	L3	1	1.3.3
7b	Write a program that displays your favorite poem. Use an appropriate escape sequence for the line breaks. If you don't have a favorite poem, you can borrow this one by Ogden Nash:Candy is dandy, But liquor is quicker.	8	CO5	L3	1	1.3.3
7c	Explain the following term with an example for each 1)Class 2)Object	4	CO5	L2	1	1.3.3
8a	Create a class that imitates part of the functionality of the basic data type int. Call the class Int (note different capitalization). The only data in this class is an int variable. Include member functions to initialize an Int to 0, to initialize it to an int value, to display it (it looks just like an int), and to add two Int values. Write a program that exercises this class by creating one uninitialized and two initialized Int values, adding the two initialized values and placing the	8	CO5	L3	1	1.3.3

	response in the uninitialized value, and then displaying this result.					
8b	Imagine a publishing company that markets both book and audiocassette versions of its works. Create a class publication that stores the title (a string) and price (type float) of a publication. From this class derive two classes: book, which adds a page count (type int), and tape, which adds a playing time in minutes (type float). Each of these three classes should have a get data () function to get its data from the user at the keyboard, and a put data () function to display its data. Write a main () program to test the book and tape classes by creating instances of them, asking the user to fill in data with get data(), and then displaying the data with put data().	8	CO5	L3	1	1.3.3
8c	What is pure virtual function? Explain with an example.	8	CO5	L3	1	1.3.3

FMTH0303-3.1

Laboratory Plan

Semester: **III** Year: 2021-2022

Laboratory Title: Machine Drawing Lab	Lab Code: 19EARP203
Total Hours: 24	Duration of Exam: 2 hrs
Total Exam Marks: 20	Total ISA Marks: 80
Lab. Plan Author: Mr. Nagaraj Benakanahalli / Mr. Girish Karikatti	Date: 26-07-2021
Checked By: Mr. Amit Talli	Date: 04-08-2021

Course Outcomes:

At the end of the course students will be able to:

1. Construct free hand sketches for the given components.
2. Demonstrate the knowledge of GD&T feature control frames, and explain the impact on manufacturing and inspection.
3. Create 3D parts using the various commands which are available in 3D modeling software and assemble the 3D parts using the assembly modeling module.
4. Create a detailed drawing of a part using GD and T standards.
5. Design and simulate the kinematic study of the assemblies.
6. Analyze a component using finite element approach.
7. Investigate the environmental impact of designed component using sustainability module.
8. Demonstrate the knowledge of electrical routing by creating the electrical assembly.
9. Reproduce a physical component with all features, tolerances and details using reverse engineering process.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Laboratory (Course) Title: Machine Drawing Laboratory Course Code: 19EARP203
Semester: **III** Year: 2021-2022

Course Outcomes / Program Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Construct free hand sketches for the given components.	M													
2. Demonstrate the knowledge of GD&T feature control frames, and explain the impact on manufacturing and inspection.					H				M					
3. Create 3D parts using the various commands which are available in 3D modeling software and assemble the 3D parts using the assembly modeling module.	M								M					
4. Create a detailed drawing of a part using GD and T standards.	H				H				H					
5. Design and simulate the kinematic study of the assemblies.	H				H				H					
6. Analyze a component using finite element approach.					H			H	L					
7. Investigate the environmental impact of designed component using sustainability module.	H				H				H					
8. Demonstrate the knowledge of electrical routing by creating the electrical assembly.	M				M			L	L					
9. Reproduce a physical component with all features, tolerances and details using reverse engineering process.	H				H			H	H	H				

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 Demonstrate the competence in mathematical modeling	1.1.1 Apply mathematical techniques to solve problems
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply elements of mechanical engineering principles and laws to solve problems
	1.3.2 Apply basic electrical & electronics engineering principles and laws to solve problems
5.2 Demonstrate an ability to select and apply discipline specific tools, techniques and resources	5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) Monitoring system performance, and (iv) creating engineering designs.
	5.2.2 Demonstrate proficiency in using discipline specific tools
5.3 Demonstrate an ability to evaluate the suitability and limitations of the tools used to solve an engineering problem	5.3.1 Discuss limitations and validate tools, techniques and resources
	5.3.2 Verify the credibility of results from tool use with reference to accuracy and limitations, and the assumptions inherent in their use.
8.1 Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
9.2 Demonstrate effective individual and team operations--communication, problem solving, conflict resolution and leadership skills	9.2.1 Demonstrate effective communication, problem solving, conflict resolution and leadership skills
9.3 Demonstrate success in a team-based project	9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
10.1 Demonstrate an ability to comprehend technical literature and document project work.	10.1.1 Read, understand and interpret technical and non-technical information
	10.1.2 Produce clear, well-constructed, and well-supported written engineering documents
	10.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
10.2 Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others
	10.2.2 Deliver effective oral presentations to technical and non-technical audiences
10.3 Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations

Experiment wise plan

1. *List of experiments/jobs planned to meet the requirements of the course.*

Category: Demonstration		Total Weightage: 25	No. of lab sessions: 5
Expt./Job No.	**Experiment/job Details**	**No. of Lab. Session/s per batch (estimate)**	**Marks/Experiment**
1	**Title: Free Hand Sketching** Learning outcomes: 1. Understand the basic representation of a component. 2. Identify different types of lines and other entities. 3. Understand the importance of shading the sketches. 4. Represent the different views of the components. 5. Use isometric sheets for drawing the sketches of components.	1	5
2	**Title: Geometric Dimensioning and Tolerancing and Isometric Drawing** Learning outcomes: 1. Discuss the drawing conventions used in GD&T for ANSI and ISO applications. 2. Demonstrate the knowledge of limits, fits and datum systems. 3. Construct the isometric drawing for the given components. 4. Represent a component using the GD & T tools - Form, Orientation, Profile, Run out and Location. 5. Discuss the standardization of GD&T concepts.	1	5
3	**Title: Introduction to Solidworks Software** Learning outcomes: 1. Demonstrate the knowledge of GUI of the Solidworks software and the tools available for the generic use. 2. Select an appropriate plane and create 2D sketches using the various commands available in the sketch module of Solidworks software.	1	5
4	**Title: Part Modeling & Drafting**	2	10

	Learning outcomes: 1. Create the part models using part modeling module, given the two dimensional drawing of a component by using the various commands available in Solid Works. 2. Reinforce the understanding of 3D features that add and remove geometry. 3. Use add and remove geometry features - Extrude boss, Extrude Cut, Revolve, Sweep and Loft to create the different types of parts. 4. Assign the appropriate material for the parts. 5. Creation of 2D drawings of the parts with the standard GD & T representation & annotate the dimensions.		
Category: Exercise		**Total Weightage: 40**	**No. of lab sessions: 4**
Expt./Job No.	**Experiment/job Details**	**No. of Lab. Session/s per batch (estimate)**	**Marks/Experiment**
5	**Title: Assembly**	1	15
	Learning outcomes 1. Use the part models, appropriate mate commands and assemble them to achieve the product. 2. Create the 2D drawing of the assembly/product and represent it using BOM, Balloons.		
6	**Title: Kinematic Analysis**	1	10
	Learning outcomes: 1. Demonstrate the knowledge of allocating actuators and motion elements at the appropriate location. 2. Achieve required mechanisms using the commands in the Motion Study Module. 3. Acquire the output results and correlate them to the input values, for validation of the mechanism.		
7	**Title: Finite Element Analysis**	1	10
	Learning outcomes: 1. Demonstrate the knowledge of meshing the components. 2. Apply boundary conditions and other parameters for the analysis. 3. Read the results of the analysis and infer them.		
8	**Title: Solidworks Routing**	1	5
	Learning outcomes: 1. Demonstrate the knowledge of creating an electrical circuit/connection for the product. 2. Select various components for creating the connections. 3. Simulate the flow of energy through the wires and the components.		
Category: Structured Enquiry		**Total Weightage: 5**	**No. of lab sessions: 1**
Expt./Job No.	**Experiment/job Details**	**No. of Lab. Session/s per batch (estimate)**	**Marks/Experiment**

	Title: Solidworks Sustainability	1	5
9	Learning outcomes: 1. Demonstrate the knowledge of the basic concepts of sustainable design. 2. Select the appropriate materials to manufacture the product. 3. Measure the environmental impacts of various design choices, including material, manufacture location, and more on the various parts and assemblies.		

Category: Open Ended		**Total Weightage: 10**	**No. of lab sessions: 2**
Expt./Job No.	**Experiment / Job Details**	**No. of Lab Sessions per batch (estimate)**	**Marks / Experiment**
10	**Title: Project Work**	2	10
	Learning Outcomes: 1. Identify the system's components and their interrelationships. 2. Create representations of the system in another form or a higher level of abstraction. 3. Create the virtual representation of that system. Tasks Involved: 1. Study the system components and their interrelationships 2. Disassemble the given product 3. Take measurements with tolerance 4. Capture the surface details like texture, color, pattern etc. 5. Identify the material 6. Reproduce the same components using Solidworks 7. Assemble all the components in Solidworks 8. Kinematic analysis of the assembled component.		

Date: 04-08-2021 **Head of Department**

Laboratory Plan **FMTH0303-3.0**

Semester: 3 *Year:* 2021-2022

Laboratory Title: **Analog and Digital Electronic Circuits Lab**	Lab. Code: **18EARP201**
Total contact Hours: **28**	Duration of ESA: **3 hours**
Total ISA Marks: **80**	Total ESA Marks: **20**
Lab. Plan Author: Mrs. C.B.Kolanur	Date: 24/09/2021
Checked By: Prof. Rakesh Tapaskar	Date: 25/09/2021

Course Outcomes-(CO)

At the end of the course student will be able to:

1. Select appropriate instruments like Cathode Ray Oscilloscope, DSO, Multimeter to measure the signal parameters and sources like power supplies, function generators etc.
2. Practically verify and apply network theorems to structured inquiry and open-ended problems.
3. Develop various circuit design, draw schematic, simulate and realize the electronic circuits and explain the behavioral difference between virtual and real-world circuit models for given problem.
4. Identify, comprehend and model the real-world problem to develop a solution based on application of the acquired conceptual and practical skills in course of circuit studio laboratory as an open-ended project work with appropriate documentation

Course Articulation Matrix: Mapping of Course Learning Outcomes (CLO) with Program outcomes

Laboratory (Course) Title: Analog and Digital Electronic Circuits Lab   Laboratory (Course) code: 18EARP201   Semester: **III**   Year: **2021-2022**

Course Outcomes-CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
i. Select appropriate instruments like Cathode Ray Oscilloscope, DSO, Multimeter to measure the signal parameters and sources like power supplies, function generators etc.					**M**									
ii. Practically verify and apply network theorems to structured inquiry and open-ended problems.			**M**		**M**									
iii. Develop various circuit design, draw schematic, simulate and realize the electronic circuits and explain the behavioral difference between virtual and real-world circuit models for given problem.			**M**	**M**	**H**									
iv. Identify, comprehend and model the real-world problem to develop a solution based on application of the acquired conceptual and practical skills in course of circuit studio laboratory as an open-ended project work with appropriate documentation.	**M**			**M**	**H**				**H**	**M**	**M**			

Degree of compliance   **L**: Low   **M**: Medium   **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3-Demonstrate competence in engineering fundamentals	1.3.2-Apply basic electrical and electronics engineering principles and laws to solve problems
3.1-Demonstrate an ability to define a complex open-ended problem in engineering terms	3.1.6-Determines design objectives, functional requirements and arrives at specifications
4.1-Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.2-Relate modern engineering experimentation including experiment design, system calibration, data acquisition, analysis and presentation
	4.1.3-Apply appropriate, instrumentation, and/or software tools to make measurements of physical quantities
4.2-Demonstrate their ability to design experiments to solve open ended problems	4.2.1-Develop and design experimental approach, specify appropriate equipment and procedures, implement these procedures, and interpret the resulting data to characterize an engineering material, component, or system.
	4.2.2-Understand the importance of statistical design of experiments and choose an appropriate experimental design plan based on the study objectives
4.3-Demonstrate an ability to critically analyze data to reach a valid conclusion	4.3.1-Use appropriate procedures, tools and techniques to collect and analyze data
	4.3.3-Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions
	4.3.4-Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
5.1-Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1-Identify modern engineering tools, techniques and resources for engineering activities
	5.1.2-Create/adapt/modify/extend tools and techniques to solve problems
5.2-Demonstrate an ability to select and apply discipline specific tools, techniques and resources	5.2.1-Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) Monitoring system performance, and (iv) creating engineering designs.

9.1-Demonstrate an ability to form a team and define a role for each member	9.1.2-Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal
9.2-Demonstrate effective individual and team operations-- communication, problem solving, conflict resolution and leadership skills	9.2.1-Demonstrate effective communication, problem solving, conflict resolution and leadership skills
9.3-Demonstrate success in a team-based project	9.3.1-Present results as a team, with smooth integration of contributions from all individual efforts
11.3-Demonstrate an ability to plan/manage an engineering activity within time and budget constraints	11.3.1-Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks
	11.3.2-Use project management tools to schedule an engineering project so it is completed on time and on budget

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Experiment wise Plan

List of experiments/jobs planned to meet the requirements of the course.

Category: Demonstration		**Total Weightage: 10.00**		**No. of lab sessions: 2.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
01	Demonstration of lab equipments and components: CRO, Multimeter, Function Generator, Power supply-Active/Passive Components & Bread Board. Demonstration of Software – Multisim / Matlab.	1.00		
	Learning Objectives: The students should be able to: 1. Identify and demo knowledge of functioning and purposes of different components like Resistors, Inductors, capacitors, transistors etc. 2. Identify and demo knowledge of functioning and purposes of different Test and Measuring equipments such as Multimeters, Power Supplies, CROs and Function generators etc. 3. Simulate circuits using Multisim/Matlab software.			UNIT I Chapter 1
Category: Exercise		**Total Weightage: 5.00**		**No. of lab sessions: 1.00**
2	Design and implementation of Rectifiers with and without filters.	1.00	5.00	
	Learning Objectives: The students should be able to: 1. Draw and understand the use of diodes in half wave and fullwave rectifiers without filter and with filter. 2. Calculate the ripple and efficiency. 3. Calculate the peak value of the output voltage of the rectifiers given the rms input value. 4. The process of AC to DC conversion			UNIT I Chapter 2
3	Construction and implementation of linear voltage regulators and Zener diode as a voltage regulator	1.00	10.00	

	Learning Objectives: The students should be able to: 1. Build, modify, and test the regulator ability to maintain the output voltage constant. 2. Learn about control element, reference voltage, error detector and sample circuit. 3. Study the Applications of the Zener diode as a voltage Regulators.			UNIT I Chapter 1
4	Construction and implementation of voltage dividers and optocoupler.	2.00	5.00	
	Learning Objectives: The students should be able to: 1. Designing, building and analyzing real circuits. 2. Using this techniques to design a circuit for a high intensity LED 3. Understand the design of optocoupler circuits in different applications			UNIT II Chapter 5
5	Verification of Superposition, Thevinen's and Network theorems.	2.00	5.00	
	Learning Objectives: The students should be able to: 1. Explain and Learn circuit analysis using these theorems. 2. How to solve linear circuit problems and short circuit current. 3. Verifification of Network theorems using Multisim and Matlab software			UNIT II Chapter 5
Category: Structured Enquiry		**Total Weightage: 10.00**		**No. of lab sessions: 2.00**
6	Construction of switch using MOSFET and simulation of Transistor biasing and Darlington amplifier.	2.00	10.00	
	Learning Objectives: The students should be able to: 1. Simulation of transistors amplification circuit using Multisim/Matlab. 2. Design and Simulation of transistor amplifier using NPN and PNP transistor. 3. Understand and analyze the transistor biasing, transistor amplifier, and Darlington amplifier. 4. Design and construction of MOSFET as a switch.			UNIT II Chapter 4
7	Design and implementation of code convertors, encoder, and decoder using logic gates	2.00	10.00	

	Learning Objectives: The students should be able to: 1. Design and implementation of converters using logic gates 2. Learn how to design and implementation of encoders and decoders 3. Learn how and where to use encoders and decoders			UNIT II Chapter 5
8	Design an 8-bit ADC circuit that utilizes LEDs to indicate its binary output value. Use a reference voltage of 2.5V to 5 VDC.	2.00	10.00	
	Learning Objectives: The students should be able to: 1. Learn how to design and implement 8 bit ADC circuit that to indicate its binary output values. 2. Understands why to use Analog to Digital converter.			UNIT II Chapter 6
9	Measurement of data from sensor-LM35 sensor	2.00	10.00	
	Learning Objectives: The students should be able to: 1. Learn how to measure and calibrate analog data from sensor. 2. Understands how to convert Analog data to Digital data.			UNIT III Chapter 7
10	Demonstrate the characterization of Ultrasonic sensor	2.00	10.00	
	Learning Objectives: The students should be able to: 1. Learn how to measure distance from ultrasonic sensor. 2. Understands how to calibrate data from ultrasonic sensor.			UNIT III Chapter 7
Category: Viva, Journal and Attendance		**Total Weightage: 10**		**No. of lab sessions: 01**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
09	Viva, Journal and Attendance	01	5	

	Learning Outcomes : The students should be able to: 1. Command of appropriate communication skills such as technical reports, viva and presentations through the lab. 2. Maintaining the punctuality to all the lab sessions.			
Category: Open Ended Enquiry		**Total Weightage: 20**		**No. of lab sessions: 02**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
10	Project	02	20	
	Learning Outcomes : The students should be able to: 1. Carryout a project in a team. 2. Come up with PCB design using Eagle software.			

Materials and Resources Required:

I. Books/References:
   a. Foundation of Analog and Digital Electronics Circuits by Anant Agarwal.

II. Manuals: Analog and Digital Electronics Lab Manual.
   a. Others: Matlab Simulink and multisim tutorials from google.

Experiment wise plan

1. ***Evaluation*:**

Students Assessment through ISA (80%) + ESA (20%)

Type of Evaluation	Types of laboratory work	Assessment				
		Aim	Material	Method	Answer	**Weightage in Marks**
Internal Semester Assessment (80%)	Demonstration	Given	Given	Given	Given	
	Exercise	Given	Given	Given	Open	25
	Structured Enquiry	Given	Given	Open	Open	50
	Quiz(Viva)/Attendance/Journal					05
End Semester Assessment (20%)	Open Ended Enquiry (Project)	Open	Open	Open	Open	20
					Total	**100**

Date: 30/09/2021 Head of the Department

FMTH0303-3.1

Laboratory Plan

Semester :3

Year:2021-2022

Laboratory Title: Kinematics of Machinery lab	*Lab. Code:*18EARP202
Total Hours: 24	*Duration of Exam*:3 hrs
Total Exam Marks: 100	*Total ISA. Marks*: 80
Lab. Plan Author: Asst. Prof. AmitTalli	*Date*: 18-10-2021
Checked By: Asst. Prof. Shilpa T	*Date*: 21-10-2021

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Demonstrate knowledge and develop the skill of multibody simulation using MATLAB Simscape.
2. Demonstrate knowledge and develop skills to synthesize and analyze the kinematics of mechanisms.
3. Demonstrate knowledge and develop skills to import CAD files into Simscape Multibody to analyze the mechanism's position, velocity, and acceleration.
4. Demonstrate the skill of designing a mechanism for a specific application as a course project and should be able to produce well constructed and well-supported engineering documents.

DEPARTMENT OF AUTOMATION & ROBOTICS

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: Kinematics of Machinery Lab	Semester:3 - Semester
Course Code:18EARP202	Year:2021 - 2022

Course Outcomes / Program Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Demonstrate knowledge and develop the skill of multibody simulation using MATLAB Simscape.	**H**				**M**									
Demonstrate knowledge and develop skills to synthesize and analyze the kinematics of mechanisms.	**H**				**M**									
Demonstrate knowledge and develop skills to import CAD files into Simscape Multibody to analyze the mechanism's position, velocity, and acceleration.	**M**									**M**				
Demonstrate the skill of designing a mechanism for a specific application as a course project and should be able to produce well constructed and well-supported engineering documents.	**H**				**H**					**M**				

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency: 1.3	Demonstrate competence in engineering fundamentals
PI Code: 1.3.1	Apply elements of mechanical engineering principles and laws to solve problems
Competency: 5.1	Demonstrate an ability to identify/ create modern engineering tools, techniques and resources
PI Code: 5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
PI Code: 5.1.2	Create/adapt/modify/extend tools and techniques to solve problems
Competency: 10.1	Demonstrate an ability to comprehend technical literature and document project work.
PI Code: 10.1.1	Read, understand and interpret technical and non-technical information
PI Code: 10.1.2	Produce clear, well-constructed, and well-supported written engineering documents
PI Code: 10.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear

Experiment wise Plan

List of experiments/jobs planned to meet the requirements of the course.

Category: Demonstration		**Total Weightage: 10.00**		**No. of lab sessions: 3.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1	Introduction to Multibody Simulation	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. Define standard rigid bodies, including geometry and inertia properties. 2. Add coordinate frames using frame transform definitions. 3. Connect solids with joints to model a dynamic system.			UNIT – I
2	Simple Pundulum	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. Define standard rigid bodies, including geometry and inertia properties. 2. Add coordinate frames using frame transform definitions. 3. Connect solids with joints to model a dynamic system.			UNIT – I
3	Double Pendulum and pendulum of cart	1.00	10.00	
	Learning Outcomes: The students should be able to: 1. Define standard rigid bodies, including geometry and inertia properties. 2. Add coordinate frames using frame transform definitions. 3. Connect solids with joints to model a dynamic system.			UNIT – I
Category: Exercise		**Total Weightage: 50.00**		**No. of lab sessions: 9.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1	Slide crank mechanism	2.00	10.00	
	Learning Outcomes: The students should be able to:			UNIT-I

	1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis. 4. Set initial positions and velocities of bodies in a machine and verify their correctness.			
2	Four bar mechanism	1.00	10.00	
	Learning Outcomes: The students should be able to: 1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis. 4. Set initial positions and velocities of bodies in a machine and verify their correctness.			UNIT-I
3	Pendulum waves	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis.			UNIT-I
4	Inline –Three Engine	1.00	10.00	
	Learning Outcomes: The students should be able to: 1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis. 4. Set initial positions and velocities of bodies in a machine and verify their correctness.			UNIT-I
5	Importing CAD model in Matlab	2.00	5.00	
	Simscape™ Multibody™ Link is a CAD plug-in for exporting CAD assemblies from SolidWorks®, Autodesk Inventor®, and PTC® Creo™ software. The plug-in generates an XML file detailing the structure and properties of your CAD assembly and 3-D geometry files for visualizing the various CAD parts. You can then import the files into Simscape Multibody software, which parses the XML data and automatically generates an equivalent multibody model.			UNIT-I

Category: Project		**Total Weightage: 10.00**		**No. of lab sessions: 2.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1	Course Project	2.00	10.00	UNIT-III

	Learning Outcomes: Demonstrate the skill of designing a mechanism for a specific application as a course project and should be able to produce well constructed and well-supported engineering documents.	

1. ***Evaluation*:**

Students Assessment through ISA (80%) + ESA (20%)

Type of Evaluation	Types of laboratory work	**Assessment**				
		Aim	Material	Method	Answer	**Weightage in Marks**
Internal Semester Assessment (80%)	Demonstration	Given	Given	Given	Given	**20**
	Exercise	Given	Given	Given	Open	**40**
	Project	Given	Open	Open	Open	**10**
	Quiz(Viva)/Attendance	-	-	-	-	**10**
End Semester Assessment (20%)	Project	Open	Open	Open	Open	**20**
					Total	**100**

Date: 22-10-2021

Head of School/Department

FMTH0301/Rev.5.3

Course Plan

Semester: **IV** Year: **2021-2022**

Course Title: **Control Systems**	Course Code: **19EARC207**
Total Contact hours: **50 hrs**	Duration of ESA: **3 hrs**
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr. Nagaraj Benakanahalli	Date: 02-02-2022
Checked By: Mr. Arun C. Giriyapur	Date: 05-02-2022

Prerequisites:

1. Basic concepts of analog and digital electronic circuits
2. Basic mechanical engineering concepts

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Find the transfer function for Linear Time Invariant (LTI) electrical systems, mechanical systems, gear systems and electro mechanical systems.
2. Apply block diagram reduction technique to reduce block diagram of multiple subsystems to a single block representing the transfer function from input to output and find the transfer function of multiple subsystems using Mason's rule.
3. Interpret the time response of different order systems for standard test input signals and write performance specifications for a control system in terms of its transient response, steady state error and disturbance response and select the proper controller and controller parameters, to achieve desired dynamic response of a given application.
4. Analyze system stability using Routh-Hurwitz Criterion, Root locus techniques, Bode and Nyquist plots.
5. Apply state space approach to find the state equations for Linear Time Invariant (LTI) electrical and mechanical systems and design Lead, Lag and Lead-Lag compensators using frequency response methods.

.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Control Systems	Semester: 4
Course Code: 19EARC207	Year: 2021 - 2022

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Find the transfer function for Linear Time Invariant (LTI) electrical systems, mechanical systems, gear systems and electro mechanical systems.	H													
2. Apply block diagram reduction technique to reduce block diagram of multiple subsystems to a single block representing the transfer function from input to output and find the transfer function of multiple subsystems using Mason's rule.	M													
3. Interpret the time response of different order systems for standard test input signals and write performance specifications for a control system in terms of its transient response, steady state error and disturbance response and select the proper controller and controller parameters, to achieve desired dynamic response of a given application.	H				M									
4. Analyze system stability using Routh-Hurwitz Criterion, Root locus techniques, Bode and Nyquist plots.	M													
5. Apply state space approach to find the state equations for Linear Time Invariant (LTI) electrical and mechanical systems and design Lead, Lag and Lead-Lag compensators using frequency response methods.	M													

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 - Demonstrate the competence in mathematical modelling	1.1.2 - Apply discipline specific advanced mathematical techniques to modeling and problem solving
5.2 - Demonstrate an ability to select and apply discipline specific tools, techniques and resources	5.2.2 - Demonstrate proficiency in using discipline specific tools

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: **19EARC207**	Course Title: **Control Systems**	
L-T-P : 4-0-0	Credits: 4	Contact Hours: 50 hrs
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 50 hrs		Exam Duration: 3 hrs

Content	Hrs
Unit - 1	
Chapter No. 1. Introduction to Control Systems and System Modeling in Frequency domain System Configurations (open-loop & closed loop systems), Analysis and Design Objectives, The Design Process. Mathematical modeling of physical Systems: Transfer function, Electrical networks, Mechanical systems, Transfer Functions for Systems with Gears, Electromechanical System Transfer Functions, Analogous systems, Block diagram representation and reduction, Signal flow graph representation and reduction using Mason's Gain formula.	**8**
Chapter No. 2. Time Response Introduction, Poles, Zeros, and System Response, Standard test signals, First-order system response to step, ramp and impulse inputs, Second-order system response to step input; Un-damped, Under damped, Critical damped and Over damped systems. Time response specifications of first and second order systems, Analysis and Design of Feedback Systems, Steady state errors and error constants.	**8**
Chapter No. 3. Controllers Introduction, Proportional control, Integral Control, Proportional Plus Integral (P-I) Control, Proportional Plus Derivative (P-D) Control, Proportional-Integral-Derivative (PID) control, Guideline for selection of controller mode.	**4**
Unit - 2	
Chapter No. 4. Stability Analysis Concepts of stability, Necessary conditions for Stability, Routh-Hurwitz Criterion, Routh-Hurwitz Criterion: Special Cases.	**5**
Chapter No. 5: Root Locus Techniques Defining the Root locus, General rules for constructing root loci, Sketching the Root locus, Effect of gain adjustment, addition of pole and addition of zero on system response and system stability.	**5**
Chapter No. 6 : Frequency Domain Analysis Introduction, Stability analysis, Bode plot and Nyquist plot to obtain phase margin and gain margin of a given system.	**10**
Unit - 3	
Chapter No. 7 : Design Via Frequency Response Transient Response via Gain Adjustment, Lag Compensation, Lead Compensation, Lag-Lead Compensation.	**5**
Chapter No. 8: Modeling in the Time Domain (State Space) General State-Space Representation, Applying the State-Space Representation, Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function.	**5**

Text Books (List of books as mentioned in the approved syllabus)

1. Norman S. Nise, “Control Systems Engineering”, John Wiley & Sons, Inc, Sixth edition, 2011.

References

1. Benjamin C. Kuo, Automatic Control Systems, PHI, 7th edition.
2. K. Ogata “Modern Control Engineering”, Pearson Education Asia/ PHI, 4th Edition, 2002.

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
ISA - 1	15
ISA - 2	15
Tutorial	20
Total	50

Course Unitization for ISA and End Semester Assessment

Topics / Chapters	Teaching Credits	No. of Questions in ISA - 1	No. of Questions in ISA - 2	No. of Questions in Tutorial	No. of Questions in ESA
Unit I					
1. Introduction to Control Systems and System Modeling in Frequency domain	8	1.5	-	1	1.5
2. Time Response	8	1	-	1	1.0
3. Controllers	4	0.5	-	1	0.5
Unit II					
4. Stability Analysis	5	-	1	1	1
5. Root-Locus Techniques	5	-	1	1	1
6. Frequency Domain Analysis	10	-	1	1	1
Unit III					
7. Design Via Frequency Response	5	-	-	1	1
8. Modeling in the Time Domain (State Space)	5	-	-	1	1

Note:

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA I, II and ESA
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Course Assessment Plan

Course Title: **Control Systems**		Code: **19EARC207**			
Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		ISA-1	ISA-2	Tutorials	ESA
1. Find the transfer function for Linear Time Invariant (LTI) electrical systems, mechanical systems, gear systems and electro mechanical systems.	15%	✓		✓	✓
2. Apply block diagram reduction technique to reduce block diagram of multiple subsystems to a single block representing the transfer function from input to output and find the transfer function of multiple subsystems using Mason's rule.	15%	✓		✓	✓
3. Interpret the time response of different order systems for standard test input signals and write performance specifications for a control system in terms of its transient response, steady state error and disturbance response and select the proper controller and controller parameters, to achieve desired dynamic response of a given application.	25%	✓		✓	✓
4. Analyze system stability using Routh-Hurwitz Criterion, Root locus techniques, Bode and Nyquist plots.	30%		✓	✓	✓
5. Apply state space approach to find the state equations for Linear Time Invariant (LTI) electrical and mechanical systems and design Lead, Lag and Lead-Lag compensators using frequency response methods.	15%	✓			✓
Weightage		15%	15%	20%	50%

Date: 05-02-2022 **Head of Department**

Chapter wise Plan

UNIT – I

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **1 Introduction to Control Systems and System Modeling in Frequency domain**	Planned Hours: **8 hrs**

Learning Outcomes:-

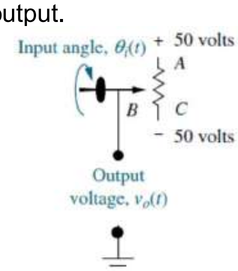
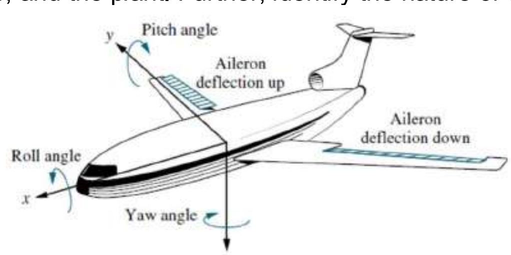
At the end of the topic the student should be able to:

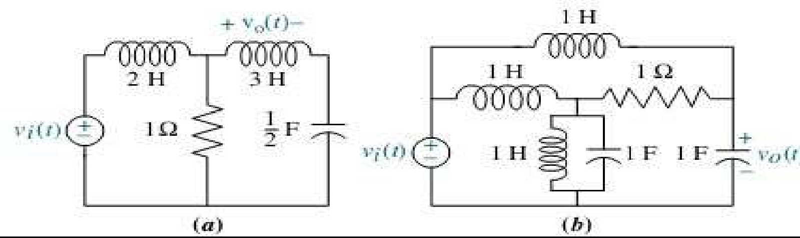
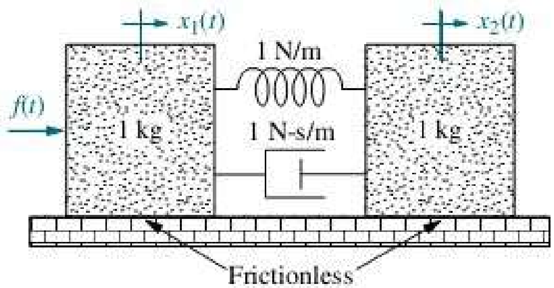
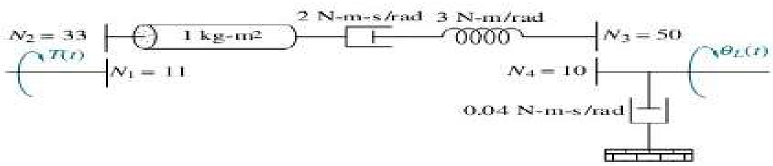
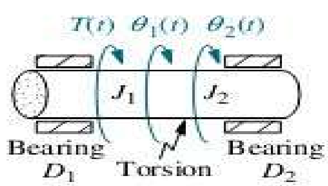
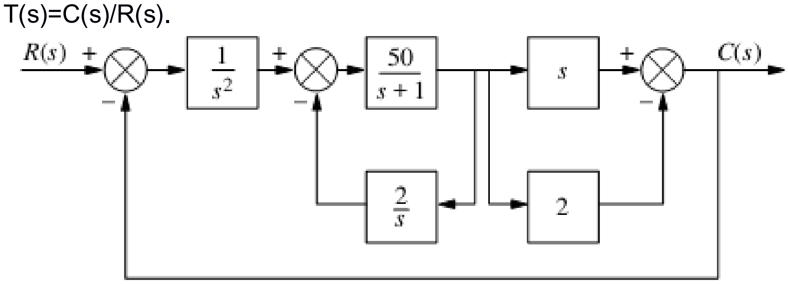
Topic Learning Outcomes	COs	BL	CA Code
1. Define a control system and describe some applications.	1	L1	1.1
2. Identify the different components of a control system.	1	L2	1.1
3. Describe the basic features and configurations of control systems.	1	L2	1.1
4. Draw control system block diagram for a given system.	1	L3	1.1
5. Discuss the application of Laplace transforms and their role in obtaining transfer functions.	1	L2	1.1
6. Find the transfer function for Linear Time Invariant - electrical networks, mechanical systems and electromechanical systems.	1	L3	1.1
7. Explain block diagrams and signal-flow graphs and their role in analyzing control systems.	2	L2	1.1
8. Reduce a block diagram of multiple subsystems to a single block representing the transfer function from input to output.	2	L3	1.1
9. Convert block diagrams to signal-flow diagrams.	2	L3	1.1
10. Find the transfer function of multiple subsystems using Mason's rule.	2	L3	1.1

Lesson Schedule Class No. - Portion covered per hour	
1.	System Configurations (open-loop & closed loop systems), Analysis and Design Objectives, The Design Process
2.	Mathematical modeling of physical Systems: Electrical networks
3.	Mathematical modeling of physical Systems: Electrical networks
4.	Mathematical modeling of physical Systems: Mechanical systems
5.	Mathematical modeling of physical Systems: Mechanical systems
6.	Mathematical modeling of physical Systems: Electro Mechanical System Transfer Functions
7.	Analogous systems, Block diagram representation and reduction
8.	Signal flow graph representation and reduction using Mason's Gain formula

Review Questions

Sr.No	Questions	TLO	BL	PI Code
1.	Functionally, how do closed-loop systems differ from open-loop systems?	3	L2	1.1.2
2.	Name three reasons for using feedback control systems and at least	3	L2	1.1.2

	one reason for not using them.			
3.	Define control system. Name three applications for feedback control systems.	1	L2	1.1.2
4.	A university wants to establish a control system model that represents the student population as an output, with the desired student population as an input. The administration determines the rate of admissions by comparing the current and desired student populations. The admissions office then uses this rate to admit students. Draw a functional block diagram showing the administration and the admissions office as blocks of the system. Also show the following signals: the desired student population, the actual student population, the desired student rate as determined by the administration, the actual student rate as generated by the admissions office, the dropout rate, and the net rate of influx.	2	L2	1.1.2
5.	A variable resistor, called a potentiometer, is shown below. The resistance is varied by moving a wiper arm along a fixed resistance. The resistance from A to C is fixed, but the resistance from B to C varies with the position of the wiper arm. If it takes 10 turns to move the wiper arm from A to C, draw a block diagram of the potentiometer showing the input variable, the output variable, and (inside the block) the gain, which is a constant and is the amount by which the input is multiplied to obtain the output. 	4	L3	1.1.2
6.	A temperature control system operates by sensing the difference between the thermostat setting and the actual temperature and then opening a fuel valve an amount proportional to this difference. Draw a functional closed-loop block diagram identifying the input and output transducers, the controller, and the plant. Further, identify the input and output signals of all subsystems previously described.	4	L3	1.1.2
7.	An aircraft's attitude varies in roll, pitch, and yaw as defined in Figure below. Draw a functional block diagram for a closed-loop system that stabilizes the roll as follows: The system measures the actual roll angle with a gyro and compares the actual roll angle with the desired roll angle. The ailerons respond to the roll angle error by undergoing an angular deflection. The aircraft responds to this angular deflection, producing a roll angle rate. Identify the input and output transducers, the controller, and the plant. Further, identify the nature of each signal. 	4	L3	1.1.2
8.	Find the transfer function, G(s)= Vo(s)/Vi(s), for each network shown in Figure below. Solve the problem using mesh analysis.	6	L3	1.1.2

				
9.	Find the transfer function, G(s)=X2(s)/ F(s) , for the translational mechanical network shown in Figure. 	6	L3	1.1.2
10.	For the rotational system shown in Figure, find the transfer function, G(s)= θ_L(s)/T(s) . 	6	L3	1.1.2
11.	Draw a series and parallel electrical analogy for the rotational mechanical system of figure shown below. 	6	L3	1.1.2
12.	Reduce the block diagram shown in Figure to a single transfer function, T(s)=C(s)/R(s). 	8	L3	1.1.2
13.	Label signals and draw a signal-flow graph for the block diagram shown below.	8	L3	1.1.2

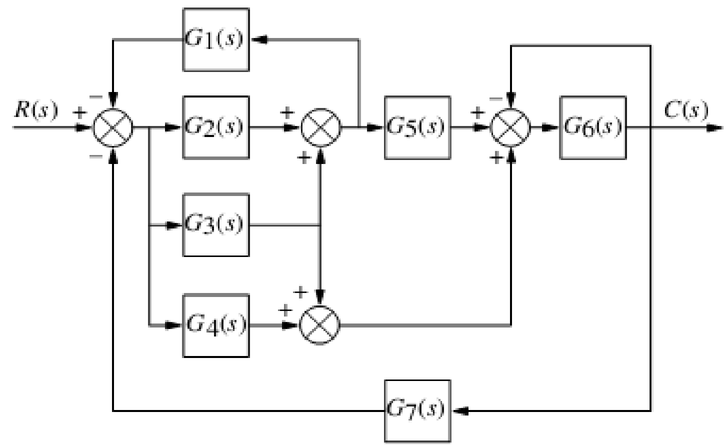
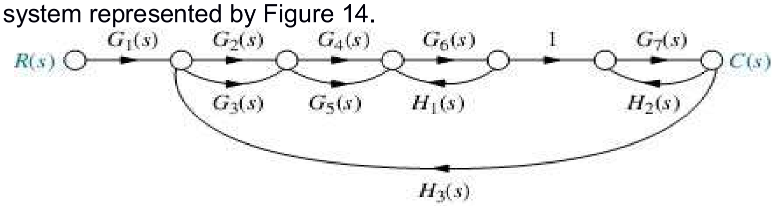
<table>
<tr><td></td><td>
</td><td></td><td></td><td></td></tr>
<tr><td>14.</td><td>Using Mason's rule, find the transfer function, T(s)=C(s)/R(s) , for the system represented by Figure 14.


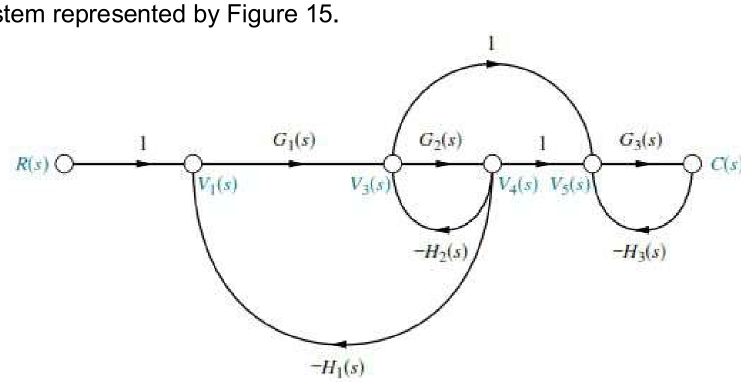
Figure 14</td><td>10</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>15.</td><td>Using Mason's rule, find the transfer function, T(s)= C(s) / R(s) , for the system represented by Figure 15.


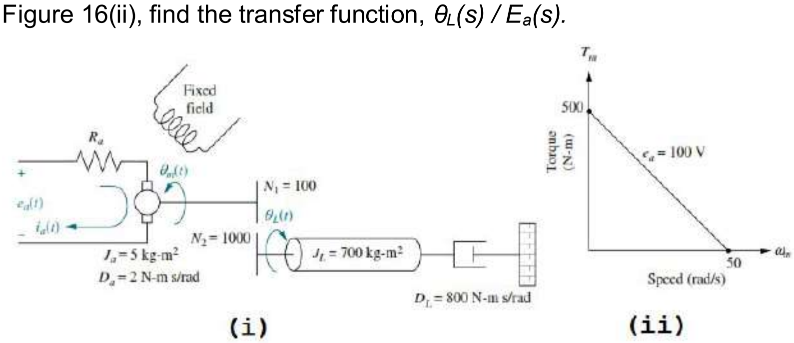
Figure 15</td><td>10</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>16.</td><td>Given the system torque and torque-speed curve of Figure 16(i) and Figure 16(ii), find the transfer function, $\theta_L(s) / E_a(s)$.


Figure 16</td><td>6</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>17.</td><td>Find the transfer function, $G(s) = V_o(s) / V_i(s)$, for the below operational amplifier circuit shown in Figure 17.</td><td>6</td><td>L3</td><td>1.1.2</td></tr>
</table>

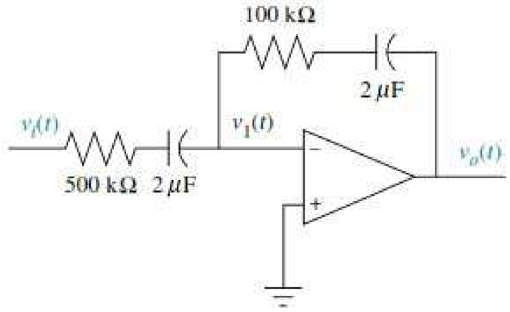
<table>
<tr><td></td><td>

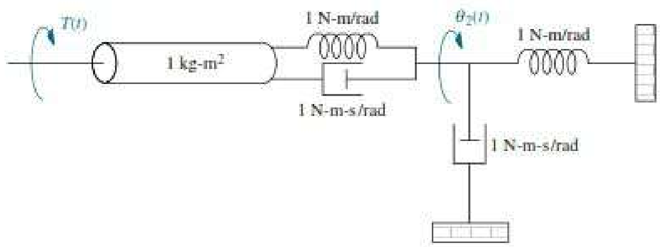
Figure 17</td><td></td><td></td><td></td></tr>
<tr><td>18.</td><td>Find the transfer function, G(s) = $\theta_2(s)$ / T(s), for the rotational mechanical system shown in Figure 18.


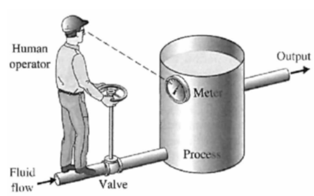
Figure 18</td><td>6</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>19.</td><td>An automobile driver uses a control system to maintain the speed of the car at a prescribed level. Sketch a block diagram to illustrate this feedback system.</td><td>4</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>20.</td><td>A CD player employs a rotating disk, held at a constant speed of rotation in spite of motor wear and variation and other component changes. Suggest a control system for the CD player speed control that will ensure that the actual speed of rotation is within a specified percentage of the desired speed with block diagram.</td><td>4</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>21.</td><td>A valve control system uses a human operator as part of a closed-loop control system. Sketch the block diagram of the valve control system shown in figure 21.


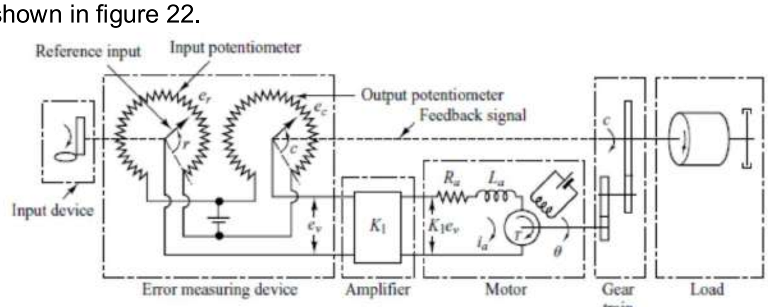
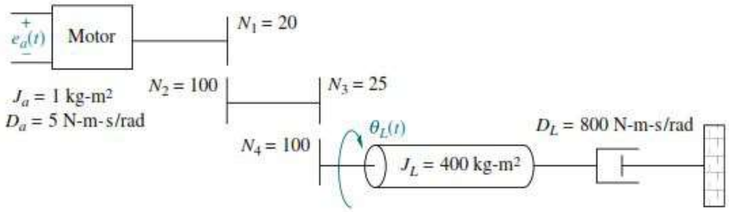
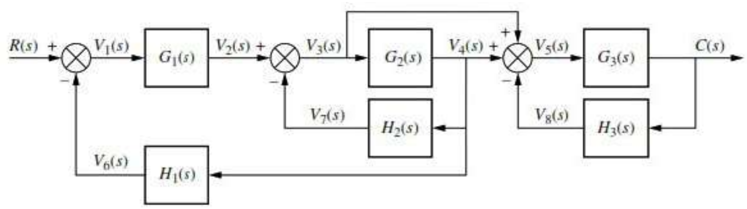
Figure 21</td><td>4</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>22.</td><td>Draw block diagram and find transfer function of following Servo system shown in figure 22.


Figure 22</td><td>4</td><td>L3</td><td>1.1.2</td></tr>
<tr><td>23.</td><td>Find the transfer function, G(s) = $\theta_L(s) / E_a(s)$, for the motor and load</td><td>6</td><td>L3</td><td>1.1.2</td></tr>
</table>

	shown in figure 23. The torque-speed curve is given by $T_m = -8\omega_m + 200$ when the input voltage is 100 volts.  Figure 23			
24.	Given the following differential equation, solve for y(t) if all initial conditions are zero. Use the Laplace transform. $\frac{d^2y}{dt^2} + 12\frac{dy}{dt} + 32y = 32u(t)$	5	L2	1.1.2
25.	Convert the block diagram of figure shown below to a signal-flow graph.  	9	L3	1.1.2

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **2. Time Response**	Planned Hours: **8 hrs**

Learning Outcomes:-

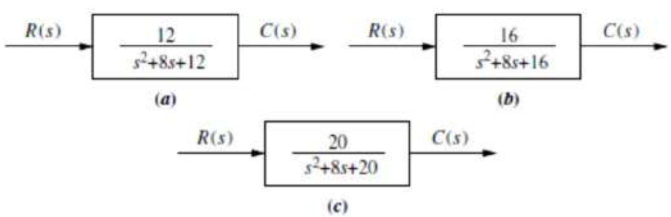
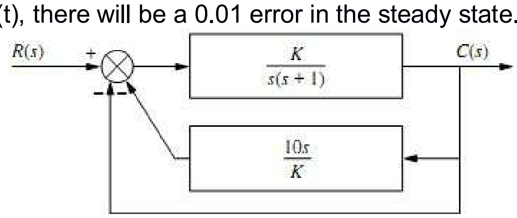
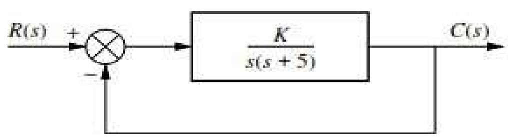
At the end of the topic the student should be able to:

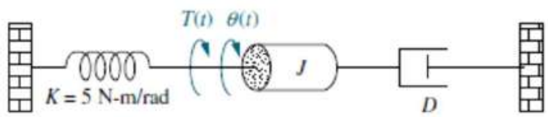
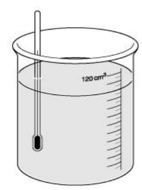
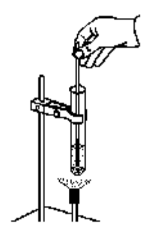
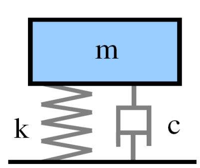
TLO's	CO's	BL	CA code
1. Define poles and zeros of a transfer function and use poles and zeros of transfer functions to determine the time response of a control system.	3	L2	1.1
2. Explain the differences between controlling the transient response and the steady state response of a system.	3	L2	1.1
3. Describe quantitatively the transient response and steady state response of first-order systems for the step, ramp and impulse input.	3	L3	1.1
4. Describe quantitatively the transient response and steady state response of second-order systems for varying damping ratio for the step input.	3	L3	1.1
5. Find the damping ratio and natural frequency of a second-order system.	3		
6. Draw general response curve of given system for given input nature.	3	L3	1.1
7. Find the steady-state error for unity and non-unity feedback systems.	3	L3	1.1
8. Design the gain of a closed-loop system to meet a steady-state error specification.	3	L3	1.1
9. Calculate values of system parameter for given response.	3	L3	1.1

Lesson Schedule Class No. - Portion covered per hour	
1.	Introduction, Poles, Zeros, and System Response, Standard test signals
2.	First-order system response to step, ramp and impulse inputs
3.	First-order system response to step, ramp and impulse inputs
4.	Second-order system response to step input; Un-damped, Under damped, Critical damped and Over damped systems
5.	Time response specifications of first order systems
6.	Time response specifications of second order systems
7.	Steady state errors and error constants
8.	Steady state errors and error constants

Review Questions

Sr. No	Questions	TLO	BL	PI Code
1	Determine the system response of first order system for a step input x(t) = X for all t≥0.	3	L2	1.1.2
2	Determine the system response of second order system for step input x(t) = X for all t≥0, when ξ <1.	4	L2	1.1.2
3	Find the transfer function of a second-order system that yields a 12.3% overshoot and a settling time of 1 second.	4	L3	1.1.2

4	Industrial robots are used for myriad applications. A robot used to move 55-pound bags of salt pellets; a vacuum head lifts the bags before positioning. The robot can move as many as 12 bags per minute .Assume a model for the open-loop swivel controller and plant of $$G_e(s) = \frac{\omega_o(s)}{V_i(s)} = \frac{K}{(s+10)(s^2+4s+10)}$$ Where $\omega_0(s)$ is the Laplace transform of the robot's output swivel velocity and Vi(s) is the voltage applied to the controller. **a.** Evaluate percent overshoot, settling time, peak time, and rise time of the response of the open- loop swivel velocity to a step-voltage input. Justify all second-order assumptions. **b.** Represent the open-loop system in state space.	4	L3	1.1.2
5	For each of the transfer functions shown below, find the locations of the poles and zeros, plot them on the s-plane, and then write an expression for the general form of the step response without solving for the inverse Laplace transform. State the nature of each response (overdamped, underdamped, and so on). **a.** $T(s) = \frac{2}{s+2}$ **d.** $T(s) = \frac{20}{s^2+6s+144}$ **b.** $T(s) = \frac{5}{(s+3)(s+6)}$ **e.** $T(s) = \frac{s+2}{s^2+9}$ **c.** $T(s) = \frac{10(s+7)}{(s+10)(s+20)}$ **f.** $T(s) = \frac{(s+5)}{(s+10)^2}$	6	L3	1.1.2
6	For each of the systems shown below, find the value of ζ and report the kind of response expected. 	6	L3	1.1.2
7	For an unity feedback system with G(s) given as $$G(s) = \frac{450(s+8)(s+12)(s+15)}{s(s+38)(s^2+2s+28)}$$ find the steady-state errors for the following test inputs: 25u(t); 37tu(t); $47t^2u(t)$.	7	L3	1.1.2
8	Given the system of Figure below, design the value of K so that for an input of 100tu(t), there will be a 0.01 error in the steady state. 	8	L3	1.1.2
9	Design the value of gain. K, for the feedback control system of Figure below, so that the system will respond with a 10% overshoot. 	8	L3	1.1.2
10	For a unity feedback control system with a forward-path transfer function	8	L3	1.1.2

	$G(s) = \frac{16}{s(s+a)}$, design the value of "a" to yield a closed-loop step response that has 5% overshoot.			
11	Given the system shown below figure, find J and D to yield 20% overshoot and a settling time of 2 seconds for a step input of torque T(t). 	9	L3	1.1.2
12	Mercury thermometer, initially at 0^{o} C is immersed into a hot bath at constant 50^{o}C. Write mathematical model and derive correlation for rate of change temperature and calculate reading of thermometer after 5 second if product of thermal resistance and thermal capacitance of system is equal to 10. 	9	L3	1.1.2
13	Mercury thermometer, initially at 0^{o}C is immersed into a hot bath getting heated up at the rate of 10^{o}C/min. Write mathematical model and derive correlation for rate of change temperature and calculate reading of thermometer after 2 minutes if product of thermal resistance and thermal capacitance of system is equal to 20. 	9	L3	1.1.2
14	Mercury thermometer, initially at 0^{o}C is used to check a patient having 38^{o}C fever. How long will it take to give actually temperature if product of thermal resistance and thermal capacitance of system is equal to 15 ?	9	L3	1.1.2
15	Generalized model of weighing machine is shown below, M=10 kg, c= 2Ns/m and k=200N/m. Find error in reading of machine when a person weighing 60kg step on it.  	9	L3	1.1.2

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **3. Controllers**	Planned Hours: **4 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA code
1. Explain the improvement of transient response in closed loop with P-controller,	3	L2	1.1
2. Explain the elimination of steady state error with Integral Control.	3	L3	1.1
3. Explain the advantages of P-I controller over simple P and I actions.	3	L3	1.1
4. Analyze effects of proportional, integral and derivative component on system performance.	3	L3	1.1
5. Recommend a suitable controller configuration for a particular process.	3	L3	1.1

Lesson Schedule Class No. - Portion covered per hour
1. Introduction, Proportional control, Integral Control
2. Proportional Plus Integral (P-I) Control, Proportional Plus Derivative (P-D) Control
3. Proportional-Integral-Derivative (PID) control
4. Guideline for selection of controller mode

Review Questions

Sr.No	Questions	TLO	BL	PI Code
1	A P-I controller has a proportional band of 50% and integration time of 2sec. Find the transfer function of the controller.	3	L2	1.1.2
2	Suggest the controller to reduce both the rise time and the steady-state error and not consider the overshoot. Explain with example	5	L3	1.1.2
3	How does incorporation of derivative action in the controller improve the closed loop performance?	4	L3	1.1.2
4	A second order mechanical weighing system producing maximum overshoot therefore suggest suitable controller to increase damping and to reduce maximum overshoot. Explain with an example.	4	L3	1.1.2

UNIT - II

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **4. Stability Analysis**	Planned Hours: **5 hrs**

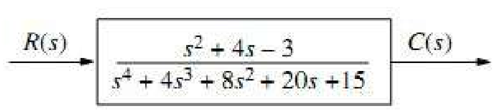
Learning Outcomes:-

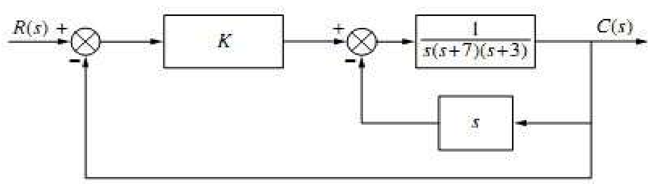
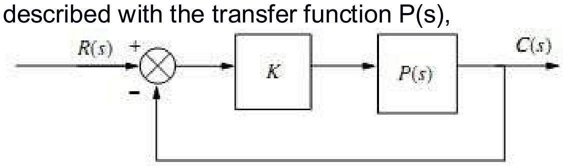
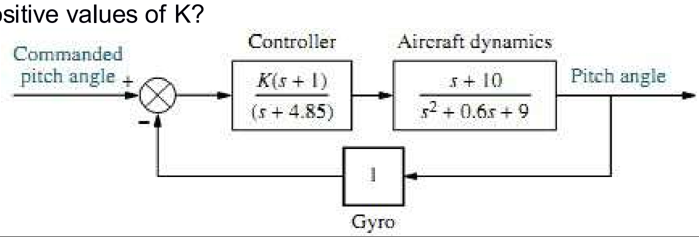
At the end of the topic the student should be able to:

TLO's	CO's	BL	CA code
1. Explain the concepts of stability.	4	L2	1.1
2. Construct and interpret a basic Routh table to determine the stability of a system. (Routh-Hurwitz Criterion)	4	L3	1.1
3. Construct and interpret a Routh table where either the first element of a row is zero or an entire row is zero.	4	L3	1.1

Lesson Schedule Class No. - Portion covered per hour	
1.	Concepts of stability
2.	Necessary conditions for Stability
3.	Routh-Hurwitz Criterion
4.	Routh-Hurwitz Criterion: Examples
5.	Routh-Hurwitz Criterion: Special Cases

Review Questions

Sr.No	Questions	TLO	BL	PI Code
1	Locate poles and zeros of G(S) H(S) on S- plane. $G(S)\,H(S) = (S+1) / S(S+4)\,(S^2+4S+20)$.	1	L2	1.1.2
2	What part of the output response is responsible for determining the stability of a linear system?	1	L2	1.1.2
3	What causes a zero to show up only in the first column of the Routh table?	1	L2	1.1.2
4	If a Routh table has two sign changes above the even polynomial and five sign changes below the even polynomial, how many right–half-plane poles does the system have?	1	L2	1.1.2
5	Find how many poles are there in the right half-plane, in the left half-plane, and on the jω-axis for the open-loop system of Figure shown below. 	2	L3	1.1.2
6	Consider the following Routh table. Notice that the s^5 row was originally all zeros. Tell how many roots of the original polynomial were in the right half-plane, in the left half-plane, and on the jω -axis.	2	L3	1.1.2

	$\begin{array}{ccccc} s^7 & 1 & 2 & -1 & -2 \\ s^6 & 1 & 2 & -1 & -2 \\ s^5 & 3 & 4 & -1 & 0 \\ s^4 & 1 & -1 & -3 & 0 \\ s^3 & 7 & 8 & 0 & 0 \\ s^2 & -15 & -21 & 0 & 0 \\ s^1 & -9 & 0 & 0 & 0 \\ s^0 & -21 & 0 & 0 & 0 \end{array}$			
7	For the unity feedback system with $$G(s) = \frac{K(s+6)}{s(s+1)(s+4)}$$ Determine the range of K to ensure stability.	2	L3	1.1.2
8	For the system shown in Figure, find the value of gain K, that will make the system oscillate. Also, find the frequency of oscillation. 	2	L3	1.1.2
9	The read/write head assembly arm of a computer hard disk drive (HDD) can be modeled as a rigid rotating body with inertia I_b: Its dynamics can be described with the transfer function P(s),  $$P(s) = \frac{X(s)}{F(s)} = \frac{1}{I_b s^2}$$ where X(s) is the displacement of the read/write head and F(s) is the applied force. Show that if the HDD is controlled in the configuration shown in Figure, the arm will oscillate and cannot be positioned with any precision over a HDD track. Find the oscillation frequency.	2	L3	1.1.2
10	A model for an airplane's pitch loop is shown in Figure. Find the range of gain, K, that will keep the system stable. Can the system ever be unstable for positive values of K? 	2	L3	1.1.2
11	Determine the stability of the closed-loop transfer function. (Stability via Epsilon Method) $$T(s) = \frac{10}{s^5+2s^4+3s^3+6s^2+5s+3}$$	3	L3	1.1.2
12	Determine the number of right-half-plane poles in the closed-loop transfer function. (Stability via Routh Table with Row of Zeros) $$T(s) = \frac{10}{s^5+7s^4+6s^3+42s^2+8s+56}$$	3	L3	1.1.2

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **5. Root Locus Techniques**	Planned Hours: **5 hrs**

Learning Outcomes:-

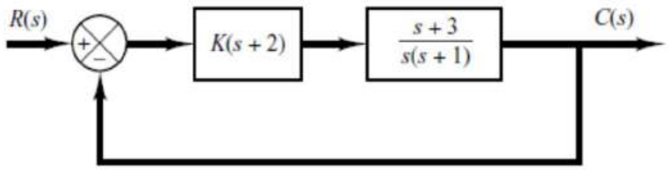
At the end of the topic the student should be able to:

TLO's	CO's	BL	CA code
1. Define a root locus.	4	L1	1.1
2. State the properties of a root locus.	4	L2	1.1
3. Write the general rules for constructing the root locus.	4	L2	1.1
4. Sketch a root locus and find the coordinates of points on the root locus and their associated gains.	4	L3	1.1
5. Analyze the stability of the systems using the root locus plot.	4	L3	1.1
6. Analyze the effect of altering component of system on system stability.	4	L3	1.1

Lesson Schedule Class No. - Portion covered per hour	
1.	Defining the Root locus, General rules for constructing root loci
2.	Sketching the Root locus
3.	Sketching the Root locus: Examples
4.	Effect of gain adjustment
5.	Addition of pole and addition of zero on system response and system stability

Review Questions

Sr.No	Questions	TLO	BL	PI Code
1	What is a root locus? How can you tell from the root locus if a system is unstable?	1	L2	1.1.2
2	What rules for plotting the root locus are the same whether the system is a positive- or a negative-feedback system?	3	L2	1.1.2
3	For an unity feedback system with the following transfer function: $$G(s) = \frac{K\left(s+\frac{2}{3}\right)}{s^2(s+6)}$$ a. Plot the root locus. b. Write an expression for the closed-loop transfer function at the point where the three closed-loop poles meet.	5	L3	1.1.2
4	Let, $$G(s) = \frac{-K(s+1)^2}{s^2+2s+2}$$ With K > 0 for an unity feedback system. a. Find the range of K for closed-loop stability. b. Sketch the system's root locus. c. Find the position of the closed-loop poles when K =1and K = 2.	6	L3	1.1.2
5	Sketch the root locus of the unity feedback system , where	5	L3	1.1.2

	$$G(s) = \frac{K(s+3)(s+5)}{(s+1)(s-7)}$$ and find the break-in and breakaway points.			
6	Sketch the root loci for the system shown in figure (The gain K is assumed to be positive.) Observe that for small or large values of K the system is over-damped and for medium values of K it is underdamped. 	6	L3	1.1.2
7	For a system $$G(s)H(s) = \frac{K}{s(s+1)(s+2)(s+3)} \quad H(s) = 1$$ do the following: a. Sketch the root locus. b. Mark the real axis segments which lie on root locus. c. Find the centroid. d. Find the asymptotes. e. Find break away point. f. Find the value of gain that will make the system marginally stable.	5	L3	1.1.2
8	For a unity feedback system with $$G(s)H(s) = \frac{K}{(s+2)(s+4)(s+6)}$$ do the following: a. Sketch the root locus. b. Mark the real axis segments which lie on root locus. c. Find the centroid. d. Find the asymptotes. e. Find the value of gain that will make the system marginally stable.			
9	Sketch the root locus for the system having $G(s)\,H(s) = \frac{K}{S(S^2+2S+2)}$. For what value of K the system is stable. Comment on stability.	5	L3	1.1.2

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **6. Frequency Domain Analysis**	Planned Hours: **10 hrs**

Learning Outcomes:-

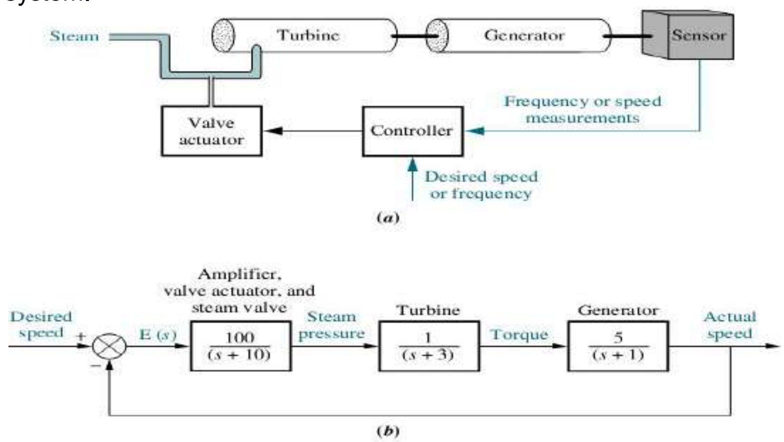
At the end of the topic the student should be able to:

TLO's	CO's	BL	CA code
1. Define and plot the frequency response of a system.	4	L2	1.1
2. Plot asymptotic approximations to the frequency response of a system.	4	L2	1.1
3. Draw both magnitude & phase plots on the same semi log graph sheet on a common frequency scale, analyze the stability of the system.	4	L3	1.1
4. Sketch a Nyquist diagram and analyze the stability of the system using the Nyquist criterion.	4	L3	1.1
5. Find the bandwidth, peak magnitude, and peak frequency of a closed-loop frequency response given the closed-loop time response parameters of peak time, settling time, and percent overshoot.	4	L3	1.1
6. Find the closed-loop frequency response given the open-loop frequency response.	4	L3	1.1
7. Find the closed-loop time response parameters of peak time, settling time, and percent overshoot given the open-loop frequency response.	4	L3	1.1

Lesson Schedule Class No. - Portion covered per hour	
1.	Introduction, Correlation between time and frequency response
2.	Stability analysis
3.	Bode plot to obtain phase margin and gain margin of a given system
4.	Bode plot to obtain phase margin and gain margin of a given system
5.	Nyquist plot to obtain phase margin and gain margin of a given system.
6.	Nyquist plot to obtain phase margin and gain margin of a given system.
7.	Examples: Bode Plot
8.	Examples: Nyquist Plot
9.	Introduction to lead, lag and lead-lag compensating networks
10.	Introduction to lead, lag and lead-lag compensating networks

Review Questions

Sr.No	Questions	TLO	BL	PI Code
1	Find analytical expressions for the magnitude and phase responses of $$G(s)=\frac{1}{(s+2)(s+4)}$$	2	L3	1.1.2
2	Draw the Bode plots for an unity feedback system, where $$G(s)=\frac{K(s+3)}{s(s+3)(s+2)}$$	3	L3	1.1.2

3	Speed controls find wide application throughout industry and the in home. Figure (a) shows one application: output frequency control of electrical power from a turbine and generator pair. By regulating the speed, the control system ensures that the generated frequency remains within tolerance. Deviations from the desired speed are sensed, and a steam valve is changed to compensate for the speed error. The system block diagram is shown in Figure (b). Sketch the Nyquist diagram for the system.  (a) Turbine and generator; (b) block diagram of speed control system	4	L3	1.1.2
4	For an unity feedback system, where $G(s) = \dfrac{K}{(s+2)(s+4)(s+6)}$ do the following: a. Plot the Nyquist diagram. b. Use the Nyquist diagram to find the range of gain, for stability. c. Find the gain margin and the 180^0 frequency if K =100.	4	L3	1.1.2
5	For an unity feedback system, where $G(s) = \dfrac{K}{(s+5)(s+20)(s+50)}$ do the following: a. Draw the Bode log-magnitude and phase plots. b. Find the range of K for stability from your Bode plots. c. Evaluate gain margin, phase margin, zero dB frequency, and 180^0 frequency from the Bode plots for K = 10,000.	3	L3	1.1.2
6	Find the closed-loop bandwidth required for 20% overshoot and 2-seconds settling time.	5	L3	1.1.2
7	A unity feedback control system has $G(s) = \dfrac{10}{s(1+0.2s)(1+0.01s)} \quad , \quad H(s) = 1$ a. Draw the Bode plot. b. Determine Gain margin(GM) and Phase margin(PM), c. Find Gain cross over frequency (ω_{gc}) and Phase cross over frequency (ω_{pc}) d. Comment on stability.	3	L3	1.1.2
8	Using the open-loop frequency response for an unity feedback system, where	7	L3	1.1.2

	$$G(s) = \frac{100}{s(s+5)}$$ estimate the percent overshoot, settling time, and peak time for the closed-loop step response.			
9	Sketch the Bode plot and find the gain margin, phase margin, zero dB frequency , and -180 frequency for a unity feedback system with $$G(s)\,H(s) = \frac{5(s+6)}{s(s^2+4s+15)}$$ Determine whether the system is stable.	3	L3	1.1.2

UNIT - III

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **7. Design Via Frequency Response**	Planned Hours: **5 hrs**

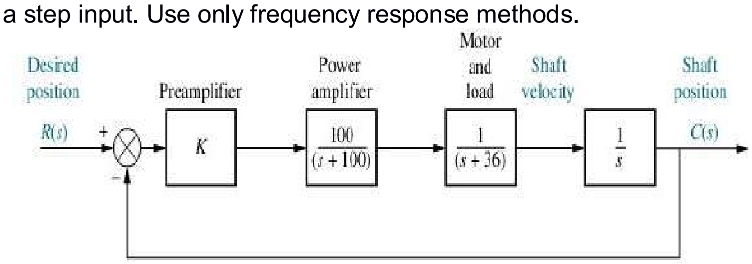
Learning Outcomes:-

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA code
1. Use frequency response techniques to adjust the gain to meet a transient response specification.	5	L3	1.1
2. Use frequency response techniques to design cascade compensators to improve the steady-state error.	5	L3	1.1
3. Use frequency response techniques to design cascade compensators to improve the transient response.	5	L3	1.1
4. Use frequency response techniques to design cascade compensators to improve both the steady-state error and the transient response.	5	L3	1.1

Lesson Schedule Class No. - Portion covered per hour	
1.	Transient Response via Gain Adjustment
2.	Lag Compensation
3.	Lead Compensation
4.	Lag-Lead Compensation
5.	Examples

Review Questions

Sr.No	Questions	TLO	BL	PI Code
1	For the position control system shown in Figure, find the value of preamplifier gain, K, to yield a 9.5% overshoot in the transient response for a step input. Use only frequency response methods. 	1	L3	1.1.2
2	For an unity feedback system with a forward transfer function $$G(s) = \frac{K}{s(s+50)(s+120)}$$ Use frequency response techniques to find the value of gain, K, to yield a closed loop step response with 20% overshoot.	1	L3	1.1.2
3	An electric ventricular assist device (EVAD) that helps pump blood concurrently to a defective natural heart in sick patients can be shown to	2	L3	1.1.2

	have a transfer function $$G(s) = \frac{P_{ao}(s)}{E_m(s)} = \frac{1361}{s^2 + 69s + 70.85}$$ The input, $E_m(s)$, is the motor's armature voltage, and the output is $P_{ao}(s)$, the aortic blood pressure. The EVAD will be controlled in the closed-loop configuration Design a phase lag compensator to achieve a tenfold improvement in the steady-state error to step inputs without appreciably affecting the transient response of the uncompensated system.			
4	The transfer function from applied force to arm displacement for the arm of a hard disk drive has been identified as $$G(s) = \frac{X(s)}{F(s)} = \frac{3.3333 \times 10^4}{s^2}$$ The position of the arm will be controlled using the feedback loop. Design a lead compensator to achieve closed-loop stability with a transient response of 16% over-shoot and a settling time of 2 msec for a step input.	3	L3	1.1.2
5	Given an unity feedback system where $$G(s) = \frac{K}{s(s+1)(s+4)}$$ design a passive lag-lead compensator using Bode diagrams to yield a 13.25% overshoot, a peak time of 2 seconds, and $K_v = 12$.	2	L3	1.1.2

Course Code and Title: **19EARC207 / Control Systems**	
Chapter Number and Title: **8. Modeling in the Time Domain (State Space)**	Planned Hours: **5 hrs**

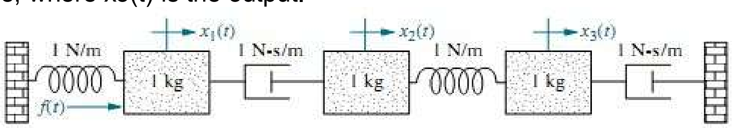
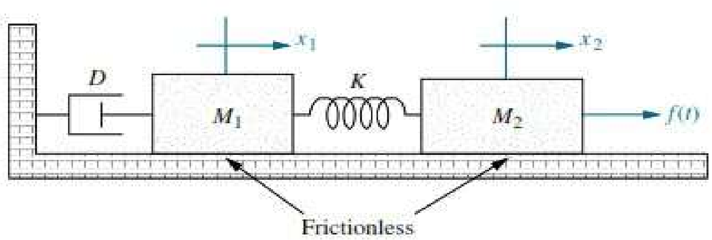
Learning Outcomes:-

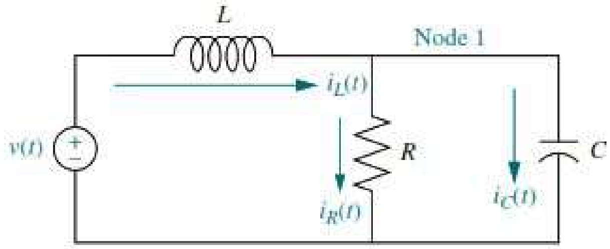
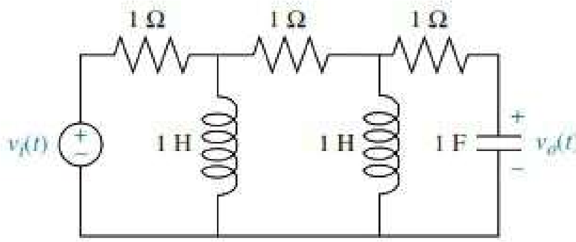
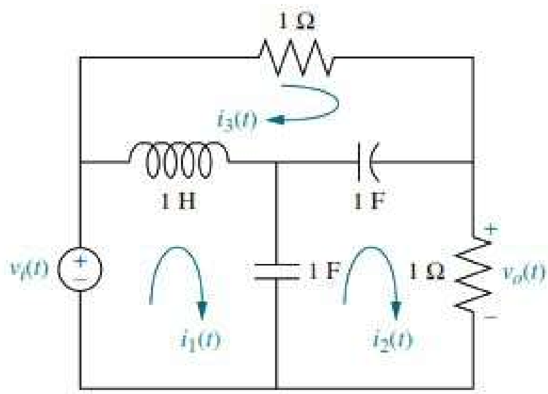
At the end of the topic the student should be able to:

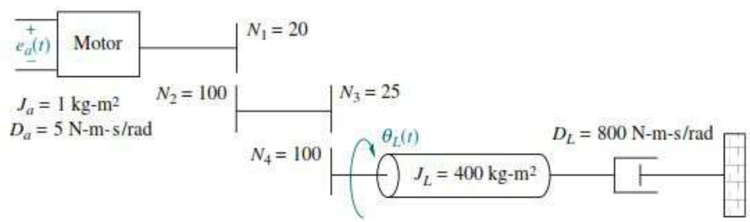
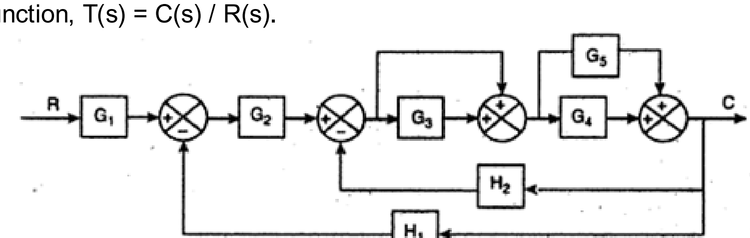
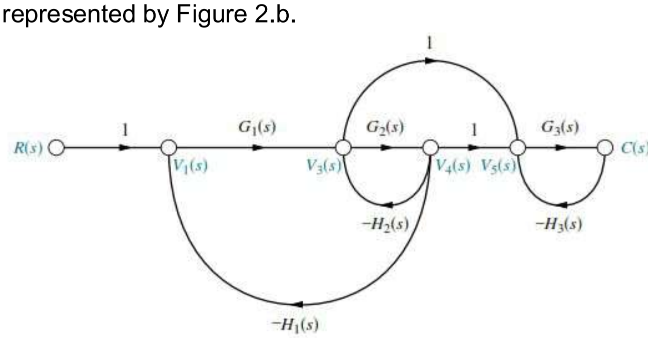
TLO's	CO's	BL	CA code
1. Find a mathematical model, called a state-space representation, for a linear, time invariant system.	5	L2	1.1
2. Model electrical and mechanical Linear Time Invariant (LTI) systems in state space.	5	L2	1.1
3. Convert a transfer function to state space and a state-space representation to a transfer function.	5	L3	1.1

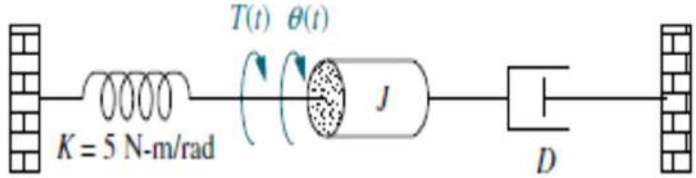
Lesson Schedule Class No. - Portion covered per hour
1. General State-Space Representation
2. Applying the State-Space Representation
3. Applying the State-Space Representation
4. Converting a Transfer Function to State Space
5. Converting from State Space to a Transfer Function

Review Questions

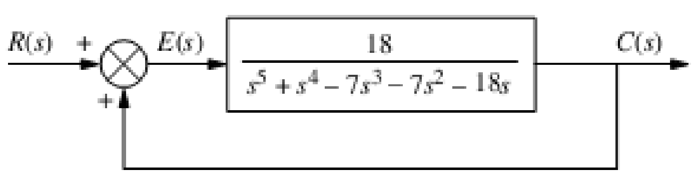
Sr. No	Questions	TLO	BL	PI Code
1	Represent the translational mechanical system shown in Figure 1 in state space, where x3(t) is the output.  Figure 1	2	L3	1.1.2
2	Find the state equations for the translational mechanical system shown in Figure 2.  Figure 2	2	L3	1.1.2
3	Given the electrical network of Figure 3, find a state-space representation if the output is the current through the resistor.	2	L3	1.1.2

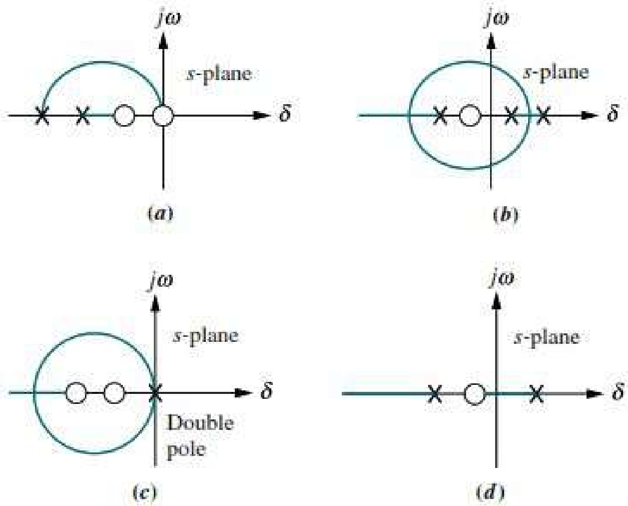
	 Figure 3			
4	Represent the electrical network shown in Figure 4 in state space, where Vo(t) is the output.  Figure 4	2	L3	1.1.2
5	Find the state-space representation of the network shown in Figure 5 if the output is Vo(t).  Figure 5	2	L3	1.1.2

Model Question Paper for ISA – I							
Course Code:	**19EARC207**	Course Title: **Control Systems**					
Duration:	1hr : 15 Min						
Max. Marks	40						
	Note: Answer any two full questions.						
Q.No	Questions	Marks	CO	BL	PO	PI Code	
1a	Find the transfer function, $G(s) = \theta_L(s) / E_a(s)$, for the motor and load shown in figure 1.a. The torque-speed curve is given by $T_m = -8\omega_m + 200$ when the input voltage is 100 volts.  Figure 1.a	10	1	L3	1	1.1.2	
1b	Reduce the block diagram shown in Figure 1.b to a single transfer function, T(s) = C(s) / R(s).  Figure 1.b	10	2	L3	1	1.1.2	
2a	Determine the transfer function for the PID controller.	10	3	L3	1	1.1.2	
2b	Using Mason's rule, find the transfer function, T(s) = C(s) / R(s) , for the system represented by Figure 2.b.  Figure 2.b	10	2	L3	1	1.1.2	
3a	Determine the system response of 1st order system for unit step input and for unit ramp input.	10	3	L3	1	1.1.2	

3b	Given the system shown in figure 3.b, find J and D to yield 20% overshoot and a settling time of 2 seconds for a step input of torque T(t).  Figure 3.b	10	3	L3	1	1.1.2

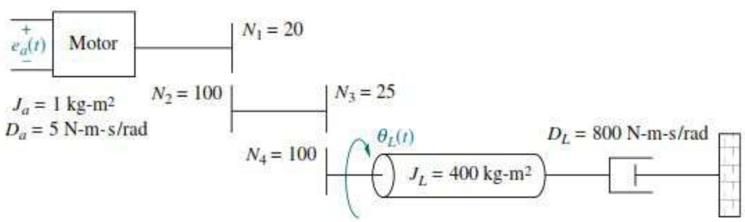
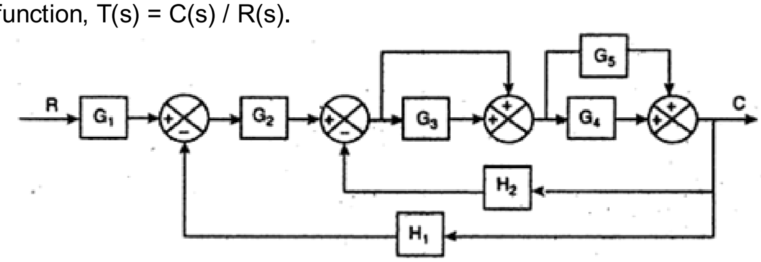
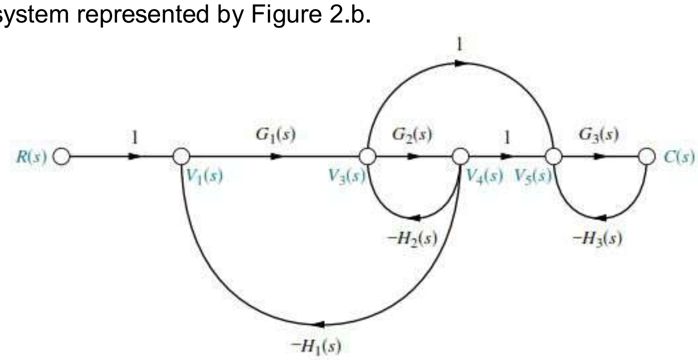
Model Question Paper for ISA – II		
Course Code:	**19EARC207**	Course Title: **Control Systems**
Duration:	1hr : 15 Min	
Max. Marks	40	

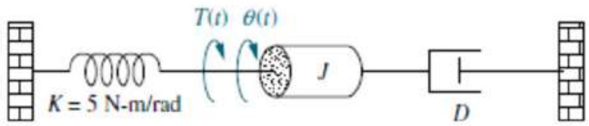
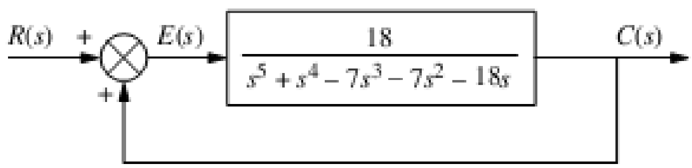
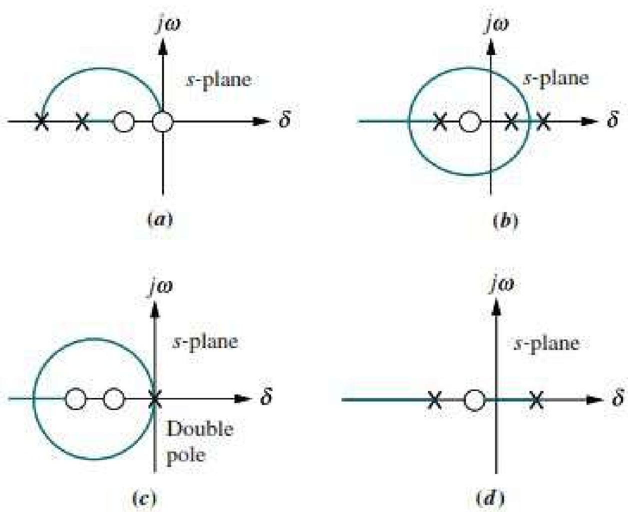
	Note: Answer any two full questions.					
Q.No	Questions	Marks	CO	BL	PO	PI Code
1a	For the system of Figure 1(a), tell how many closed-loop poles are located in the right half-plane, in the left half-plane, and on the j ω-axis. Notice that there is positive feedback.  Figure 1.(a)	10	4	L3	1	1.1.2
1b	Determine the stability of the closed-loop transfer function $T(s) = \frac{10}{s^5+2s^4+3s^3+6s^2+5s+3}$	10	4	L3	1	1.1.2
2a	For each of the root loci shown in Figure 2, tell whether or not the sketch can be a root locus. If the sketch cannot be a root locus, explain why. Give all reasons.	10	4	L3	1	1.1.2

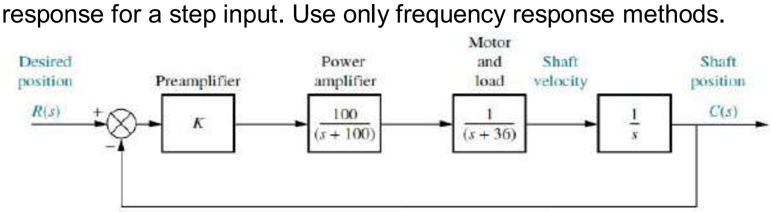
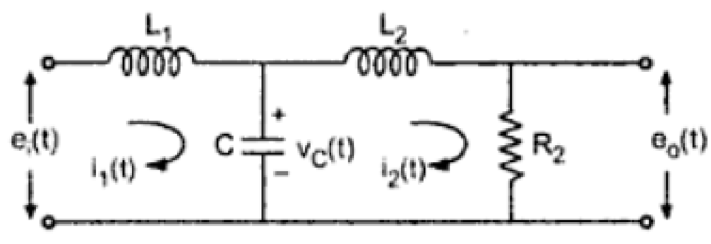
	 Figure 2					
2b	For a unity feedback system with $$G(s)H(s) = \frac{K}{(s+2)(s+4)(s+6)}$$ do the following: a. Sketch the root locus. b. Mark the real axis segments which lie on root locus. c. Find the centroid. d. Find the asymptotes. e. Find the value of gain that will make the system marginally stable.	10	4	L3	1	1.1.2
3a	A unity feedback control system has $$G(s) = \frac{10}{s(1+0.2s)(1+0.01s)} \quad , \quad H(s) = 1$$ a. Draw the Bode plot. b. Determine Gain margin(GM) and Phase margin(PM), c. Find Gain cross over frequency (ω_{gc}) and Phase cross over frequency (ω_{pc}) d. Comment on stability.	10	4	L3	1	1.1.2
3b	For an unity feedback system, where $$G(s) = \frac{K}{(s+2)(s+4)(s+6)}$$ do the following: a. Plot the Nyquist diagram. b. Use the Nyquist diagram to find the range of gain, for stability. c. Find the gain margin and the 180^0 frequency if K =100.	10	4	L3	1	1.1.2

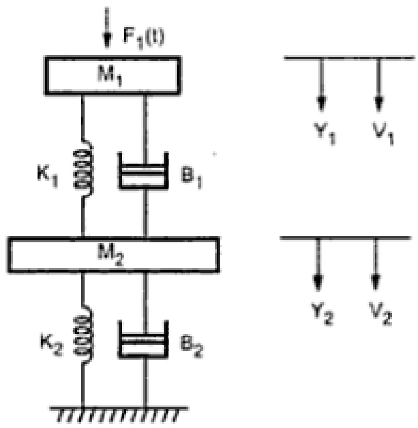
Model Question Paper for End Semester Assessment (ESA)		
Course Code:	**19EARC207**	Course Title: **Control Systems**
Duration:	3 hrs	
Max. Marks	100	
	Note: Answer any two full questions.	

UNIT - I

Q.No	Questions	Marks	CO	BL	PO	PI Code
1a	Find the transfer function, G(s) = $\theta_L(s) / E_a(s)$, for the motor and load shown in figure 1.a. The torque-speed curve is given by $T_m = -8\omega_m + 200$ when the input voltage is 100 volts.  Figure 1.a	10	1	L3	1	1.1.2
1b	Reduce the block diagram shown in Figure 1.b to a single transfer function, T(s) = C(s) / R(s).  Figure 1.b	10	2	L3	1	1.1.2
2a	Determine the transfer function for the PID controller.	10	3	L3	1	1.1.2
2b	Using Mason's rule, find the transfer function, T(s) = C(s) / R(s) , for the system represented by Figure 2.b.  Figure 2.b	10	2	L3	1	1.1.2
3a	Determine the system response of 1st order system for unit step input and for unit ramp input.	10	3	L3	1	1.1.2

3b	Given the system shown in figure 3.b, find J and D to yield 20% overshoot and a settling time of 2 seconds for a step input of torque T(t).  Figure 3.b	10	3	L3	1	1.1.2
UNIT - II						
4a	For the system of Figure 1(a), tell how many closed-loop poles are located in the right half-plane, in the left half-plane, and on the j ω-axis. Notice that there is positive feedback.  Figure 1.(a)	10	4	L3	1	1.1.2
4b	Determine the stability of the closed-loop transfer function $T(s) = \frac{10}{s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3}$	10	4	L3	1	1.1.2
5a	For each of the root loci shown in Figure 2, tell whether or not the sketch can be a root locus. If the sketch cannot be a root locus, explain why. Give all reasons.  Figure 2	10	4	L3	1	1.1.2
5b	For a unity feedback system with $G(s)H(s) = \frac{K}{(s+2)(s+4)(s+6)}$ do the following: a. Sketch the root locus. b. Mark the real axis segments which lie on root locus.	10	4	L3	1	1.1.2

	c. Find the centroid. d. Find the asymptotes. e. Find the value of gain that will make the system marginally stable.					
6a	A unity feedback control system has $G(s) = \frac{10}{s(1+0.2s)(1+0.01s)}$, $H(s) = 1$ a. Draw the Bode plot. b. Determine Gain margin(GM) and Phase margin(PM), c. Find Gain cross over frequency (ω_{gc}) and Phase cross over frequency (ω_{pc}) d. Comment on stability.	10	4	L3	1	1.1.2
6b	For an unity feedback system, where $G(s) = \frac{K}{(s+2)(s+4)(s+6)}$ do the following: a. Plot the Nyquist diagram. b. Use the Nyquist diagram to find the range of gain, for stability. c. Find the gain margin and the 180^0 frequency if K =100.	10	4	L3	1	1.1.2
UNIT – III						
7	For the position control system shown in Figure 7, find the value of preamplifier gain, K, to yield a 9.5% overshoot in the transient response for a step input. Use only frequency response methods.  Figure 7	20	5	L3	1	1.1.2
8.a	Obtain the state model of the given electrical network in the standard form.  Figure 8.a	10	5	L3	1	1.1.2
8.b	Consider the mechanical system shown in figure. For shown displacements and velocities obtain the state model in the standard form.	10	5	L3	1	1.1.2

	Figure 8.b					

FMTH0301/Rev.5.3

Course Plan

Semester: IV Year: 2022

Course Title: **Machine Design**	Course Code: 18EARC206
Total Contact Hrs: **40**	Duration of ESA: **3 hours**
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr. Vinod Kumar V Meti	Date: 18-2-2022
Checked By: Mr. Amit Talli	Date: 19-2-2022

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Apply the knowledge of the process of materials selection and be able to make decisions on materials selection for engineering applications.
2. Analyze shafts, keys, spur, helical, bevel, and worm gears under strength and wear considerations.
3. Differentiate the helical and leaf springs, clutch, and brakes based on parametric design to meet the design specifications.
4. Analyze rolling contact bearings, machine frames, bolted connections and welded joints, and their selection from the manufacturer's catalog.
5. Select a suitable product, check the specifications of the manufacturer's mechanical components, determine the new components that can be used to replace the existing components, and reflect on the effectiveness of the design methodology applied.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Machine Design														Semester: 4
Course Code: 18EARC206														Year: 2022
Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Apply the knowledge of process of materials selection and be able to make decisions on materials selection for engineering applications.	H	M												
2. Analyze shafts, keys, spur, helical, bevel and worm gears under strength and wear considerations.	M	M												
3. Differentiate the helical and leaf springs, clutch and brakes based on parametric design to meet the design specifications.	M		M											
4. Analyze rolling contact bearings, machine frames, bolted connections and welded joints and its selection from manufacturer's catalogue.	M	M	M											
5. Select a suitable product, check the specifications of the mechanical components given by the manufacturer and determine the new components that can be used to replace the existing components and reflect on the effectiveness of the design methodology applied.	M		M											

Degree of compliance **L**: Low **M**: Medium **H**: High

Course Content

Course Code: 18EARC206	Course Title: Machine Design	
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Duration of ESA: 3 hrs

Content	Hrs
Unit - 1	
Chapter No. 1. THE DESIGN PROCESS Introduction, Materials in Design, The Evolution of Engineering Materials, The Evolution of Materials in Products, the Design Process, Types of Design, Design Tools and Materials Data, Function, Material, Shape, and Process.	5
Chapter No. 2. MATERIAL PROPERTY CHARTS Exploring Material Properties, Modulus–density chart Strength–density chart, Modulus–strength chart, Maximum service temperature chart, Cost bar charts, The modulus–relative cost chart, and The strength–relative cost chart. **ENGINEERING MATERIALS, THEIR PROPERTIES AND MATERIAL SELECTION** The Families of Engineering Materials, Materials Information for Design, Material Properties and Units.	5
Chapter No. 3. KINEMATICS OF GEARS AND GEAR DESIGN Spur Gear Geometry: Involute-Tooth Form, Interference Between Mating Spur Gear Teeth, Devising Gear Trains, Forces, Torque And Power In Gearing, Gear Manufacture, Gear Quality, Allowable Stress Numbers, Stresses In Gear Teeth, Selection Of Gear Material Based On Bending Stress, Design Of Spur Gears, Power-Transmitting Capacity, Practical Considerations For Gears And Interfaces With Other Elements. Forces and stresses on helical gear teeth, design of helical gears, bearing forces on shafts carrying bevel gears, bending moments on shafts carrying bevel gears, design of bevel gears for pitting resistance, forces, friction, and efficiency in worm gear sets, stress in worm gear teeth, surface durability of worm gear drives.	5
Unit - 2	
Chapter No. 4. KEYS, COUPLINGS, SEALS AND SHAFT DESIGNS Materials for keys, stress analysis to determine key length, other methods of fastening elements to shafts, couplings, universal joints, retaining rings and other means of axial location, types of seals, seal materials, shaft design procedure, forces exerted on shafts	5

by machine elements, stress concentrations in shafts, design stresses for shafts, shafts in bending and torsion only, shaft design example, recommended basic sizes for shafts, shaft rigidity and dynamic considerations, flexible shafts	
Chapter No. 5. LINEAR MOTION ELEMENTS, SPRINGS, FASTNERS Power screws, ball screws, application considerations for power screws and ball screws, bolt materials and strength, externally applied force on a bolted joint, thread stripping strength, other means of fastening and joining. Kinds of springs, helical compression springs, stresses and deflection for helical compression springs, analysis of spring characteristics, design of helical compression springs, helical torsion springs, improving spring performance by shot peening, spring manufacturing.	5
Chapter No. 6. CLUTCHES AND BRAKES Descriptions of clutches and brakes, types of friction clutches and brakes, performance parameters, time required accelerating a load, inertia of a system referred to the clutch shaft speed, effective inertia for bodies moving linearly, energy absorption: heat-dissipation requirements, response time, friction materials and coefficient of friction, plate-type clutch or brake.	5
Unit - 3	
Chapter No. 7. BEARINGS: ROLLING CONTACT & SURFACE CONTACT Types of rolling contact bearings, thrust bearings, mounted bearings, bearing materials, load/life relationship, design life, bearing selection: radial loads only, bearing selection: radial and thrust loads combined, mourning of bearings, tapered roller bearings, practical considerations in the application of bearings, importance of oil film thickness in bearings, life prediction under varying loads.	5
Chapter No. 8. MACHINE FRAMES, BOLTED CONNECTIONS AND WELDED JOINTS Machine frames and structures, recommended deflection limits, design to resist bending, design of members to resist torsion, eccentrically loaded bolted joints, types of joints, types of welds, size of weld, method of treating weld as a line, welded joints.	5

Text Book (List of books as mentioned in the approved syllabus)

1. Robert L. Norton, Machine Design, Pearson Education edition, Prentice Hall, 2005
2. Robert L. Mott, Machine Elements in Mechanical Design, Fourth edition, PEARSON Prentice Hall, 2004

References

1. Shigley J.E. and Mischke C.R, Mechanical Engineering Design, McGraw Hill Publication Co. Ltd
2. Michael F. Ashby, Materials Selection in Mechanical Design, Fourth Edition, 2014, 2014
3. Michael F. Ashby, Materials Selection in Mechanical Design, Fourth Edition, 2014, 2014

Evaluation Scheme

ISA Scheme

Assessment	**Weightage in Marks**
Design Study	25
Midterm Exam	25
Total	**50**

Course Unitization for ISA and ESA

Topics / Chapters	Teaching Hours	No. of Questions in Design Study	No. of Questions in Midterm Exam	Number of Questions in ESA
Unit I				
1. **The design process**	5	1	1	1
2. Material property charts, engineering materials, their properties and material selection	5	1	1	1
3. **Kinematics of gears and gear design**	5	1	1	1
Unit II				
4. Keys, couplings, seals and shaft designs	5	1	1	1
5. Linear motion elements, springs, fasteners	5	1	1	1
6. Clutches and brakes	5	1	1	1
Unit III				
7. Bearings: Rolling contact & surface contact	5	1	--	1
8. Machine frames, bolted connections and welded joints	5	1	--	1

Note

- Each Question carries 20 marks and may consist of sub-questions.
- Mixing of sub-questions from different chapters within a chapter (***only for Chapter I and Chapter II***) is allowed in midterm and ESA.
- Answer 5 full questions of 20 marks each (***two full questions from Chapter I, Chapter II, and 1 full question from Chapter III***) out of 8 in ESA.

Course Assessment Plan

Course Title: Machine Design		Code: 18EARC206		
Course outcomes (COs)	Weightage in assessment	Assessment Methods		
		Design Study	Midterm Exam	ESA
Apply the knowledge of process of materials selection and be able to make decisions on materials selection for engineering applications.	25%	✓	✓	✓
Analyze shafts, keys, spur, helical, bevel and worm gears under strength and wear considerations.	15%	✓	✓	✓
Differentiate the helical and leaf springs, clutch and brakes based on parametric design to meet the design specifications.	15%	✓	✓	✓
Analyze rolling contact bearings, machine frames, bolted connections and welded joints and its selection from manufacturer's catalogue.	15%	✓	✓	✓
Select a suitable product, check the specifications of the mechanical components given by the manufacturer and determine the new components that can be used to replace the existing components and reflect on the effectiveness of the design methodology applied.	30%	✓	✓	✓
Weightage		25%	25%	50%

Date: 21-02-2022

Head of Department

Chapter wise Plan
Unit - I

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **1. THE DESIGN PROCESS**	Planned Hours: **5hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Discuss the various types of design.	1	L2	1.3
2. Explain the different steps involved in the design process and role played by the materials.	1	L2	1.3
3. Discuss the role of function, shape and process in material selection	1	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction, Materials in Design
2. The Evolution of Engineering Materials
3. The Evolution of Materials in Products,
4. The Design Process, Types of Design
5. Design Tools and Materials Data, Function, Material, Shape, and Process

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Describe in detail the various types of design.	1	L2	1.3.1
2. Explain the various steps involved in the design process with the flow chart.	2	L2	1.3.1
3. Explain how design data and material data play an important role in design process	2	L2	1.3.1
4. Explain how the function, shape, and process are important in the selection of the material.	3	L2	1.3.1

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **2. ENGINEERING MATERIALS AND THEIR PROPERTIES**; **MATERIAL PROPERTY CHARTS**	Planned Hours: **5hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Discuss the classification of materials.	1	L2	1.3
2. Discuss the factors to be considered for the selection of materials for design of machine elements.	1	L2	1.3
3. Explain the different types of engineering material properties.	1	L2	1.3
4. Indentify the SI units of the material properties.	1	L1	1.3
5. Apply the material property to explore and plot material property chart.	1	L3	1.3
6. Discuss various types of property charts or graph.	1	L3	1.3
7. Select the materials from the property chart or graph.	1	L4	2.2

Lesson Schedule Class No. - Portion covered per hour
6. Exploring Material Properties, modulus–density chart
7. strength–density chart, modulus–strength chart
8. maximum service temperature chart, Cost bar charts
9. The modulus–relative cost chart, The strength–relative cost chart
10. The Families of Engineering Materials, Materials Information for Design, Material Properties and 4. Units

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Classify the materials of engineering into the six broad families.	1	L2	1.3.1
2. What are the factors to be considered for the selection of materials for the design of machine elements?	2	L2	1.3.1
3. Explain the terms : (i)Strength (ii) hardness iii) Elasticity	3	L2	1.3.1
4. Explain the terms : (i)Toughness (ii) endurance limit	3	L2	1.3.1
5. List out the basic design – limiting material properties under general, mechanical, Thermal, Electrical, Optical and Eco properties	3	L2	1.3.1
6. Identify the SI units of material properties as shown below: Density Price Elastic moduli (Young's, shear, bulk) Tensile (ultimate) strength Yield strength Compressive strength Failure strength Hardness Elongation Fatigue endurance limit Fracture toughness Toughness Loss coefficient (damping capacity) Wear rate (Archard) constant Melting point Maximum service temperature Glass temperature Minimum service temperature Thermal conductivity Specific heat Thermal expansion coefficient Thermal shock resistance Electrical resistivity Dielectric constant Breakdown potential Power factor Refractive index Embodied energy Carbon footprint	4	L2	1.3.1
7. Plot Young's modulus E is plotted against the density ρ and show the different material class.	5	L4	2.2.1
8. From the chart given below: Illustrate the class of metallic alloy, which is the lightest? Which is the heaviest? Which is the stiffest? Which is the least stiff?	6	L4	2.2.1
9. A metal is needed in which longitudinal waves travel at 300 m/s. Use Figure to identify.	7	L4	2.2.1
10. Select any two applications that, in your judgment, need high stiffness and low weight.	7	L4	2.2.1
11. Analyze strategic thinking associated with matching materials to design.	7	L4	2.2.1

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **3. KINEMATICS OF GEARS AND GEAR DESIGN**	Planned Hours: **5hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Sr.No	TLO's	CO's	B L	CA Code
1	Involute tooth is different from cycloid tooth with respect to geometry, describe how it is different.	2	L2	1.3
2	Interpret the important operating characteristics of various types of gears with regard to the similarities and differences among them and their general advantages and disadvantages.	2	L2	1.3
3	Analyze the contact stresses exerted on the surfaces of the teeth to cause pitting of the teeth.	2	L4	2.2
4	Evaluate the technical aspect of spur gear.	2	L4	2.2

Lesson Schedule *Class No. - Portion covered per hour*
11. Spur gear geometry: Involute-tooth form, interference between mating spur gear teeth
12. Devising gear trains, forces, torque and power in gearing, gear manufacture
13. Gear quality, allowable stress numbers
14. Stresses in gear teeth, selection of gear material based on bending stress
15. Design of spur gears, Power-transmitting capacity, Practical considerations for gears and interfaces with other elements.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Comment on construction of Involute tooth profile. Support your answer with neat sketches.	1	L2	1.3.1
2	A helical gear has a transverse diametral pitch of 12, a transverse pressure angle of 14°, 28 teeth, a face width of 1.25 in. and a helix angle of 30°. Solve circular pitch, normal circular pitch, normal diametral pitch, axial pitch, pitch diameter, and the normal pressure angle. Determine the number of axial pitches in the face width.	2	L4	2.2.1
3	Different factors that effects the growth of contact stresses exerted on the surfaces of the teeth to cause pitting, interpret with your answer.	3	L4	2.2.1
4	Design a pair of spur gears to be used as a part of the drive for a chipper to prepare pulpwood for u.se in a paper mill. Intermittent use is expected. An electric motor transmits 3.0 horsepower to the pinion at 1750 rpm and the gear must rotate between 460 rpm and 465 rpm. A compact design is desired.	4	L4	2.2.1
5	Illustrate the values for the geometrical features for a pair of straight bevel gears having a diametral pitch of 8, a 20° pressure angle, 16 teeth in the pinion, and 48 teeth in the gear. The shafts are at 90°.	4	L4	2.2.1
6	The following particulars of a single reduction spur gear are given: Gear ratio=10:1; Distance between centres=660mm approximately; Pinion transmits 50 kW at 1800 r.p.m.; Involute teeth of standard proportions (addendum=m) with pressure angle of 22.5°; Permissible normal pressure between teeth=175 N per mm of width. Evaluate: 1. The nearest standard module if no interference is to occur; 2. The number of teeth on each wheel; 3. The necessary width of the pinion; and 4. The load on the bearings of the wheels due to power transmitted.	4	L4	2.2.1

7	A bronze spur pinion rotating at 600 r.p.m. drives a cast iron spur gear at a transmission ratio of 4:1. The allowable static stresses for the bronze pinion and cast iron gear are 84 MPa and 105 MPa respectively. The pinion has 16 standard 20° full depth involute teeth of module 8 mm. The face width of both the gears is 90 mm. Evaluate the power that can be transmitted from the standpoint of strength.	4	L4	2.2.1
8	A pair of straight teeth spur gears is to transmit 20 kW when the pinion rotates at 300 rpm. The velocity ratio is 1: 3. The allowable static stresses for the pinion and gear materials are 120 MPa and 100 MPa respectively. The pinion has 15 teeth and its face width is 14 times the module. Illustrate: 1. module; 2. face width; and 3. pitch circle diameters of both the pinion and the gear from the standpoint of strength only, taking into consideration the effect of the dynamic loading.	4	L4	2.2.1
9	A gear drive is required to transmit a maximum power of 22.5 kW. The velocity ratio is 1:2 and rpm of the pinion is 200. The approximate centre distance between the shafts may be taken as 600 mm. The tooth has 20° stub involute profiles. The static stress for the gear material (which is cast iron) may be taken as 60 MPa and face width as 10 times the module. Solve the module, face width and number of teeth on each gear. Check the design for dynamic and wear loads. The deformation or dynamic factor in the Buckingham equation may be taken as 80 and the material combination factor for the wear as 1.4.	4	L4	2.2.1
10	A reciprocating compressor is to be connected to an electric motor with the help of spur gears. The distance between the shafts is to be 500 mm. The speed of the electric motor is 900 r.p.m. and the speed of the compressor shaft is desired to be 200 r.p.m. The torque, to be transmitted is 5000 N-m. Taking starting torque as 25% more than the normal torque, Examine: 1. Module and face width of the gears using 20 degrees stub teeth, and 2. Number of teeth and pitch circle diameter of each gear. Assume suitable values of velocity factor and Lewis factor.	4	L4	2.2.1

Unit - II

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **4. KEYS, COUPLINGS, SEALS AND SHAFT DESIGNS**	Planned Hours: **5hrs**

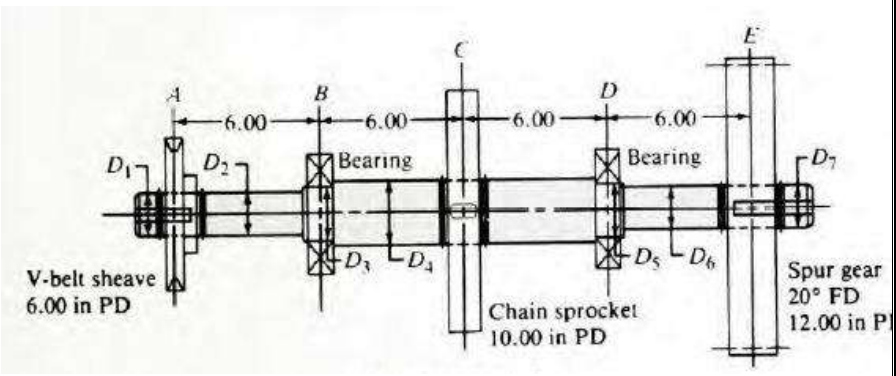
Learning Outcomes:-

At the end of the topic the student should be able to:

Sr.No	TLO's	CO's	B L	PI Code
1	Explain the importance of keys in couplings.	2	L4	2.2
2	Pin keys are different from woodruff keys, discuss with your answer.	2	L2	1.3
3	Differentiate the several alternate methods of fastening machine elements to shafts.	2	L4	2.2
4	Analyze the shafts technically by considering various parameters like stress, deflection, torsion and so on.	2	L4	2.2

Lesson Schedule *Class No. - Portion covered per hour*
16. Materials for keys, stress analysis to determine key length
17. Other methods of fastening elements to shafts
18. Couplings, universal joints, retaining rings and other means of axial location
19. Types of seals, seal materials, shaft design procedure, forces exerted on shafts by machine elements, stress concentrations in shafts
20. Design stresses for shafts, shafts in bending and torsion only, Shaft design example, recommended basic sizes for shafts, Shaft rigidity and dynamic considerations, flexible shafts

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Describe different kinds of keys used in shafts.	1	L2	1.3.1
2	Pin keys are only used in couplings, interpret with your answer.	2	L3	1.3.1
3	Analyze the importance of fasteners in manufacturing's industries.	3	L4	2.2.1
4	Shaft shown in figure receives 110 hp from a water turbine through a chain sprocket at point C. The gear pair at E delivers 80 hp to an electrical generator. The V-belt sheave at A delivers 30 hp to a bucket elevator that carries grain to an elevated hopper. The shaft rotates at 1700 rpm. The sprocket, sheave, and gear are located axially by retaining rings. The sheave and gear are keyed with sled runner key seats, and there is a profile key seat at the sprocket. Use AISI 1040 cold-drawn steel for the shaft. Examine the minimum acceptable diameters D through D-, as defined in Figure below. 	4	L4	2.2.1
5	A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10 000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 700 MPa and an ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, Evaluate the diameter of the shaft.	4	L4	2.2.1
6	A shaft supported at the ends in ball bearings carries a straight tooth spur gear at its mid span and is to transmit 7.5 kW at 300 r.p.m. The pitch circle diameter of the gear is 150 mm. The distances between the centre line of bearings and gear are 100 mm each. If the shaft is made of steel and the allowable shear stress is 45 MPa, Evaluate the diameter of the shaft. Show in a sketch how the gear will be	4	L4	2.2.1

	mounted on the shaft; also indicate the ends where the bearings will be mounted? The pressure angle of the gear may be taken as 20°.			
7	A shaft made of mild steel is required to transmit 100 kW at 300 r.p.m. The supported length of the shaft is 3 metres. It carries two pulleys each weighing 1500 N supported at a distance of 1 metre from the ends respectively. Assuming the safe value of stress, Evaluate the diameter of the shaft.	4	L4	2.2.1
8	A shaft is supported by two bearings placed 1 m apart. A 600 mm diameter pulley is mounted at a distance of 300 mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25 kN. Another pulley 400 mm diameter is placed 200 mm to the left of right hand bearing and is driven with the help of electric motor and belt, which is placed horizontally to the right. The angle of contact for both the pulleys is 180° and μ = 0.24. Evaluate the suitable diameter for a solid shaft, allowing working stress of 63 MPa in tension and 42 MPa in shear for the material of shaft. Assume that the torque on one pulley is equal to that on the other pulley.	4	L4	2.2.1
9	A shaft is supported on bearings A and B, 800 mm between centres. A 20° straight tooth spur gear having 600 mm pitch diameter, is located 200 mm to the right of the left hand bearing A, and a 700 mm diameter pulley is mounted 250 mm towards the left of bearing B. The gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 180° angle of wrap. The pulley also serves as a flywheel and weighs 2000 N. The maximum belt tension is 3000 N and the tension ratio is 3:1. Determine the maximum bending moment and the necessary shaft diameter if the allowable shear stress of the material is 40 MPa.	4	L4	2.2.1
10	A steel solid shaft transmitting 15 kW at 200 r.p.m. is supported on two bearings 750 mm apart and has two gears keyed to it. The pinion having 30 teeth of 5 mm module is located 100 mm to the left of the right hand bearing and delivers power horizontally to the right. The gear having 100 teeth of 5 mm module is located 150 mm to the right of the left hand bearing and receives power in a vertical direction from below. Using an allowable stress of 54 MPa in shear, Evaluate the diameter of the shaft.	4	L4	2.2.1

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **5. LINEAR MOTION ELEMENTS, SPRINGS, FASTNERS**	Planned Hours: **5hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Sr.No	TLO's	CO's	B L	PI Code
1	Describe the operation of a power screw and the general form of square threads, Acme threads, and buttress threads as they are applied to power screws	3	L2	1.3
2	Describe a bolt in comparison with a machine screw	3	L2	1.3
3	Sheet-metal screws are preferred over lag screws in sheet metal work. Describe in brief.	3	L2	1.3
4	Design linear motion elements / springs for withstanding properties like compression / tensile strength when subjected to various types of loading.	3	L4	3.1

Lesson Schedule *Class No. - Portion covered per hour*
21. Power screws, ball screws, application considerations for power screws and ball screws.
22. Bolt materials and strength, externally applied force on a bolted joint.
23. Thread stripping strength, other means of fastening and joining, Kinds of springs, helical compression springs.
24. Stresses and deflection for helical compression springs, Analysis of spring characteristics, design of helical compression springs.
25. Helical torsion springs, improving spring performance by shot peening, spring manufacturing.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Describe power screws and ball screws based upon their application.	1	L2	1.3.1
3	Explain the different methods of bolt tightening.	2	L2	1.3.1
4	Distinguish between sheet-metal screws and lag screws.	3	L2	1.3.1
5	A helical compression spring is to exert a force of 8.0 KN when compressed to a length of 175 mm. At a length of 125 mm, the force must be 2kg. The spring will be installed in a machine that cycles slowly, and approximately 200 000 cycles total are expected. The temperature will not exceed 200°C. The spring will be installed in a hole having a diameter of 10mm. For this application, specify a suitable material, wire diameter, mean diameter, OD, ID, free length, solid length, number of coils, and type of end condition. Analyze the stress at the maximum operating load and at the solid length condition. The first of two solution procedures will be shown. The numbered steps can be used as a guide for future problems and as a kind of algorithm for the spreadsheet approach that follows the manual solution.	4	L4	3.1.6
6	Helical spring is made from a wire of 6 mm diameter and has outside diameter of 75 mm. If the permissible shear stress is 350 MPa and modulus of rigidity 84 kN/mm^2, evaluate the axial load which the spring can carry and the deflection per active turn	4	L4	3.1.6
7	Design a spring for a balance to measure 0 to 1000 N over a scale of length 80 mm. The spring is to be enclosed in a casing of 25 mm diameter. The approximate number of turns is 30. The modulus of rigidity is 85 kN/mm^2. Also calculate the maximum shear stress induced.	4	L4	3.1.6
8	Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity, G = 84 kN/mm^2. Neglect the effect of stress concentration. Draw a fully dimensioned sketch of the spring, showing details of the finish of the end coils.	4	L4	3.1.6

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **6. CLUTCHES AND BRAKES**	Planned Hours: **5hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Sl.No	TLO's	CO's	B L	PI Code
1	Discuss the mechanism of clutch coupling.	3	L2	1.3
2	Discuss the working clutch and brake module.	3	L2	1.3
3	Name the different types of clutches and brakes. Describe with the help of neat sketches the working principles of two different types of clutches and brakes.	3	L2	1.3
4	A weight is brought to rest by applying brakes to the hoisting drum driven by an electric motor. How will you estimate the total energy absorbed by the brake.	3	L4	3.1
5	Describe, with the help of a neat sketch, a centrifugal clutch and deduce an expression for the total frictional torque transmitted. Analyze how the shoes and springs are designed for such a clutch.	3	L4	3.1
6	Design Clutch / Brake technically for practical applications	3	L4	3.1

Lesson Schedule *Class No. - Portion covered per hour*
26. Descriptions of clutches and brakes
27. Types of friction clutches and brakes, performance parameters
28. Time required accelerating a load, inertia of a system referred to the clutch shaft speed
29. Effective inertia for bodies moving linearly, Energy absorption: heat-dissipation requirements
30. Response time, friction materials and coefficient of friction, Plate-type clutch or brake.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Describe mechanism of clutch coupling.	1	L2	1.3.1
2	Explain clutch module with example.	2	L2	1.3.1
3	Describe with the help of neat sketches the working principles of two different types of clutches and brakes.	3	L2	3.1.6
4	A weight is brought to rest by applying brakes to the hoisting drum driven by an electric motor. Describe how you will estimate the total energy absorbed by the brake.	4	L2	3.1.6
4	The conveyor moves at 80 ft/min, the combined weight of the belt and the parts on it is 140 lb. Solve the equivalent inertia for the conveyor referred to the shaft driving the belt.	5	L4	3.1.6
6	A plate clutch having a single driving plate with contact surfaces on each side is required to transmit 110 kW at 1250 rpm. The outer diameter of the contact surfaces is to be 300 mm. The coefficient of friction is 0.4. (a) Assuming a uniform pressure of 0.17 N/mm2; determine the inner diameter of the friction surfaces. (b) Assuming the same dimensions and the same total axial thrust; evaluate the maximum torque that can be transmitted and the maximum intensity of pressure when uniform wear conditions have been reached.	6	L4	3.1.6
7	A dry single plate clutch is to be designed for an automotive vehicle whose engine is rated to give 100 kW at 2400 rpm and maximum torque 500 N-m. The outer radius of the friction plate is 25% more than the inner radius. The intensity of pressure between the plates is not to exceed 0.07 N/mm2. The coefficient of friction may be assumed equal to 0.3. The helical springs required by this clutch to provide axial force necessary to engage the clutch are eight. If each spring has stiffness equal to 40 N/mm, evaluate the dimensions of the friction plate and initial compression in the springs.	6	L4	3.1.6

8	A single dry plate clutch is to be designed to transmit 7.5 kW at 900 rpm. Evaluate: 1. Diameter of the shaft, 2. Mean radius and face width of the friction lining assuming the ratio of the mean radius to the face width as 4, 3. Outer and inner radii of the clutch plate, and 4. Dimensions of the spring, assuming that the number of springs are 6 and spring index = 6. The allowable shear stress for the spring wire may be taken as 420 MPa.	6	L4	3.1.6
9	The diameter of the drum is 250 mm and the angle of contact is 90°. If the operating force of 700 N is applied at the end of a lever and the coefficient of friction between the drum and the lining is 0.35, evaluate the torque that may be transmitted by the block brake	6	L4	3.1.6
10	A rope drum of an elevator having 650 mm diameter is fitted with a brake drum of 1 m diameter. The brake drum is provided with four cast iron brake shoes each subtending an angle of 45°. The mass of the elevator when loaded is 2000 kg and moves with a speed of 2.5 m / s. The brake has a sufficient capacity to stop the elevator in 2.75 metres. Assuming the coefficient of friction between the brake drum and shoes as 0.2. Evaluate: 1. width of the shoe, if the allowable pressure on the brake shoe is limited to 0.3 N/mm^2; and 2. heat generated in stopping the elevator.	6	L4	3.1.6

Unit - III

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **7. BEARINGS: ROLLING CONTACT & SURFACE CONTACT**	Planned Hours: **5hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Sr.No	TLO’s	CO’s	B L	PI Code
1	Identify the types of rolling contact bearings that are commercially available, and select the appropriate type for a given application, considering the manner of loading and installation conditions.	4	L2	1.3
2	Describe several types of commercially available mounted bearings and their application to machine design.	4	L2	1.3
3	Understand certain practical considerations involved in the application of bearings, including lubrication, sealing, limiting speeds, bearing tolerance classes, and standards related to the manufacture and application of bearings.	4	L2	1.3
4	Illustrate the equivalent load on a bearing corresponding to combinations of radial and thrust loads applied to it.	4	L4	3.1

Lesson Schedule *Class No. - Portion covered per hour*
31. Types of rolling contact bearings
32. Bearing materials
33. Bearing selection: radial loads only
34. Mourning of bearings
35. Practical considerations in the application of bearings

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Explain important features of roller contact bearings.	1	L2	1.3.1
2	How actually thrust bearing and mounted bearing differ in their construction.	1	L2	1.3.1
3	Explain commercially used bearing materials.	2	L2	1.3.1
4	List and explain the practical considerations made in the designing of bearings.	3	L2	1.3.1
5	A catalogue lists the basic dynamic load rating for a ball bearing to be 7050 lb for a rated life of 1 million rev. Evaluate, what would be the expected life of the bearing if it were subjected to a load of 3500 lb.	4	L4	3.1.6
6	A full journal bearing of 50 mm diameter and 100 mm long has a bearing pressure of 1.4 N/mm^2. The speed of the journal is 900 r.p.m. and the ratio of journal diameter to the diametral clearance is 1000. The bearing is lubricated with oil whose absolute viscosity at the operating temperature of 75°C may be taken as 0.011 kg/m-s. The room temperature is 35°C. Evaluate: 1. The amount of artificial cooling required, and 2. The mass of the lubricating oil required, if the difference between the outlet and inlet temperature of the oil is 10°C. Take specific heat of the oil as 1850 J / kg / °C.	4	L4	3.1.6
7	A 150 mm diameter shaft supporting a load of 10 kN has a speed of 1500 rpm. The shaft runs in a bearing whose length is 1.5 times the shaft diameter. If the diametral clearance of the bearing is 0.15 mm and the absolute viscosity of the oil at the operating temperature is 0.011 kg/m-s, Evaluate the power wasted in friction.	4	L4	3.1.6
8	A 80 mm long journal bearing supports a load of 2800 N on a 50 mm diameter shaft. The bearing has a radial clearance of 0.05 mm and the viscosity of the oil is 0.021 kg / m-s at the operating temperature. If the bearing is capable of dissipating 80 J/s. Evaluate the maximum safe speed.	4	L4	3.1.6

Course Code and Title: **18EARC206 / Machine Design**	
Chapter Number and Title: **8. MACHINE FRAMES, BOLTED CONNECTIONS AND WELDED JOINTS**	Planned Hours: **5hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Sr.No	TLO's	CO's	B L	PI Code
1	Describe the principles of stress and deflection to get reasonable and efficient shape for a structure or frame and for the components involved.	4	L2	1.3
2	Specify different materials with justifications that are well suited to the demands of a given design, given certain conditions of load, environment, fabrication requirements, safety, and aesthetics.	4	L2	1.3
3	Design welded joints to carry many types of loading patterns like axial or radial.	4	L4	3.1

Lesson Schedule *Class No. - Portion covered per hour*
36. Machine frames and structures, recommended deflection limits
37. Design to resist bending, design of members to resist torsion
38. Eccentrically loaded bolted joints, types of joints, types of welds, size of weld
39. Method of treating weld as a line
40. Welded joints.

Review Questions

Sr.No	Questions	TO	B L	PI Code
1	Explain the major factors to be considered in starting a design project for a frame.	1	L2	1.3.1
2	Elaborate suggestions that are made for design of frames to resist bending.	2	L2	1.3.1
3	Explain types of welds which are most commonly used.	1	L2	1.3.1
4	Explain general procedure for designing welded joints.	2	L2	1.3.1
5	Design a bracket to the column, having bracket length 2m high and is made from ASTM A36 steel having a thickness of 6mm. The column is also made from A36 steel and is 8m in wide.	3	L4	3.1.6
6	A circular steel bar 50 mm diameter and 200 mm long is welded perpendicularly to a steel plate to form a cantilever to be loaded with 5 kN at the free end. Evaluate the size of the weld, assuming the allowable stress in the weld as 100 MPa.	3	L4	3.1.6
7	A 65 mm diameter solid shaft is to be welded to a flat plate by a fillet weld around the circumference of the shaft. Evaluate the size of the weld if the torque on the shaft is 3 kN-m. The allowable shear stress in the weld is 70 MPa.	3	L4	3.1.6
8	A 125 × 95 × 10 mm angle is joined to a frame by two parallel fillet welds along the edges of 150 mm leg. The angle is subjected to a tensile load of 180 kN. Evaluate the lengths of weld if the permissible static load per mm weld length is 430 N.	3	L4	3.1.6

Model Question Paper for ISA I					
Course Code: 18EARC206	Course Title: Machine Design				
Duration: 75 min	Max. Marks: 40				
Note: Answer any two full questions.					
Q.No	Questions	BL	CO	PI Code	Marks
1. a	Explain the nomenclature of spur gear tooth with the help of neat sketch.	L2	1	1.3.1	06
b	Explain the classifications of engineering materials with the help of flow chart.	L2	1	1.3.1	06
c	Select any two applications that, in your judgment, need high stiffness and low weight.	L4	1	2.2.1	08
2a	Problem: Design the spur-gear train using helical gears and compare their safety factors. Given: The kinematics, bending stresses, surface stresses, and safety factors for a 3-gear train with the following data: W_t=1780N (400lb), N_p=14, N_{idler}=17, N_g=49, $\phi=22^0$, p_d=8, F=67.7mm (2.667in), pinion speed=2200rpm and 15kW (20hp). The velocity factor K_v=0.66. Assumptions: The teeth are standard AGMA full-depth profiles. The load and source are both uniform in nature. A gear-quality index of 8 will be used. All gears are steel with v=0.28. The service life required is 5years of one shift operation. Operating temperature is 200^0F. Based on the assumption of uniform load and source, the application factor $K_a=C_a$ can be set to 1. The load distribution factor can be estimated based on the assumed face width: $K_m=C_m$=1.6. The idler factor K_I=1 for the pinion and gear and K_I=1.42 for	L4	2	2.2.1	20

	the idler gear. The size factor $K_s=C_s=1$ for all three gears. $C_f=1$. $K_B=1$. Keep the same ϕ and p_d as mentioned above and try a 24^0 helix angle. The elastic coefficient C_p is 2276 and the corrected bending-fatigue strength of the steel is $268895 kN/m^2$ ($S_{fb}=39kpsi$), and its corrected surface-fatigue strength is $723949 kN/m^2$ ($S_{fc}=105kpsi$). Also assume $J_{pinion}=0.51$, $J_{idler}=0.54$ & $J_{gear}=0.66$.				
3a	Analyze strategic thinking associated with matching materials to design.	L4	1	2.2.1	10
b	Problem: Determine the bending and surface stresses and safety factors in a straight bevel gearset made of the steel materials, and operating temperature is 180^0F, and 6-year of service life. Given: The corrected bending strength is 38937 psi and the surface strength is 118000 psi uncorrected and 105063 psi corrected. $N_p=20$, $N_g=35$, $\phi=24^0$, $p_d=6$, passing 12 hp at 2500 rpm. Assumptions: $K_a=C_a=K_s=C_s=C_f=C_H=C_R=C_T=1$, $K_m=C_m=1.6$, $K_v=C_v=0.652$, $C_L=0.890$, and $C_p=2276$. From this section assume: $C_{xc}=K_x=1$, $C_b=0.634$ $C_{md}=1.5$, $z=0.667$.	L4	2	2.2.1	10

Model Question Paper for ISA II					
Course Code: 18EARC206	Course Title: Machine Design				
Duration:75 min	Max. Marks: 40				
Note: Answer any two full questions.					
Q.No	Questions	BL	CO	PI Code	Marks
1a	Explain Centrifugal clutch with the help of neat sketch.	L2	3	1.3.1	10
1b	Problem: Determine a suitable size and required force for an axial disk clutch. Given: The clutch must pass 5.6kW (7.5hp) at 1750rpm with a service factor of 2. Assumptions: Use a uniform-wear model. Assume a single dry disk with a molded lining.	L4	3	3.1.6	10
2a	Problem Design a shaft to support the attachment shown in Figure 1 with a minimum design safety factor of 2. Given A preliminary design of the shaft configuration is shown in figure 1. It must transmit 1.5kW (2hp) at 1700rpm.The torque and the force on the gear are both constant with time. Assumptions There are no applied axial loads. Steel will be used for infinite life. Assume a stress-concentration factor of 3.5 for the step radii in bending, 2 for step radii in torsion, and 4 at the keyways. Since the torque is steady and the bending moment fully reversed, the ASME method of equation can be used. Select trial material to be an inexpensive, low-carbon, cold-rolled such as SAE 1020 with S_{ut}=448159kN/m^2 (65kpsi), S_y=262000kN/m^2 (38kpsi) and	L4	2	2.2.1	20

	S_f=188226 kN/m^2 (27.3kpsi). Assume notch radius as 2.54m (0.01in).				
3a	Problem: Design a compression spring for a static load over a known deflection. Given: The spring must give a minimum force of 445N (100 lb) and a maximum force of 667N (150 lb) over an adjustment range of 19mm (0.75 in) deflection. Assumptions: Use the least expensive, unpeened, music wire (spring wire) (ASTM A228) since the loads are static. Take G=80E6kN/m^2 (11.5E6 lb/in^2) and ρ=0.28. Assume a trial wire diameter of 4mm (0.148 in) from available sizes and spring index of 8. Try increasing the wire diameter slightly, perhaps to 5mm (0.207in). Assume plain ground ends and also clash allowance of 20% of the working deflection.	L4	3	3.1.6	20

Question Paper Title: Model Question Paper for End Semester Assessment		
Total Duration (H:M):03:00	**Course :Machine Design (18EARC206)**	**Maximum Marks :100**
Note: Use of design data handbook is permitted. These questions are just for reference purpose only. Actual questions will differ in content, pattern, difficulty level, etc.		

Unit I

		BL	CO	PI	Marks
Q1:a)	Explain the nomenclature of spur gear tooth with the help of neat sketch.	L2	1	1.3.1	06
b)	Explain the classifications of engineering materials with the help of flow chart.	L2	1	1.3.1	06
c)	Select any two applications that, in your judgment, need high stiffness and low weight.	L4	1	2.2.1	08
Q2:a)	Problem: Design the spur-gear train using helical gears and compare their safety factors. Given: The kinematics, bending stresses, surface stresses, and safety factors for a 3-gear train with the following data: W_t=1780N (400lb), N_p=14, N_{idler}=17, N_g=49, $\phi=22^0$, p_d=8, F=67.7mm (2.667in), pinion speed=2200rpm and 15kW (20hp). The velocity factor K_v=0.66. Assumptions: The teeth are standard AGMA full-depth profiles. The load and source are both uniform in nature. A gear-quality index of 8 will be used. All gears are steel with v=0.28. The service life required is 5years of one shift operation. Operating temperature is 200^0F. Based on the assumption of uniform load and source, the application factor $K_a=C_a$ can be set to 1. The load distribution factor can be estimated based on the assumed face width: $K_m=C_m$=1.6. The idler factor K_I=1 for the pinion and gear and K_I=1.42 for the idler gear. The size factor $K_s=C_s$=1 for all three gears. C_f=1. K_B=1. Keep the same ϕ and p_d as mentioned above and try a 24^0 helix angle. The elastic coefficient C_p is 2276 and the corrected bending-fatigue strength of the steel is 268895kN/m^2 (S_{fb}=39kpsi), and its corrected surface-fatigue strength is 723949kN/m^2 (S_{fc}=105kpsi). Also assume J_{pinion}=0.51,	L4	2	2.2.1	20

	$J_{idler}=0.54$ & $J_{gear}=0.66$.				
Q3:a)	Analyze strategic thinking associated with matching materials to design.	L4	1	2.2.1	10
b)	Problem: Determine the bending and surface stresses and safety factors in a straight bevel gearset made of the steel materials, and operating temperature is 180^0F, and 6-year of service life. Given: The corrected bending strength is 38937 psi and the surface strength is 118000 psi uncorrected and 105063 psi corrected. $N_p=20$, $N_g=35$, $\phi=24^0$, $p_d=6$, passing 12 hp at 2500 rpm. Assumptions: $K_a=C_a=K_s=C_s=C_f=C_H=C_R=C_T=1$, $K_m=C_m=1.6$, $K_v=C_v=0.652$, $C_L=0.890$, and $C_p=2276$. From this section assume: $C_{xc}=K_x=1$, $C_b=0.634$ $C_{md}=1.5$, $z=0.667$.	L4	2	2.2.1	10
Unit II					
Q4:a)	Explain Centrifugal clutch with the help of neat sketch.	L2	3	3.1.6	10
b)	Problem: Determine a suitable size and required force for an axial disk clutch. Given: The clutch must pass 5.6kW (7.5hp) at 1750rpm with a service factor of 2. Assumptions: Use a uniform-wear model. Assume a single dry disk with a molded lining.	L4	3	3.1.6	10
Q5:a)	Problem Design a shaft to support the attachment shown in Figure 1 with a minimum design safety factor of 2. Given A preliminary design of the shaft configuration is shown in figure 1. It must transmit 1.5kW (2hp) at 1700rpm.The torque and the force on the gear are both constant with time. Assumptions There are no applied axial loads. Steel will be used for infinite life. Assume a stress-concentration factor of 3.5 for the step radii in bending, 2 for step radii in torsion, and 4 at the keyways. Since the torque is steady and the bending moment fully reversed, the ASME method of equation can be used. Select trial material to be an inexpensive, low-carbon, cold-rolled such as SAE 1020 with	L4	2	2.2.1	20

	S_{ut}=448159kN/m^2 (65kpsi), S_y=262000kN/m^2 (38kpsi) and S_f=188226 kN/m^2 (27.3kpsi). Assume notch radius as 2.54m (0.01in).				
Q6.a)	Problem: Design a compression spring for a static load over a known deflection. Given: The spring must give a minimum force of 445N (100 lb) and a maximum force of 667N (150 lb) over an adjustment range of 19mm (0.75 in) deflection. Assumptions: Use the least expensive, unpeened, music wire (spring wire) (ASTM A228) since the loads are static. Take G=80E6kN/m^2 (11.5E6 lb/in^2) and ρ=0.28. Assume a trial wire diameter of 4mm (0.148 in) from available sizes and spring index of 8. Try increasing the wire diameter slightly, perhaps to 5mm (0.207in). Assume plain ground ends and also clash allowance of 20% of the working deflection.	L4	3	3.1.6	20
	Unit III				
Q7:a)	Problems: Design sleeve bearings to replace the rolling element bearings on the shaft shown in Figure 1. Given: The maximum transverse loads on the shaft at the bearings are 72N (16 lb) at R_1 and 240N (54 lb). Since the load at R_2 is 4x that at R_1, one design can be created for R_2 and used also at R_1. Shaft diameters at R_1 and R_2 are 0.015m (0.591 in). The shaft speed is 1800rpm.The bearings are stationary. Assumptions: Use a clearance ratio of 0.0017 and an *l/d* ratio of 0.75. Keep the Ocvirk number at 30 or below, preferably about 25 (O_N=24). Use e=0.00037 Compute: The bearing eccentricity ratio, maximum pressure and its location, minimum film thickness, coefficient of friction, torque, and power lost in bearing. Choose a suitable lubricant to operate at 200^{0}F.	L4	4	3.1.6	20
Q8:a)	Problem: Determine a suitable bolt size and preload for the joint shown in figure 2. Find its safety factor against yielding and separation. Determine the optimum preload as a percentage of proof strength to maximize the safety factors. Given: The joint dimensions are D=25.4mm (1in) and *l*=50.8mm (2in). The applied load P=8896N (2000lb).	L4	4	3.1.6	20

<table>
<tr><td></td><td>Assumptions: Both of the clamped parts are steel. The effects of the flanges on the joint stiffness will be ignored. A preload of 85% of the bolt’s proof strength will be applied as a first trial.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>

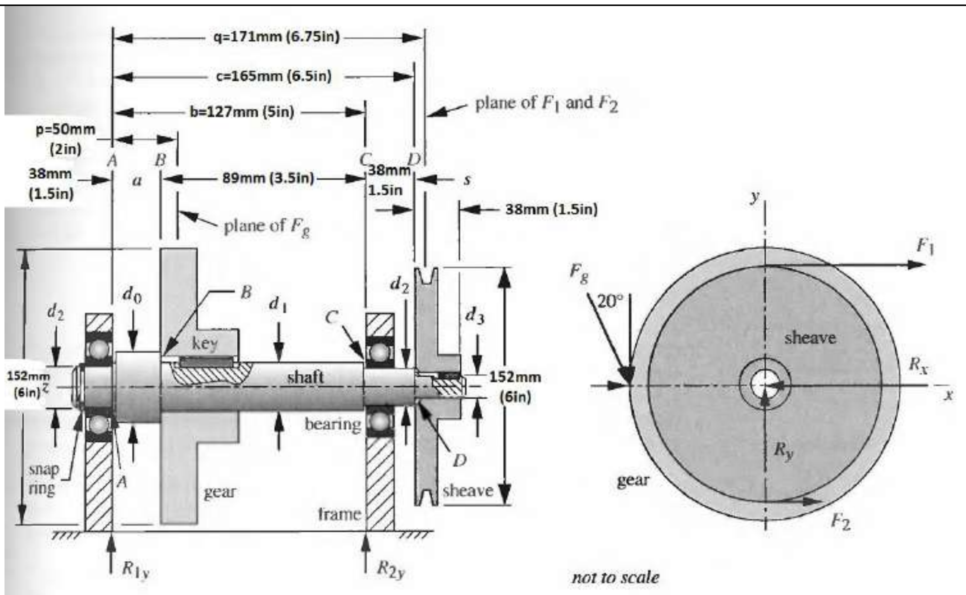


Figure 1.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>

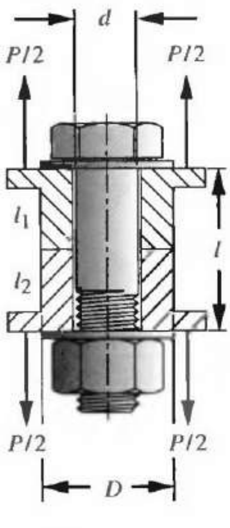


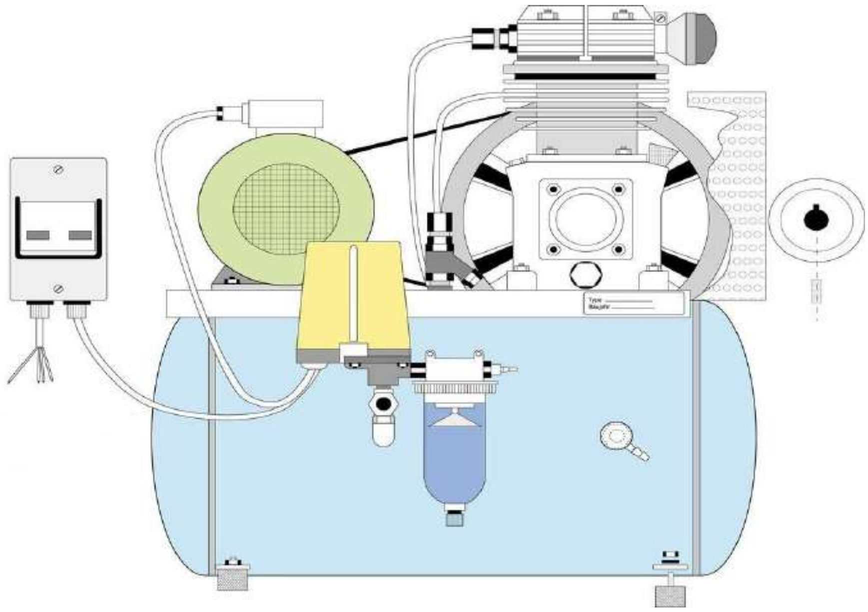
Figure 2.</td><td></td><td></td><td></td><td></td></tr>
</table>

Design Study:

Problem: Select an air compressor from any manufacturer which has the electric motor driving the compressor by a belt drive system and design a new drive system involving a gear box to replace the existing drive system.

Given: The toque-time function on the output shaft is as shown. The required gear ratio is a 2.5:1 reduction in velocity from the input to the output shaft. Out shaft velocity is 1500rpm. The compressor bore is 80mm diameter. The head thickness at the attachment points is 10mm.

Assumptions: Try an input gear (pinion) diameter of 102mm and output gear diameter of 254mm, both of 51mm thickness and 200 pressure angle. Ball bearings of standard diameters will be used on all shafts. A 10years life of 1 shift operation is desired. AGMA standard full depth teeth will be used. The pinion and gear will be through hardened steel. Use standard hex-head cap screws without washers. The operating temperature is less than 350^0F. Use 99.9% reliability.



Model	Tank (Lt.)	Displacement L/min cfm	Motor	RPM	Volt	Max pressure bar psi	Dimension Size	Weight (Kg)
N50/AB360/2	50	350 - 12.4	2HP	1200	220	9 / 131	900 300 690	49
N100/E2.8/2	100	241 - 8.5	2HP	1200	220	9 / 131	1150 350 770	64
N100/E3/3	100	315 - 11.1	3HP	1200	220	9 / 131	1150 350 770	69
N150/E2.8/2	150	241 - 8.5	2HP	1200	220	9 / 131	1330 400 830	78
N150/E3/2	150	315 - 11.1	2HP	1200	220	9 / 131	1330 400 830	81
N150/AB360/3	150	350 - 12.4	3HP	1200	220	9 / 131	1330 400 830	83
N200/E3/2	200	315 - 11.1	2HP	1200	220	9 / 131	1470 430 920	97
N200/E3/3	200	315 - 11.1	3HP	1200	220	9 / 131	1470 430 920	99
N200/AB360/2	200	350 - 12.4	2HP	1200	220	9 / 131	1470 430 920	99
N300/E3/3	300	315 - 11.1	3HP	1200	220	9 / 131	1680 500 1060	129
N300/E4/3	300	481 - 16.9	3HP	1200	220	9 / 131	1680 500 1060	130
N300/E4/4	300	481 - 16.9	4HP	1200	380	9 / 131	1680 500 1060	133
N300/AB360/3	300	350 - 12.4	3HP	1200	380	9 / 131	1680 500 1060	131

B. V. Bhoomaraddi College Campus, Vidyanagar, Hubballi - 580031. Karnataka (India)
DEPARTMENT OF AUTOMATION AND ROBOTICS

Course Plan

FMTH0301/Rev.5.3

Semester: IV | Year: 2021

Course Title: Microcontrollers Programming & Interfacing	Course Code: 18EARC208
Total Contact Hours: 50 Hours	Duration of ESA: 3 Hours
ISA Marks: 50	ESA Marks: 50
Lesson Plan Author: Shridhar T Doddamani	Date: 05/03/21
Checked By: Rakesh P. Tapaskar	Date: 06/03/21

Prerequisites

C-Programming, ADC.

Course Outcomes (COs):

At the end of the course student will be able to:

i. Differentiate microprocessors from microcontrollers.
ii. Code PIC with assembly and C language instructions to create loops, handle ports for input and output, create time delay and perform arithmetic and logical operation.
iii. Describe various modes of the PIC timers and serial communication by programming in assembly and C language to transmit and receive messages.
iv. Code PIC for interrupt based serial communication using assembly and C language.
v. Describe ADC, DAC and sensor interfacing.
vi. Explain the functions and capabilities of STM MCUs.
vii. Program STM32 to control flow of instructions using Interrupts and Timers.

KLE TECH. KLE Technological University
Creating Value
Leveraging Knowledge

B. V. Bhoomaraddi College Campus, Vidyanagar, Hubballi - 580031. Karnataka (India)
DEPARTMENT OF AUTOMATION AND ROBOTICS

Course Articulation Matrix: Mapping of Course Learning Outcomes (CLO) with Program outcomes

Course Title: Microcontrollers Programming & Interfacing   Course code: 18EARC208   Semester: IV   Year: 2021

Course Learning Outcomes-CLO	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Compare and contrast microprocessors and microcontrollers.	H				L									
2. Code PIC with assembly and C language instructions to create loops, handle ports for input and output, create time delay and perform arithmetic and logical operation.	H				M									
3. Describe various modes of the PIC timers and serial communication by programming in assembly and C language to transmit and receive messages	M													
4. Code PIC for interrupt based serial communication using assembly and C language.	H				M									
5. Describe ADC, DAC and sensor interfacing.	H				L									
6. Compare various types of high end processors like 80386 and 80486.	H				M									
7. Explain the functions and capabilities of STM MCUs.	M				L									
8. Program STM32 to control flow using Interrupts and Timers.							M							

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 - Demonstrate the competence in mathematical modelling.	1.1.2 - Apply discipline specific advanced mathematical techniques to modeling and problem solving
1.2 - Demonstrate the competence in basic sciences	1.2.2 - Apply laws of Maxwellian physics to solve problems
1.3 - Demonstrate competence in engineering fundamentals	1.3.1 - Apply elements of mechanical engineering principles and laws to solve problems
	1.3.2- Apply basic electrical and electronics engineering principles and laws to solve problems
	1.3.3 - Apply computer programming skills to solve problems by building algorithm, flow charts and debugging.
5.1 Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1 - Identify modern engineering tools, techniques and resources for engineering activities
10.2 - Demonstrate competence in listening, speaking, and presentation	10.2.2 - Deliver effective oral presentations to technical and non-technical audiences

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: 18EARC208	Course Title: Microcontrollers Programming & Interfacing		
L-T-P-**SS**: **4-0-0-0**	Credits:4	Contact Hrs: 4	
ISA Marks: 50	ESA Marks: 50	Total Marks: 100	
Teaching Hrs: 50		Exam Duration: 100	

Unit I		
No	**Content**	**Hrs**
1	**Chapter 1: Introduction to Microcontroller** Introduction To Microprocessor and Microcontroller: History and Evolution, types of microprocessors, Difference between Microprocessors and Microcontrollers. CPU architectures: RISC/CISC and Harvard/Von-Neumann, Overview of PIC Microcontroller family, Introduction to different microcontroller families (8051, ATMEL/AVR, and ARM).	**5 Hrs**
2	**Chapter 2: PIC Microcontroller Architecture and assembly language programming** Architecture and pin functions, Registers and Instructions, Data formats and directives, Introduction to assembly language programming, Program counter and program ROM space. Branch, Call and Time delay loop: Branch instructions and looping, Call instruction and stack, Time delay instructions and pipeline. Timing diagrams.	**7 Hrs**
3	**Chapter 3: I/O Port programming** I/O port programming, I/O bit manipulation programming, Arithmetic, logic instructions and programs: Arithmetic instructions, Signed number concepts and arithmetic operations, logic and compare instructions, rotate instructions and data serialization, BCD and ASCII conversion.	**8 Hrs**
	Unit II	
4	**Chapter 4: PIC and AVR programming in C** Data types and time delays in C, I/O programming, logic operations, data serialization, program ROM allocation, Program ROM allocation inC18, State diagrams, Timing diagrams in-depth.	**5 Hrs**
5	**Chapter 5: Timer and Serial port programming** Programming TIMERS 0 and 1, counter programming, Programming TIMER0 and 1 in C, Basics of serial communications, PIC18 connection to RS232, PIC18 serial port programming in assembly and C	**8 Hrs**
6	**Chapter 6: Interrupt programming in Assembly and C** Polling Vs interrupts, PIC18 Interrupts, Programming timer interrupts, programming external hardware interrupts, programming the serial communication interrupt, PortB change interrupts. ADC, DAC and sensor interfacing: ADC characteristics, ADC programming in the PIC18, DAC interfacing, sensor interfacing and signal interfacing.	**7 Hrs**
	Unit – III	

7	**Chapter 7: Introduction to the STMicroelectronics Line of Microcontrollers** STM Nucleo Boards, STM32CubeMX Application: Pinout Tab, MCU Alternative Functions, Integrated Peripheral (IP) Tree Pane, Creating a Project using CubeMX, ARM Cortex Microcontroller Software Interface Standard, Memory-Mapped Peripherals, Core Memory Addresses, Peripheral Memory Addresses, HAL_GPIO Module	**5 Hrs**
8	**Chapter 8: Interrupts and Timers:** Interrupts, NVIC Specifications, Interrupt Process, External Interrupts, Interrupt Demonstration, STM Timer Peripherals STM Timer Configuration, Update Event Calculation, Polled or Non-interrupt Blink LED Timer Demonstration, Test Run: Interrupt-Driven Blink LED Timer Demonstration, Test Run: Multi-rate Interrupt-Driven Blink LED Timer Demonstration	**5 Hrs**

Text Book

1. Mazidi & Mazidi, " PIC Micrcontroller and Embedded systems", Pearson Edition
2. Mazidi & Mazidi, " Introduction to AVR Micrcontroller and Embedded systems", Pearson Edition
3. Donald Norris, "Programming with STM32 getting started with Nucleo board and C/C++", McGraw-Hill Education

Reference Books

1. Ramesh Gaonkar , Fundamentals of microcontrollers and Applications in Embedded Systems. Penram International Publishing(India) Pvt. Ltd.
2. Ajay V Deshmukh, "Microcontroller: Theory and Applications"
3. M Krishnakumar, "Microprocessors and Microcontrollers".

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
Minor Exam 1	25
Minor Exam 2	25
Total	**50**

Course Unitization for Minor Exams and End Semester Assessment

Topics / Chapters	Teaching Credits	No. of Questions in Minor Exam-1	No. of Questions in Minor Exam-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
Introduction to Microcontrollers.	5	1			1
PIC and AVR Microcontroller Architecture and ALP	7	1			1
I/O Port programming	8	1			1
Unit II					
PIC and AVR programming in C	5		1		1
Timer and Serial port programming	8		1		1
Interrupt programming in Assembly and C	7		1		1
Unit III					
Introduction to the STMicroelectronics Line of Microcontrollers	5				1
Interrupts and Timers	5				1

Note* *Each Question carries 20 marks and may consist of sub-questions.*

- Mixing of sub-questions from different chapters within a unit (***only for Unit I and Unit II***) is allowed in Minor I, II and SEE.
- Answer 5 full questions of 20 marks each (***two full questions from Unit I, Unit II, and 1 full question from Unit III***) out of 8 in SEE

Course Assessment Plan

Course Title: Microcontrollers Programming & Interfacing					Code: 18EARC208	
Course outcomes (COs)	Weightage in assessment	Assessment Methods				
		Minor1	Monor2	Assignment	Course project	Semester End Exam
Differentiate microprocessors from microcontrollers.	10%	✓				✓
Code PIC with assembly and C language instructions to create loops, handle ports for input and output, create time delay and perform arithmetic and logical operation.	30%	✓				✓
Describe various modes of the PIC timers and serial communication by programming in assembly and C language to transmit and receive messages.	20%		✓			✓
Code PIC for interrupt based serial communication using assembly and C language.	15%		✓			✓
Describe ADC, DAC and sensor interfacing.	5%		✓			✓
Explain the functions and capabilities of STM MCUs.	10%					✓
Program STM32 to control flow using Interrupts and Timers.	10%					✓
Weightage		25%	25%			50%

Date: 06/03/2021

Head of Department

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: *1* **Introduction to Microcontrollers**	*Planned Hours: 5*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	Differentiate Microprocessors from Microcontrollers.	1	2	122
2	List and explain the advantages of microcontrollers.	1	2	122
3	Identify the difference between CISC and RISC architecture.	1	2	122
4	Explain the difference between PIC, AVR and 8051 microcontrollers with respect to their performance.	1	3	123

Lesson Schedule
Class No. Portion covered per hour

1. Introduction To Microprocessor and Microcontroller: History and Evolution, types of microprocessors
2. CPU architectures: RISC and CISC and Harvard/Von-Neumann,
3. Overview of PIC Microcontroller family
4. Introduction to different microcontroller families (8051, ATMEL/AVR, and ARM).
5. Introduction to different microcontroller families (8051, ATMEL/AVR, and ARM).

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Define microprocessor and microcontroller.	1	1	122
2	Explain the components of embedded microcontroller-based system.	3	2	122
3	List different types of microprocessors and microcontrollers.	1	2	122
4	Discuss Microprocessor and microcontroller unit.	1	2	122
5	Discuss difference between CISC and RISC architecture.	2	2	122
6	List and explain the features of RISC machine.	2	2	122
7	Summarize the working of Von- Neumann and Harvard architecture.	2	2	122

10	Discuss the role of Microcontroller in building and standalone system.	2	3	122
11	Differentiate between PIC and 8051 microcontroller.	4	2	122
12	Explain the difference between PIC and ARM microcontroller.	4	2	122

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: ***2.*** **PIC Architectures and Assembly Language Programming**	*Planned Hours: 7*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	Discuss the file register of the PIC microcontroller.	2	2	122
2	Manipulate data using the WREG and MOVE instructions.	2	2	112
3	Perform simple operations such as ADD and MOVE using the file register and access bank in the PIC microcontroller.	2	3	112
4	Explain the purpose of the status register.	2	2	112
5	Discuss ALU instructions of PIC18 microcontroller.	2	3	112
6	Use Branch, CALL and Loop instruction in writing programs.	3	3	112

Lesson Schedule
Class No. Portion covered per hour

1. Architecture and pin functions, Registers and Instructions,
2. Data formats and directives,
3. Introduction to assembly language programming,
4. Program counter and program ROM space,
5. Branch, Call and Time delay loop: Branch instructions and looping,
6. Call instruction and stack,
1. Time delay instructions and pipeline. Timing diagrams.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Discuss different instruction set of PIC18.	2	2	122

3	Explain different ALU instructions of PIC18 microcontroller.	5	2	122
4	Explain different branch and call instructions.	6	2	122
5	List and explain the instructions for accessing various locations of the data memory in PIC.	3	2	122
6	Discuss the different bits of PIC18 status register.	4	2	122
7	Write a program to a) load the PORTB SFR register with the values 55H, and b) complement Port B 700 times.	6	3	511
8	Show the status of the C,DC and Z flags after the addition of 38H and 2FH in the following instructions: MOVLW 38H ADDLW 2FH ;add 2FH to WREG	4	4	122
9	Discuss different data types and data formats of PIC and AVR.	3	2	122
10	Find the number of times the following loop is performed: MOVLW D'200' MOVWF REGA BACK MOVLW D'100' MOVWF REGB HERE DECF REGB, F BNZ HERE DECF REGA, F BNZ BACK	6	4	133
11	With an example explain different assembler directives.	3	2	122
12	Explain the structure of assembly language program.	3	2	122
13	Discuss about assembling and linking a PIC program.	2	2	122
14	Explain the following : a. Branch b. Loop and c. CALL.	6	2	122

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: **3. I/O Port programming**	*Planned Hours: 8*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	List all the ports of the PIC18.	4	1	122
2	Discuss dual role of PIC18 pins.	4	2	122
3	Code in assembly language to use the ports for input or output	4	3	133
4	Explain the dual role of Ports A,B,C, and D.	4	2	122
5	Code PIC instructions for I/O handling	4	3	511
6	Code I/O bit manipulation programs for the PIC	4	3	511
7	Explain the bit-addressability of PIC ports	4	2	122

Lesson Schedule
Class No. Portion covered per hour

1. I/O port programming,
2. I/O bit manipulation programming,
3. Arithmetic, logic instructions and programs: Arithmetic instructions,,
4. Signed number concepts and arithmetic operations,
5. logic and compare instructions,
6. instructions and data serialization,
2. BCD and ASCII conversion.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Write a PIC18 C program to transfer the message "YES" serially at 9600 baud,	5	3	133
2	Explain the bit-addressability in ports of PIC18 microcontroller.	7	2	122
3	Identify the role of TRIS register in inputting and outputting the data.	5	2	122
4	List different ports of PIC18 and explain their role in handling the data.	5	2	122

5	Discuss the dual role of Ports A and B in PIC18 microcontroller.	4	2	122
6	Discuss different logical and compare instructions of PIC18 microcontroller.	3	2	112
7	What is the advantage of I/O bit manipulation? Explain various single-bit instructions.	7	2	122
8	Program the PIC18 in C to receive bytes of data serially and put them on PORTB. Set the baud rate at 9600,	6	4	133
9	Write a C18 program to create a frequency of 2500Hz on pin PORTB.1. Use Timer1 to create the delay.	3	3	133
10	Write a C program for PIC18 to transfer the letter 'G' serially at 9600 baud, continuously. Use 8-bit data and 1 stop bit. Assume XTAL = 10 MHz	5	3	133

B. V. Bhoomaraddi College Campus, Vidyanagar, Hubballi - 580031. Karnataka (India)
DEPARTMENT OF AUTOMATION AND ROBOTICS

Model Question Paper for Minor - I	
Course Code: 18EARC208	**Course Title:** Microcontrollers Programming & Interfacing
Duration:	**75 Mins**
Max. Marks:	**40**
Note:	

Q.No	Questions	Marks	CLO	PI Code	B L
1a	Distinguish between CISC and RISC architecture.	6	1	122	2
b	Explain the differences between Microprocessor and microcontroller.	6	1	122	2
c	With a neat diagram explain the RISC architecture.	8	1	122	2
2a	List different ALU instructions of PIC18 microcontroller.	4	2	112	2
b	Show the status of the C,DC and Z flags after the addition of 38H and 2FH in the following instructions: MOVLW 38H ADDLW 2FH	6	2	133	4
c	Toggle all the bits of the SFR register of Port B by sending to it the values 55H and AAH continuously. Put a time delay in between each issuing of data to Port B.18	10	2	133	3
3a	Explain the bit-addressability of PIC ports.	4	2	122	2
b	Write a C program for PIC18 to transfer the letter ‘G’ serially at 9600 baud, continuously. Use 8-bit data and 1 stop bit. Assume XTAL = 10 MHz	6	3	133	2
c	Program the PIC18 in C to receive bytes of data serially and put them on PORTB. Set the baud rate at 9600, 8-bit data, and 1 stop bit	10	4	511	3

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: **4. PIC programming in C**	*Planned Hours: 5*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	Explain different C18 data types for the PIC18 microcontroller.	5	2	132
2	Identify major reasons for writing programs in C language instead of Assembly language	5	2	132
3	Code C programs for time delay and I/O operations.	5	3	511
4	Code C programs for I/O bit manipulation	5	3	511
5	Code C programs for arithmetic and logic operations.	5	3	511
6	Differentiate between state diagrams and flowcharts	5	2	122

Lesson Schedule

Class No. *Portion covered per hour*

1. Data types and time delays in C,
2. I/O programming, logic operations,
3. serialization, program ROM allocation,
4. Program ROM allocation inC18,
5. State diagrams, Timing diagrams in-depth

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What is Bit-addressable I/O programming?	1	2	122
2	Discuss the timing diagram of PIC18 microcontroller.	3	2	122
3	Run the following program and examine the results. Void main(void) { TRISB = 0; TRISC = 0; TRISD = 0; PORTB = 0x35 & 0X0F; PORTC = 0x04 | 0x68; PORTD = 0x54 ^ 0x78;	4	4	122

	PORTB = ~0x55;
	PORTC = 0x9A >> 3;
	PORTD = 0x77 >>4;
	PORTB = 0x6 << 4;
	While(1);
	}			

4	Discuss the major reasons for writing programs in C language instead of Assembly language.	2	2	133
5	Discuss different data types widely used by C18 of PIC18 microcontroller.	1	2	122
6	What are different ways of creating time delays in C18? Explain in detail.	3	3	122
7	Write program to send hex values for ASCII characters of 0,1,2,3,4,5,A,B,C and D to Port B.	5	3	122
8	Write a program to toggle all the bits of Port C and Port D continuously with a 500 ms delay.	4	3	133
9	Write a program to get a byte of data from Port B, wait one second, and then send it to Port C.	3	3	133
10	A door sensor is connected to the RB1 pin, and a buzzer is connected to RC7. Write a program to monitor the door sensor, and when it opens, sound the buzzer. You can sound the buzzer by sending a square wave of a few hundred Hz frequencies to it.	5	4	511
11	Write a program to toggle all the bits of Port B and Port C continuously with a 250 ms delay. Use the inverting operator.	4	3	133
12	Write a program to toggle all the bits of Port B, Port C and Port D continuously with 250 ms delay. Use the EX-OR operator.	4	3	133

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: 5**. PIC18 Timer and Serial port programming in C**	*Planned Hours: 7*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	List the timers of the PIC18 and their associated registers.	6	2	122
2	Describe the various modes of the PIC18 timers.	6	2	132
3	Program the PIC18 timers in assembly and C to generate time delays.	6	3	132

4	Contrast and compare serial versus parallel communication.	7	2	133
5	Discuss advantages of serial communication over parallel communication.	7	2	133
6	Explain the protocols of serial communication.	7	2	133
7	Differentiate between synchronous versus asynchronous communication	7	2	133
8	Contrast half versus full duplex transmission	7	2	133
9	Explain the RS232 standard	7	2	122
19	Program the PIC18 timers in assembly and C to perform serial communication.	7	3	133

Lesson Schedule

Class No. Portion covered per hour

1. Programming TIMERS 0 and 1,
2. Counter programming in C,
3. Programming TIMER0 and 1 in C,
4. Basics of serial communications,
5. PIC18 connection to RS232,
6. PIC18 serial port programming in assembly and C,
7. PIC18 serial port programming in assembly and C

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	List the timers of the PIC18.	1	2	122
2	Explain different modes of the PIC18 timers?	2	2	122
3	List and explain the timers of the PIC18 and their associated registers.	2	2	122
4	Distinguish between serial V/S parallel communications.	4	2	122
5	Write a C18 program to toggle all the bits of PORTB continuously with some delay. Use Timer0, 16-bit mode, and no prescaler options to generate the delay.	3	3	133
6	Distinguish between half versus full duplex transmission.	5	2	122
7	Explain RS232 standard.	6	2	122
8	Write a C18 program to generate a frequency of 2 Hz only on pin PORTB.5. Use Timer0, 8-bit mode to create the delay.	3	3	133

9	Write a C18 program to create a frequency of 2500Hz on pin PORTB.1. Use Timer1 to create the delay.	3	3	133
10	Write a C program for PIC18 to transfer the letter 'G' serially at 9600 baud, continuously. Use 8-bit data and 1 stop bit. Assume XTAL = 10 MHz	7	3	133
11	Write a PIC18 C program to transfer the message "YES" serially at 9600 baud,	7	3	133
12	Program the PIC18 in C to receive bytes of data serially and put them on PORTB. Set the baud rate at 9600,	7	3	511

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: **6. Interrupts programming in assembly and C**	*Planned Hours: 8*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	Contrast and compare interrupts versus polling	8	2	122
2	What is Interrupt Service Routine (ISR)? Explain the role of ISR in programming interrupts.	8	2	122
3	List all the major interrupts of the PIC18.	8	2	122
4	What are the basic operations of ADC and DAC?	8	2	122
5	Program the PIC18 for interrupt based serial communication	8	3	132
6	Explain interrupt priority of the PIC18	8	2	122
7	Program PIC interrupts in c	8	3	511

Lesson Schedule

Class No. Portion covered per hour

1. Polling Vs interrupts, PIC18 Interrupts,
2. Programming timer interrupts,
3. programming external hardware interrupts,
4. programming the serial communication interrupt,
5. Port B change interrupts,
6. ADC programming in the PIC18, DAC interfacing,
7. Sensor interfacing and signal interfacing.
8. Sensor interfacing and signal interfacing.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1.	Define interrupt and polling.	1	2	122
2.	What is Interrupt Service Routine (ISR)? Explain the role of ISR in programming interrupts.	2	2	122
3.	Discuss the general aspects of ADC?	3	2	122
4.	What are the basic operations of a DAC (Digital to Analog Converter) chip?	4	2	122
5.	Discuss ADC characteristics.	4	2	122
6.	Explain ADCON0 and ADCON1 registers.	4	2	122
7.	A PIC18 is connected to the 10 MHz crystal oscillator. Calculate the conversion time for all options of ADCS bits in both the ADCON0 and ADCON1 registers.	9	4	511
8.	Explain different steps in programming the A/D converter using polling.	4	2	122
9.	Interface DAC with PIC18 and perform operations to interpret data.	5	2	133
10.	Write a program to read the sensor value and display it on PORTD.	5	3	133
11.	Write a program to get data from channel 0 of ADC and display the result on PORTC and PORTD.	5	3	511
12.	Write a program that sends the values to the DAC continuously to produce a crude sine wave.	8	3	133
13.	Program a DAC chip to produce a sine wave on an oscilloscope	6	3	133
14.	Write a program using Timer0 and Timer1 interrupts to generate square waves on pins RB1 and RB7 respectively, while data is being transferred from PORTC to PORTD.	5	3	133
15.	Write a program to read data from PORTD and write it to TXREG continuously while transmitting serially. Assume that XTAL = 10 MHz and baud rate is 9600.	7	3	133
16.	Write a program using interrupts to transmit and receive data serially	5	3	511

KLE TECH. KLE Technological University
Creating Value
Leveraging Knowledge

B. V. Bhoomaraddi College Campus, Vidyanagar, Hubballi - 580031. Karnataka (India)

DEPARTMENT OF AUTOMATION AND ROBOTICS

Model Question Paper for Minor- II	
Course Code: 18EARC208	**Course Title:** Microcontrollers Programming & Interfacing
Duration:	**75 Mins**
Max. Marks:	**40**
Note:	

Q.No	Questions	Marks	CLO	PI Code	B L
1a	Explain different ways of creating time delays in C18	4	3	122	2
b	Write a program to toggle all the bits of Port C and Port D continuously with 500ms delay.	6	3	133	2
c	The data pins of an LCD are connected to Port B. The information is latched into the LCD whenever it's Enable pin goes from HIGH to LOW. Write a program to send "	10	4	511	3
2a	Compare serial versus parallel communication	4	4	122	2
b	Write a C18 program to toggle all the bits of PORTB continuously with some delay. Use Timer0, 16-bit mode, and no prescaler options to generate the delay.	6	4	133	2
c	Write a PIC18 C program to transfer the message "YES" serially at 9600 baud, 8-bit data, and 1 stop bit. Do this continuously.	10	4	511	3
3a	Compare interrupts versus polling	4	4	122	2
b	A PIC18 is connected to the 10 MHz crystal oscillator. Calculate the conversion time for all options of ADCS bits in both the ADCON0 and ADCON1 registers.	6	3	511	3
c	Write a program to read data from PORTD and write it to TXREG continuously while transmitting serially. Assume that XTAL = 10 MHz and baud rate is 9600.	10	3	133B	3

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: **7. The Texas Instruments MSP430**	*Planned Hours: 5*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	List and explain Principal MCU Components	6	2	122
2	Explain *ARM Cortex M-4 block diagram*	6	2	122
3	Explain *Nucleo-64 block diagram.*	6	2	122
4	Write a "Hello Nucleo project "on STM32.	6	2	122
5	Discuss about STM MCU memory mapped peripherals	6	3	511
6	Explain Typical STM GPIO port pin block diagram.	6	3	511

Lesson Schedule

Class No. Portion covered per hour

1. STM Nucleo Boards, STM32CubeMX Application: Pinout Tab.
2. MCU Alternative Functions, Integrated Peripheral (IP) Tree Pane.
3. Creating a Project using CubeMX, ARM Cortex Microcontroller Software Interface Standard.
4. Memory-Mapped Peripherals, Core Memory Addresses.
5. Peripheral Memory Addresses, HAL_GPIO Module.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Explain *Nucleo-64 block diagram.*	1	2	122
2	Write a "Hello Nucleo project "on STM32.	1	2	122
3	Discuss about STM MCU memory mapped peripherals	2	2	122
4	Explain Typical STM GPIO port pin block diagram.	4	2	122
5	Write a STM program to blink an LED/ in your program include GPIO ports.	2	2	122
6	Write a STM program to demonstrate the PUSH button	3	2	122

Chapter wise Plan

Course Code and Title: 18EARC208 Microcontrollers Programming & Interfacing	
Chapter Number and Title: **8. Interrupts and Timers**	*Planned Hours: 5*

Learning Outcomes:

At the end of the topic student should be able to:

Sr.No	TLO's	COs	B L	PI Code
1	Discuss the NVIC block diagram.	7	3	122
2	List and explain different types of interrupts in STM MCU,	7	2	122
3	Explain *EXTI block diagram.*	7	2	122
4	Explain STM Timer Peripherals			

Lesson Schedule

Class No. Portion covered per hour

1. Interrupts, NVIC Specifications, Interrupt Process,
2. External Interrupts, Interrupt Demonstration,
3. STM Timer Peripherals STM Timer Configuration
4. Update Event Calculation, Polled or Non-interrupt Blink LED Timer Demonstration,
5. Test Run: Interrupt-Driven Blink LED Timer Demonstration, Test Run: Multi-rate Interrupt-Driven Blink LED Timer Demonstration.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Differentiate between polling and interrupt.	1	2	122
2	Explain the uses of timers in controlling the flow of program.	2	2	122
3	Write a program to blink an LED continuously.	4	2	122
4	Write a program using timers to blink two LEDs where one LED blink twice per second and another LED blink once in a second	3	2	122
5	Write a program to handle external hardware interrupts	4	2	122
6	Demonstrate Multi-rate Interrupt-Driven Blink LED Timer	5	2	122

Model Question Paper for End Semester Assessment	
Course Code: 18EARC208	**Course Title:** Microcontrollers Programming & Interfacing
Duration:	**3 Hrs**
Max. Marks:	**100**
Note:	

Unit-I

Q.No	Questions	Marks	CLO	PI Code	B L
1a	Explain the differences between Microprocessor and microcontroller.	4	1	122	2
b	Identify the difference between CISC and RISC	6	1	122	2
C	Illustrate the use of Microcontroller in making independent system	10	1	511	3
2a	Discuss different data types and data formats of PIC and AVR	4	2	122	2

b	Find the number of times the following loop is performed:
	`MOVLW D'200'`
	`MOVWF REGA`
	`BACK MOVLW D'100'`
	`MOVWF REGB`
	`HERE DECF REGB, F`
	`BNZ HERE`
	`DECF REGA, F`
	`BNZ BACK`
		6	2	133	4

c	Write a program to a) load the PORTB SFR register with the values 55H, and b) complement Port B 700 times.	10	2	511	3
3a	Discuss different logical and compare instructions.	4	2	122	2
b	Write a C program for PIC18 to transfer the letter 'G' serially at 9600 baud, continuously. Use 8-bit data and 1 stop bit. Assume XTAL = 10 MHz	6	3	122	2
c	Program the PIC18 in C to receive bytes of data serially and put them on PORTB. Set the baud rate at 9600, 8-bit data, and 1 stop bit.	10	3	511	3
	UNIT II				

4a	Explain different ways of creating time delays in C18	4	4	122	2
b	Explain timing diagram of PIC18	6	4	122	2
c	The data pins of an LCD are connected to Port B. The information is latched into the LCD whenever it's Enable pin goes from HIGH to LOW. Write a program to send "Hello world" to this LCD.	10	4	511	3
5a	List the advantages of serial communication over parallel.	4	4	122	2
b	Write a C18 program to generate a frequency of 2 Hz only on pin PORTB.5. Use Timer0, 8-bit mode to create the delay.	6	4	133	2
c	Write a PIC18 C program to transfer the message "YES" serially at 9600 baud, 8-bit data, and 1 stop bit. Do this continuously.	10	4	511	3
6a	Discuss ADC characteristics.	4	5	122	2
b	Explain different steps in programming the A/D converter using polling.	6	5	122	2
c	Write a program using interrupts to transmit and receive data serially.	10	4	122	3
	UNIT III				
7a	Explain Typical STM GPIO port pin block diagram.	4	6	122	2
b	Write a STM program to blink an LED/ in your program include GPIO ports.	6	6	122	2
c	Write a STM program to demonstrate the PUSH button	10	6	133	3
8a	Write a program using timers to blink two LEDs where one LED blink twice per second and another LED blink once in a second	4	7	122	2
b	Write a program to handle external hardware interrupts	6	7	122	2
c	Demonstrate Multi-rate Interrupt-Driven Blink LED Timer	10	7	122	3

FMTH0303-3.1

Laboratory Plan

Laboratory Course Plan: B.E. in A&R

Semester: IV Year: 2021-22

Laboratory Title: **Manufacturing & Metrology lab**	Lab. Code: **16EARP205**
Total Hours: **24**	Duration of ESA Hours: 3
ISA Marks: **80**	ESA Marks: **20**
Lab. Plan Author: Mr. Doddabasappa Marebal	Date: 18/02/2022
Checked By: Mr. Arun Giriyapur	Date: 19/02/2022

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Demonstrate the knowledge of laboratory safety rules to be followed while performing various machining operations.
2. Demonstrate competency in working with general purpose machines and performing machining operations like turning, facing, thread cutting, milling and drilling.
3. Demonstrate the ability to, interpret the sequence of operations; calculate machining parameters and draw the process sheet.
4. Determine the linear & angular dimensions of given component .
5. Demonstrate the ability to perform assembly operations of the suitable parts based upon the dimensions and tolerances.
6. Demonstrate the ability to select and apply specific tools like, DFM from solid works; to overcome machining difficulties.
7. Demonstrate the knowledge of advanced measuring and gauging techniques

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: Manufacturing & Metrology lab	Semester : 4
Course Code: 16EARP205	Year : 2021

Course Outcomes / Program Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1.Demonstrate the knowledge of laboratory safety rules to be followed while performing various machining operations.	H													
2.Demonstrate competency in working with general purpose machines and performing machining operations like turning, facing, thread cutting, milling and drilling.	H													
3. Demonstrate the ability to, interpret the sequence of operations; calculate machining parameters and draw the process sheet.	M													
4.Determine the linear and angular dimensions of given component	H													
5.Demonstrate the ability to perform assembly operations of the suitable parts based upon the dimensions and tolerances.	M													
6.Demonstrate the ability to select and apply specific tools like, DFM from solid works; to overcome machining difficulties.	M				M									
7.Demonstrate the knowledge of advanced measuring and gauging techniques	M				H									

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency: 1.1	Demonstrate the competence in mathematical modelling.
PI Code: 1.1.1	Apply mathematical techniques to solve problems
Competency: 1.3	Demonstrate competence in engineering fundamentals
PI Code: 1.3.1	Apply elements of mechanical engineering principles and laws to solve problems
Competency: 5.2	Demonstrate an ability to select and apply discipline specific tools, techniques and resources
PI Code: 5.2.2	Demonstrate proficiency in using discipline specific tools

Experiment wise Plan

List of experiments/jobs planned to meet the requirements of the course.

Category: Demonstration		**Total Weightage: 25**		**No. of lab sessions: 4**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1.	Material Removal Operations.	2	15	
	Learning Objectives: The students should be able to: 1. Perform various machining operations like Facing, Turning, knurling on a workpiece using a Lathe machine. 2. Perform operations like drilling of holes on a given work material using a Drilling Machine. 3. Perform surface milling operation on a given slab of metal. 4. Demonstrate grinding operation on a given metal cube to achieve predefined dimensions. 5. Demonstrate arc welding process 6. Demonstrate sheet metal cutting operations- Shearing ,Bending operations, drilling & riveting process			Unit I, II & III
2.	Metrology	1	5	
	Learning Objectives: The students should be able to: 1. Extract the dimensions of the given part using (CMM) 2. Compare the dimensions of the given part using conventional measuring instrument & CMM			Unit III
3.	Additive Manufacturing	1	5	
	Learning Objectives: The students should be able to: 1. Understand the process parameters of additive manufacturing. 2. Print the 3D CAD models to convert to a prototype.			

Category: Exercise		**Total Weightage: 45**		**No. of lab sessions: 8**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
4	Measurement for Linear and angular dimensions	2	15	
	Learning Objectives: The students should be able to: 1. Select proper instruments for measurement. 2. Calculate least count of instrument. 3. Take reading using the instrument, Collection / recording of data, Interpret the observation, results. 4. Measure dimensions of the given component using vernier caliper & micrometer. 5. Measure unknown angle of a component using Sine bar and slip gauges.			Unit II & III
5	Fabrication of X-Y positioning table	6	30	
	Learning Objectives: The students should be able to: 1. Machine a given raw material to actual dimensions. 2. Mark the work piece before going for manufacture. 3. Perform milling, drilling, reaming, tapping operations at suitable locations. 4. Take measurements at every step of operations using vernier calipers. 5. Fill machining time calculation chart. 6. Fill operation chart and inspections reports. 7. Assemble the parts based upon the dimensions and tolerances.			Unit I,II,III

Students Assessment through ISA (80%) + ESA (20%)

Type of Evaluation	Types of laboratory work	Assessment				
		Aim	Material	Method	Answer	Weightage in Marks
In Semester Assessment (80%)	Demonstration	Given	Given	Given	Given	25
	Exercise	Given	Given	Given	Open	45
	Quiz(Viva)/Attendance	-	-	-	-	10
End Semester Assessment (20%)	Project	Open	Open	Open	Open	20
					Total	**100**

Date: 19/02/2022 **Head of The Department**

FMTH0303 - 3.3

Laboratory Plan

Laboratory Course Plan: B E in A&R 2022

Semester: IV Year: Jan2022- June2022

Laboratory Title: **Microcontroller Programming and Interfacing Lab**	Lab. Code: 18EARP208
Total Hours: 28	Duration of SEE Hours: 2
SEE Marks: 20	CIE Marks: 80
Lab. Plan Author: Mrs. C B Kolanur	Date: 12-1-2022
Checked By: Mr. Rakesh Tapaskar	Date: 13-1-2022

Course Outcomes (COs):

At the end of the course the student should be able to:

i. Explain the basic building blocks of PIC and Atmega328 microcontrollers.
ii. Differentiate between wide verities of microcontrollers.
iii. Develop applications both in assembly and Embedded C using open-source software like: MPlab, MiKroC, Processor, Proteus etc.
iv. Simulate the generated .hex file in a virtual environment and then test in real hardware.
v. Interface different devices/components with the microcontroller.
vi. Code on STM, Node MCU to perform IoT and data analysis.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: **Microcontroller Programming and Interfacing Lab**	Semester: 4
Course Code:18EARP208	Year :2022

Course Outcomes / Program Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Explain the basic building blocks of PIC and Atmega328 microcontrollers.	**M**	**H**	**M**		**M**									
Differentiate between wide verities of microcontrollers.		**H**	**M**		**M**									
Develop applications both in assembly and Embedded C using open-source software like: MPlab, MiKroC, Processor, Proteus etc.		**H**	**M**		**M**									
Simulate the generated .hex file in virtual environment and then test in real hardware.		**H**	**M**		**M**									
Interface different devices/components with the microcontroller.		**H**	**H**		**H**									
Code on STM, Node MCU to perform IOT and data analysis		**H**	**M**		**M**									

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency: 1.1	Demonstrate the competence in mathematical modelling.
PI Code: 1.1.1	Apply mathematical techniques to solve problems
Competency: 1.3	Demonstrate competence in engineering fundamentals
PI Code: 1.3.2	Apply basic electrical and electronics engineering principles and laws to solve problems
PI Code: 1.3.3	Apply computer programming skills to solve problems by building algorithms ,flow charts and debugging
Competency: 2.1	Demonstrate an ability to identify and characterize an engineering problem
PI Code: 2.1.1	Identifies known and unknown information, uncertainties, and biases when presented with a complex ill-structured problem
PI Code: 2.1.2	Identifies the essential problems and objectives
PI Code: 2.1.4	Gathers engineering knowledge from the available literature and selects the most relevant
Competency: 2.2	Demonstrate an ability to formulate a solution plan and methodology for an engineering problem
PI Code: 2.2.1	Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions
PI Code: 2.2.2	Partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design
PI Code: 2.2.3	Selects appropriate analysis tools and applies those proficiently to implement the model/solution
Competency: 2.3	Demonstrate an ability to formulate and interpret a model
PI Code: 2.3.1	Evaluates the analysis for accuracy and validity of assumptions made
Competency: 2.4	Demonstrate an ability to execute a solutions process and analyze results
PI Code: 2.4.1	Ability to validate and verify using various tools
Competency: 3.1	Demonstrate an ability to define a complex open-ended problem in engineering terms
PI Code: 3.1.1	Recognizes that good problem definition assists in the design process

PI Code: 3.1.2	Elicit and document, engineering requirements from stakeholders
PI Code: 3.1.3	Synthesize engineering requirements from a review of the State of the Art
Competency: 3.2	Demonstrate an ability to generate a diverse set of alternative design solutions
PI Code: 3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions
PI Code: 3.2.2	Build models, prototypes, etc., to develop diverse set of design solutions
PI Code: 3.2.3	Identify the suitable criteria for evaluation of alternate design solutions
Competency: 3.3	Demonstrate an ability to select the optimal design scheme for further development
PI Code: 3.3.2	Consult with domain experts and stakeholders to select candidate engineering design solution for further development
Competency: 5.1	Demonstrate an ability to identify/ create modern engineering tools, techniques and resources
PI Code: 5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
Competency: 5.2	Demonstrate an ability to select and apply discipline specific tools, techniques and resources
PI Code: 5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) Monitoring system performance, and (iv) creating engineering designs.
Competency: 5.3	Demonstrate an ability to evaluate the suitability and limitations of the tools used to solve an engineering problem
PI Code: 5.3.1	Discuss limitations and validate tools, techniques and resources

RUBRICS

Experiments	Rubrics & Marks Distribution	
Demo Experiments (05 marks each)		
Write a program to demonstrate the working with I/O ports by initializing pins and blinking of LED in PIC16F877A and Arduino board using Assembly and Embedded C language.	**Basic problem solving approach (2 marks)** ● Ability to list and follow the steps of problem solving -1 mark ● Briefing the plan of implementation -1 mark	**Implementation Ability (3 marks)** ● Ability to implement individually -1.5 marks Ability to implement in group & demonstrate the solution with documentation -1.5 marks
Write a program to demonstrate a counting machine which count from 0000 to 9999 and display on 7 segment LED display using Timers of PIC16F877A in Assembly and Embedded C language.	**Basic problem solving approach (2 marks)** ● Ability to list and follow the steps of problem solving -1 mark ● Briefing the plan of implementation -1 mark	**Implementation Ability (3 marks)** ● Ability to implement individually -1.5 marks ● Ability to implement in group & demonstrate the solution with documentation -1.5 marks
Write a program to demonstrate the conversion of Analog to Digital Converters using temperature sensor's (LM35) and display Converted values on LCD.	**Basic problem solving approach (2 marks)** ● Ability to list and follow the steps of problem solving -1 mark ● Briefing the plan of implementation -1 mark	**Implementation Ability (3 marks)** ● Ability to implement individually -1.5 marks ● Ability to implement in group & demonstrate the solution with documentation -1.5 marks
In bank lockers, there is a requirement of password protection to open the locker. Develop an application Using a 4*3 keypad and LCD to secure the lockers by providing password protection.	**Basic problem solving approach (2 marks)** ● Ability to list and follow the steps of problem solving -1 mark ● Briefing the plan of implementation -1 mark	**Implementation Ability (3 marks)** ● Ability to implement individually -1.5 marks ● Ability to implement in group & demonstrate the solution with documentation -1.5 marks

Exercises (10 & 5 marks each)		
Write a program to measure an object's distance using ultrasonic sensors and display the distance in terms of centimeters and inches. Make the connections as per the schematic and develop the flowchart and code to perform the required operation.	**Basic problem solving approach (2marks)** ● Ability to list and follow the steps of problem solving - 1marks ● Briefing the plan of implementation-1marks	**Implementation Ability (3 marks)** ● Ability to implement individually - 1marks ● Ability to implement in group & demonstrate the solution with documentation -1marks **Analyzing Ability (1 marks)** ● Summarizing &Verification of the result -0.5marks ● Analysis of result in terms of pros & cons -0.5marks
Design and develop an interconnected connection of controllers to communicate and transfer data between them use Bluetooth module and controller	**Basic problem solving approach (5marks)** ● Ability to list and follow the steps of problem solving - 1marks ● Briefing the plan of implementation-1marks	**Implementation Ability (5 marks)** ● Ability to implement individually - 1marks ● Ability to implement in group & demonstrate the solution with documentation -1marks **Analyzing Ability (1 marks)** ● Summarizing &Verification of the result -0.5marks ● Analysis of result in terms of pros & cons -0.5marks
Write a program using Analog to Digital Converter where in read the speed of a motor from a user interface and convert them to digital values to control the speed of the DC, stepper, and servo motors.	**Basic problem solving approach (3marks)** ● Ability to list and follow the steps of problem solving - 1marks ● Briefing the plan of implementation-1marks	**Implementation Ability (2 marks)** ● Ability to implement individually - 1marks ● Ability to implement in group & demonstrate the solution with documentation -1marks **Analyzing Ability (1 marks)** ● Summarizing &Verification of the result -0.5marks ● Analysis of result in terms of pros & cons -0.5marks

Design and develop an IOT (Internet of Things) system to collect data from a load sensor and store the data in the cloud. Use Wi-Fi-module and controller.	**Basic problem solving approach (5marks)** • Ability to list and follow the steps of problem solving - 1marks • Briefing the plan of implementation- 1marks	**Implementation Ability (5 marks)** • Ability to implement individually - 1marks • Ability to implement in group & demonstrate the solution with documentation -1marks **Analyzing Ability (1 marks)** • Summarizing &Verification of the result -0.5marks • Analysis of result in terms of pros & cons -0.5marks
Structured Query (10 marks)		
Develop an application using Node MCU to predict the data using the existing trained module.	**Basic problem solving approach (5 marks)** • Ability to list and follow the steps of problem solving -2.5 marks • Briefing the plan of implementation -2.5 marks	**Implementation Ability (5 marks)** • Ability to implement individually - 1 marks • Ability to implement in group & demonstrate the solution with documentation - 1 marks **Analyzing Ability (3 marks)** • Summarizing &Verification of the result -1.5 marks • Analysis of result in terms of pros & cons -1.5 marks
Open Ended Enquiry (20 marks)		
The Open Ended Project is based on understanding, modeling and development of solution for a real time problem.	**Basic problem solving approach (5 marks)** • Defining the Problem -1marks • Planning the Steps – 1 marks	**Submission of Documentation (15 marks)** • Synopsis – 5 marks • Process Flow/Flow chart & Planning Action for finding solution – 10marks

Experiment wise Plan

List of experiments/jobs planned to meet the requirements of the course.

	Category: Demonstration	***Total Weightage:20***	***No. of lab sessions: 2***		
Expt./ Job No.	***Experiment/job Details***	***No. of Lab. Session/s per batch (estimate)***	***Marks/ Experiment***	***Marks obtained***	***Correlation of Experiment with the theory***
1	*Compare Architectures of different microcontrollers w.r.t to time response, frequency response, delay, process time etc.* *Write a program to demonstrate the working with I/O ports by initializing pins and blinking of LED in PIC16F877A and Arduino board using Assembly and Embedded C language*	*1*	*5*		*Chap1*

Learning Objectives :

The students should be able to:

1. *Study the data sheets and make a comparative study of the Architectures, resources, tools and applications of different microcontroller*
2. *Compare and contrast different microcontrollers.*
3. *Connect microcontroller to LED and blink LED with proper delay.*
4. *Apply suitable method or logic to solve given problem.*

Pre-lab:

i. *Download the data sheets of PIC16F877a, ATMEGA328, 8051 microcontrollers from the following websites*
   - *http://www.atmel.com/images/Atmel-8271-8-bit-AVR-Microcontroller-ATmega48A-48PA-88A-88PA-168A-168PA-328-328P_datasheet_Complete.pdf*
   - *http://ww1.microchip.com/downloads/en/DeviceDoc/39582b.pdf*
   - *http://ww1.microchip.com/downloads/en/devicedoc/41159d.pdf*
   - *http://www.atmel.com/images/doc8161.pdf*
   - *http://www.farnell.com/datasheets/46220.pdf*
   - *http://www.nxp.com/documents/data_sheet/LPC2921_23_25.pdf*

ii. *Draw the architectural layout of the following microcontrollers with pin out diagrams.*
   a. *PIC16F877a*
   b. *ATMEGA328*
   c. *8051*

iii. *Make a comparative study and fill up the table 1 given in lab manual.*

iv. *Download the application notes.*

v. *Prepare flowcharts and develop the code to demonstrate the use of the microcontroller as a simple digital output device.*

vi. *Study Proteus 8 Professional*

vii. *Study different ports and understand the basic LED program*

In lab:

i. *Must be able to explain difference between various types of Microcontrollers and its architectures.*

ii. *Setup the hardware platform and deploy the code on the hardware.*

iii. *If any errors debug the code until it works.*

iv. *Make a note of the number and types of errors.*

v. *Simulate LED blink program on Proteus 8 Professional*

Post-lab:

Analyze the cause for errors and make a note.

<table>
<tr><td rowspan="2">2</td><td>Write a program to demonstrate a counting machine which count from 0000 to 9999 and display on 7 segment LED display using Timers of PIC16F877A in Assembly and Embedded C language.</td><td>1</td><td>5</td><td></td><td>Chap2</td></tr>
<tr><td colspan="4">Learning Objectives :

The students should be able to:

1. Use 7Segment LED for counting numbers.
2. Use appropriate logic or method for counting.
Pre-lab

i. Study the application notes of Arduino and PIC16F877a
ii. Study advantages and disadvantages of Arduino and PIC16F877a microcontrollers
iii. Understand 7segment LED.
iv. Prepare flowcharts and develop the code to demonstrate the use of the microcontroller as a simple digital input and output device
v. Study different segments of LED
In-lab

i. Write program for both Arduino and PIC
ii. If any errors debug the code until it works.
iii. Make a note of the number and types of errors.
iv. Simulate in Proteus
v. Setup the hardware platform and deploy the code on the hardware.
vi. Execute the code and note the output.
Post-lab

i. Record the results and experience you got in lab
Analyze the cause for errors and make a note</td><td></td></tr>
<tr><td>3.</td><td>Write a program to read the values from the temperature sensor (LM35) and display the temperature in degree Celsius on LCD display.</td><td>1</td><td>5</td><td></td><td>Chap2,3</td></tr>
</table>

<table>
<tr>
<td></td>
<td colspan="4">Learning Objectives :

The students should be able to:
1. Connect LM35, LCD and microcontroller.
2. Write function to read values from LM35 and display it on LCD.
Pre-lab
i. Study the application notes of Arduino and PIC for interfacing LM35 and LCD.
ii. Prepare flowcharts and develop the code to demonstrate the use of the microcontroller as a simple digital input and output device.
iii. Study what is 16*2 LCD and how it works.
iv. Analyze the driver required for LCD.
In-lab
i. Write program for both Arduino and PIC
ii. Execute the code and note the output.
iii. If any errors debug the code until it works.
iv. Simulate LCD display in Proteus.
v. Setup the hardware platform and deploy the code on the hardware.
vi. Make a note of the number and types of errors.
Post-lab
i. Analyze the cause for errors and make a note.
List down different types of LCDs and sensors.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>In bank lockers, there is a requirement of password protection to open the locker. Develop an application Using a 4*3 keypad and LCD to secure the lockers by providing password protection</td>
<td>1</td>
<td>5</td>
<td></td>
<td>Chap2,3</td>
</tr>
</table>

	Learning Objectives : *The students should be able to:* 1. *Connect Keypad, LCD with microcontroller.* 2. *Write logic to read key press event from keypad.* *Pre-lab* i. *Study the application notes of Arduino and PIC for interfacing keypad and LCD.* ii. *Prepare flowcharts and develop the code to demonstrate the use of the microcontroller as a simple digital input and output device.* iii. *List down different types of keypads* iv. *Analyze the driver required for 4*3 keypad.* *In-lab* i. *Write programs for both Arduino and PIC* ii. *Execute the code and note the output.* iii. *If any errors debug the code until it works.* iv. *Make a note of the number and types of errors.* v. *Simulate both in Proteus* vi. *Setup the hardware platform and deploy the code on the hardware* *Post-lab* i. *Record the results and experience in manual* *List down the different applications of Keypad in real world.(eg. In Security applications)*	

	Category: Exercises	***Total Weightage: 30***			***No. of lab sessions:4***
Expt./ Job No.	***Experiment/job Details***	***No. of Lab. Session/ s per batch (estimate)***	***Marks/ Experi ment***	***Marks obtain ed***	***Correlatio n of Experimen t with the theory***
5	*Write a program to measure an object's distance using ultrasonic sensors and display the distance in terms of centimeters and inches. Make the connections as per the schematic and develop the flowchart and code to perform the required operation.*	*1*	*5*		*Chapter 4*

Learning Objectives :

The students should be able to:

1. *Connect Ultrasonic Distance Sensor and microcontroller*
2. *Logic to find distance in CM and Meters.*

Pre-lab

- i. *Study the application notes of Arduino and PIC for interfacing Ultrasonic Sensors.*
- ii. *Understand different types of sensors.*
- iii. *List the advantages and disadvantages of different sensors.*
- iv. *Prepare flowchart and develop the code to demonstrate the use of the microcontroller as a simple analog input sensor and convertor.*

In-lab

- i. *Write programs for both arduino and PIC*
- ii. *Execute the code and note the output.*
- iii. *If any errors debug the code until it works.*
- iv. *Make a note of the number and types of errors*
- v. *Setup the hardware platform and deploy the code on the hardware.*

Post-lab

- i. *Record the results and experience in manual*
- ii. *Try interfacing at least two other sensors and note down the readings.*

List real world applications of sensors.

Expt./ Job No.	***Experiment/job Details***	***No. of Lab. Session/s per batch (estimate)***	***Marks/ Experiment***	***Marks obtained***	***Correlation of Experiment with the theory***
6	*Design and develop an interconnected connection of controllers to communicate and transfer data between them use Bluetooth module and controller.*	*1*	*10*		*Chapter*

	Learning Objectives : *The students should be able to:* *i. Establish connection between different controllers and transfer the data.* *Pre-lab:* *i. Get familiar with Bluetooth module* *ii. Sketch circuit diagram on paper.* *In lab:* *i. Design circuit.* *ii. Simulate in Proteus* iii. *Demonstrate the hardware for both Arduino and PIC.*				*Chapter 4,5*
7	*Write a program using Analog to Digital Converter where in read the speed of a motor from a user interface and convert them to digital values to control the speed of the DC, stepper, and servo motors.*	*1*	*5*		*Chapter 4,5*
	Learning Objectives : *The students should be able to:* *1. Understand the connections from microcontroller to DC motor using drives.* *2. Discuss how motor driver helps in controlling the speed on a DC motor.* *Pre-lab:* *i. Study the application notes of Arduino and PIC for interfacing DC motor.* *ii. Study the working principle of DC motor.* *i. Study in detail about different types of DC motors and list out them* *ii. List advantages and disadvantages of DC motors* *iii. List the applications in the real world* *In lab:* *i. Write programs for both Arduino and PIC* *ii. Simulate in Proteus* *iii. Demonstrate the hardware for both Arduino and PIC.* *Post-lab* *i. Record the results and experience in manual* *ii. Measure the speed of the DC motor w.r.t voltage.*				
8	*Design and develop an IOT (Internet of Things) system to collect data from a load sensor and store the data in the cloud. Use Wi-Fi-module and controller.*	*1*	*10*		*Chap 6*

<table>
<tr><td></td><td colspan="4">Learning Objectives :
The students should be able to:
3. Develop an IOT system that must be able to record and store the data on cloud.
Pre-lab:
i. Get familiar with IOT and Wi-Fi module.
In lab:
i. Wire-up the circuit and place the sensor in the farm field/garden and collect the data .
ii. Store the collected data on cloud for analysis.
iii. Demonstrate the hardware for STM MCU.
Post-lab
i. Record the results and experience in manual</td><td></td></tr>
<tr><td></td><td colspan="5">Category: Structured Enquiry Total Weightage: 20 No. of lab sessions:4</td></tr>
<tr><td>9</td><td>Develop an application using Node MCU to predict the data using the existing trained module.</td><td>1</td><td>10</td><td></td><td>Chapter 6,7</td></tr>
<tr><td></td><td colspan="4">Learning Objectives :
The students should be able to:
i. Demonstrate the knowledge of data analysis.
Pre-lab:
i. Understand different trained modules that can be used on STM MCU.
In lab:
i. Analyze and predict data for the selected trained module.
ii. Demonstrate the hardware for STM MCU.
Post-lab
i. Record the results and experience in manual</td><td></td></tr>
<tr><td></td><td colspan="5">Category: Open Ended Total Weightage: 20 No. of lab session:2</td></tr>
</table>

Expt./ Job No.	***Experiment/job Details***	***No. of Lab. Slots per batch (estimate)***	***Marks/Experiment***	***Marks obtained***	***Correlation of Experiment with the theory***
10	The Open Ended Project is based on understanding, modeling and development of solutions for a real time problem.	*2*	*20*		*Chapter 1 to 7*
	Learning Objectives : *The students should be able to:* *1. Identify the problem and solve.* *2. Apply the knowledge of electronics, data science and programming.*				

1. ***<u>Materials and Resources Required</u>*****:**

1.Books/References: Mazidi & Mazidi, “ Introduction to AVR Micrcontroller and Embedded systems”, Pearson Edition.

2.Mazidi & Mazidi, “ PIC Micrcontroller and Embedded systems”, Pearson Edition

3.Manuals: Microcontroller Programming and Interfacing laboratory

4. Others: Proteus, PicMicroC, and Arduino IDE.

2. *Evaluation*:

Students Assessment through ISA (80%) + ESA (20%)

In Semester Assessment (80%)	**Assessment**	**Weightage in Marks**
	Demonstration	20
	Exercise	30
	Structured Enquiry	10
	Viva, journal and attendance	20
End Semester Assessment (20%)	Open Ended Enquiry (Project	**20**
	Total	**100**

Date: Head of Department

FMTH0303-3.1

Laboratory Plan

Semester :3

Year:2021-2022

Laboratory Title: Kinematics of Machinery lab	*Lab. Code:*18EARP202
Total Hours: 24	*Duration of Exam*:3 hrs
Total Exam Marks: 100	*Total ISA. Marks*: 80
Lab. Plan Author: Asst. Prof. AmitTalli	*Date*: 18-10-2021
Checked By: Asst. Prof. Shilpa T	*Date*: 21-10-2021

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Demonstrate knowledge and develop the skill of multibody simulation using MATLAB Simscape.
2. Demonstrate knowledge and develop skills to synthesize and analyze the kinematics of mechanisms.
3. Demonstrate knowledge and develop skills to import CAD files into Simscape Multibody to analyze the mechanism's position, velocity, and acceleration.
4. Demonstrate the skill of designing a mechanism for a specific application as a course project and should be able to produce well constructed and well-supported engineering documents.

DEPARTMENT OF AUTOMATION & ROBOTICS

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: Kinematics of Machinery Lab	Semester:3 - Semester
Course Code:18EARP202	Year:2021 - 2022

Course Outcomes / Program Outcomes	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Demonstrate knowledge and develop the skill of multibody simulation using MATLAB Simscape.	**H**				**M**									
Demonstrate knowledge and develop skills to synthesize and analyze the kinematics of mechanisms.	**H**				**M**									
Demonstrate knowledge and develop skills to import CAD files into Simscape Multibody to analyze the mechanism's position, velocity, and acceleration.	**M**									**M**				
Demonstrate the skill of designing a mechanism for a specific application as a course project and should be able to produce well constructed and well-supported engineering documents.	**H**				**H**					**M**				

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency: 1.3	Demonstrate competence in engineering fundamentals
PI Code: 1.3.1	Apply elements of mechanical engineering principles and laws to solve problems
Competency: 5.1	Demonstrate an ability to identify/ create modern engineering tools, techniques and resources
PI Code: 5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
PI Code: 5.1.2	Create/adapt/modify/extend tools and techniques to solve problems
Competency: 10.1	Demonstrate an ability to comprehend technical literature and document project work.
PI Code: 10.1.1	Read, understand and interpret technical and non-technical information
PI Code: 10.1.2	Produce clear, well-constructed, and well-supported written engineering documents
PI Code: 10.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear

Experiment wise Plan

List of experiments/jobs planned to meet the requirements of the course.

Category: Demonstration		**Total Weightage: 10.00**		**No. of lab sessions: 3.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1	Introduction to Multibody Simulation	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. Define standard rigid bodies, including geometry and inertia properties. 2. Add coordinate frames using frame transform definitions. 3. Connect solids with joints to model a dynamic system.			UNIT – I
2	Simple Pundulum	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. Define standard rigid bodies, including geometry and inertia properties. 2. Add coordinate frames using frame transform definitions. 3. Connect solids with joints to model a dynamic system.			UNIT – I
3	Double Pendulum and pendulum of cart	1.00	10.00	
	Learning Outcomes: The students should be able to: 1. Define standard rigid bodies, including geometry and inertia properties. 2. Add coordinate frames using frame transform definitions. 3. Connect solids with joints to model a dynamic system.			UNIT – I
Category: Exercise		**Total Weightage: 50.00**		**No. of lab sessions: 9.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1	Slide crank mechanism	2.00	10.00	
	Learning Outcomes: The students should be able to:			UNIT-I

	1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis. 4. Set initial positions and velocities of bodies in a machine and verify their correctness.			
2	Four bar mechanism	1.00	10.00	
	Learning Outcomes: The students should be able to: 1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis. 4. Set initial positions and velocities of bodies in a machine and verify their correctness.			UNIT-I
3	Pendulum waves	1.00	5.00	
	Learning Outcomes: The students should be able to: 1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis.			UNIT-I
4	Inline –Three Engine	1.00	10.00	
	Learning Outcomes: The students should be able to: 1. Define kinematics of a multibody machine. 2. Define body interfaces for Simscape Multibody joints. 3. View and log simulation data for post-simulation analysis. 4. Set initial positions and velocities of bodies in a machine and verify their correctness.			UNIT-I
5	Importing CAD model in Matlab	2.00	5.00	
	Simscape™ Multibody™ Link is a CAD plug-in for exporting CAD assemblies from SolidWorks®, Autodesk Inventor®, and PTC® Creo™ software. The plug-in generates an XML file detailing the structure and properties of your CAD assembly and 3-D geometry files for visualizing the various CAD parts. You can then import the files into Simscape Multibody software, which parses the XML data and automatically generates an equivalent multibody model.			UNIT-I
Category: Project		**Total Weightage: 10.00**		**No. of lab sessions: 2.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch (estimate)**	**Marks / Experiment**	**Correlation of Experiment with the theory**
1	Course Project	2.00	10.00	UNIT-III

	Learning Outcomes: Demonstrate the skill of designing a mechanism for a specific application as a course project and should be able to produce well constructed and well-supported engineering documents.	

1. ***Evaluation*:**

Students Assessment through ISA (80%) + ESA (20%)

Type of Evaluation	Types of laboratory work	**Assessment**				
		Aim	Material	Method	Answer	**Weightage in Marks**
Internal Semester Assessment (80%)	Demonstration	Given	Given	Given	Given	**20**
	Exercise	Given	Given	Given	Open	**40**
	Project	Given	Open	Open	Open	**10**
	Quiz(Viva)/Attendance	-	-	-	-	**10**
End Semester Assessment (20%)	Project	Open	Open	Open	Open	**20**
					Total	**100**

Date: 22-10-2021

Head of School/Department

FMTH0301/Rev.5.3

Course Plan

Semester: **6th**	Year: 2021-2022
Course Title: **Hydraulics and Pneumatics**	Course Code: **18EARC308**
Total Contact Credits: **50**	Duration of ESA: 3 Hours
ESA Marks: **50**	ISA Marks: **50**
Lesson Plan Author: Mrs. Shilpa V Tanvashi	Date: 1-1-2022
Checked By: Mr. Nagaraj B	Date: 3-1-2022

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Classify, recognize and draw various components of hydraulic & pneumatic systems using ISO standard symbols
2. Explain the construction and function of common hydraulic and pneumatic components (pumps, actuators, motors, valves, ancillary devices etc.), their use, and their performance characteristics.
3. Compute the performance of the pumps and motors.
4. Construct and interpret the operation and the potential of a hydraulic or pneumatic circuit.
5. Identify causes of faults in pneumatic or hydraulic circuits
6. Select an industrial hydraulic system from any manufacturer, check the specifications provided by the manufacturer, determine and build the circuit model and compare with the original specifications and reflect on the effectiveness of the problem-solving methodology applied

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: **Hydraulics and Pneumatics**	Semester: **6**
Course Code: **18EARC308**	Year: **2021 - 2022**

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Classify, recognize and draw various components of hydraulic & pneumatic systems using ISO standard symbols	H													
Explain the construction and function of common hydraulic and pneumatic components (pumps, actuators, motors, valves, ancillary devices etc.), their use, and their performance characteristics	H													
Compute the performance of the pumps and motors	M													
Construct and interpret the operation and the potential of a hydraulic or pneumatic circuit.		M												
Identify causes of faults in pneumatic or hydraulic circuits	M													
Select an industrial hydraulic system from any manufacturer, check the specifications provided by the manufacturer, determine and build the circuit model and compare with the original specifications and reflect on the effectiveness of the problem-solving methodology applied	H	M												

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3 - Demonstrate competence in engineering fundamentals	1.3.1 - Apply elements of mechanical engineering principles and laws to solve problems
2.1 - Demonstrate an ability to identify and characterize an engineering problem	2.1.1 Identifies known and unknown information, uncertainties, and biases when presented with a complex ill-structured problem
2.2 - Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 - Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions.

Eg: 1.2.3: Represents Program Outcome ‘1’, Competency ‘2’ and Performance Indicators‘3’.

Course Content

Course Code: **18EARC308**	Course Title: **Hydraulics and Pneumatics**	
L-T-P : : 4-0-0	Credits: 4	Contact Hrs: 50 hours
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50 hours		Exam Duration: 3 Hrs

Content	Hrs
Unit - 1	
Chapter No. 1. Introduction to Hydraulic Power and Hydraulic Pumps Pascal's law, Structure of Hydraulic Control System. The Source of Hydraulic Power: Pumps Pumping theory, pump classification, gear pumps, vane pumps, piston pumps, Variable displacement pumps, pump performance, pump selection. Problems on determining the pump flow rate pump efficiency and pump power.	7hrs
Chapter No. 2. Hydraulic Actuators: Cylinders and Motors Linear Hydraulic Actuators (cylinders), Mechanics of Hydraulic Cylinder loading, Hydraulic Rotary Actuators, Gear motors, vane motors, and piston motors, Hydraulic Motor Performance. Problems on determining motor speed, torque, power ,motor efficiency	6hrs
Chapter No. 3. Hydraulic Valves Hydraulic Valves: Directional Control Valves- classification of directional control valves, direction control valves actuating devices, Symbolic representation as per ISO 1219 and ISO 5599, pressure control valves, flow control valves- classification of flow control valves, proportional control valves, and servo valves.	7hrs
Unit - 2	
Chapter No. 4. Hydraulic Circuit Design and Analysis Control of single acting and double acting Hydraulic Cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application, Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve, cylinder synchronizing circuits, Speed control of hydraulic cylinder: Meter-in circuit, Meter-out circuit and Bleed-off circuit, speed control of hydraulic motors. Ancillary Hydraulic Devices: Reservoirs, Accumulators, Pressure Intensifiers, Sealing Devices.	6hrs
Chapter No. 5. Pneumatic Systems Structure of Pneumatic control system, Choice of working medium, characteristics of compressed air, Pneumatic Actuators: Types of Linear Actuators or Pneumatic cylinders, Cylinder mountings, Cylinder seals, End cushioning in pneumatic cylinders. Pneumatic Control Valves: Direction control valve- types of direction control valves, ISO designation of direction control valves, Non return valves, methods of actuation of pneumatic directional control valves, Flow control valves, and Pressure control valves.	5hrs
Chapter No. 6. Pneumatic Circuit Design and Hydraulic Control Systems **Pneumatic Circuit Design:** Direct and indirect control of single acting cylinder, control of single acting cylinder using "OR", "and", "NOT" valve. Direct control of a double acting cylinder, Indirect control of double acting cylinder using memory valve, Supply air throttling and exhaust air throttling, Various methods of checking end position of a cylinder, Pressure dependent controls and Time dependent controls. **Hydraulic Control Systems:** Servo Control, Valve servo systems: Valve lap, mechanical feedback, systems response, electro hydraulic servo valves and Proportional	9hrs

valves: Force control, force position control, spool position control, proportional pressure control, proportional flow control, electrical control of proportional valve, Applications of proportional control valves.	
Unit - 3	
Chapter No. 7. Electro Pneumatics Basic electrical devices- Manually actuated push button switches, Limit switches, Pressure switches, Solenoids, Relays, Timers, Temperature switches, Direct and indirect control of single acting cylinders using electro pneumatics, Direct and indirect control of double acting cylinders using electro- pneumatics, Control of double acting cylinder OR logic (Parallel circuit), Control of double acting cylinder AND logic.	5 hrs
Chapter No. 8. Hydraulic System Maintenance Common faults in a hydraulic systems, contamination, Filter and filter maintenance, pump maintenance, Hydraulic system maintenance, fault diagnosis of Hydraulic system.	5 hrs

Text Books (List of books as mentioned in the approved syllabus)

1. Anthony Esposito, Fluid Power with Applications, 6th Edition, Pearson, 2003.
2. Michael J. Pinches and John G. Ashby, Power Hydraulics, Prentice-Hall, 1989.

References

1. Herbert E. Merritt, Hydraulic Control Systems, John Wiley & Sons, 1967.
2. Peter J Chapple, Principles of Hydraulic System Design, 1st Edition, Coxmoor Publishing Company, 2003.
3. S. R. Majumdar, Oil Hydraulic Systems, Tata McGraw Hill publishing Company Ltd, 2001.

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
ISA-1	15
ISA-2	15
Activity -Course Project	20
Total	50

Course Unitization for Minor Exams and End Semester Assessment

Topics / Chapters	Teaching Credits	No. of Questions in ISA-1	No. of Questions in ISA-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
1. Introduction to Hydraulic Power and Hydraulic Pumps	7	1.00	-	-	1.00
2. Hydraulic Actuators: Cylinders and Motors	6	1.00	-	-	1.00
3. Hydraulic Valves	7	1.00	-	-	1.00
Unit II					
4.Hydraulic Circuit Design and Analysis	6	-	1.00	-	1.00
5. Pneumatic Systems	5	-	1.00	-	1.00
6.Pneumatic Circuit Design and Hydraulic Control Systems	9	-	1.00	-	1.00
Unit III					
7. Electro Pneumatics	5	-	-	-	1.00
8. Hydraulic System Maintenance	5	-	-	-	1.00

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA I, II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full question from Unit III) out of 8 questions in ESA.

Course Assessment Plan

Course Title: Hydraulics and PneumaticsCode: **18EARC308**					
Course outcomes (COs)	Weightage in Assessment	Assessment Methods			
		ISA 1	ISA 2	Activity	Semester End Exam
1. Classify, recognize and draw various components of hydraulic & pneumatic systems using ISO standard symbols	10 %	✓	✓		✓
2. Explain the construction and function of common hydraulic and pneumatic components (pumps, actuators, motors, valves, ancillary devices etc.), their use, and their performance characteristics	20 %	✓	✓		✓
3. Compute the performance of the pumps and motors	20 %	✓	✓		✓
4. Construct and interpret the operation and the potential of a hydraulic or pneumatic circuit.	20 %		✓		✓
5. Identify causes of faults in pneumatic or hydraulic circuits	10 %				✓
6. Select an industrial hydraulic system from any manufacturer, check the specifications provided by the manufacturer, determine and build the circuit model and compare with the original specifications and reflect on the effectiveness of the problem-solving methodology applied	20 %			✓	
Weightage		15%	15%	20%	50%

Date: 03-01-2022

Head of Department

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **1. Introduction to Hydraulic Power and Hydraulic Pumps**	Planned Hours:**7hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explain the main components of hydraulic system; their functions and applications.	CO2	L3	1.3
2. Select pump for fluid operated systems.	CO1	L2	1.3
3. Identify the components and Draw ISO symbols for the components used in hydraulic system.	CO1	L2	1.3
4. Determine the discharge parameters of gear, vane and piston pumps for given problems.	CO3	L3	1.3
5. Determine the performance of pumps by calculating the volumetric, mechanical and overall efficiencies.	CO3	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Pascal's law, Structure of Hydraulic Control System
2. The Source of Hydraulic Power: Pumps Pumping theory,
3. Pump classification, gear pumps
4. Vane pumps,
5. Piston pumps,
6. Variable displacement pumps,
7. Pump performance, Pump selection

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. A hydraulic pump delivers 12 L of fluid per minute against a pressure of 200 bar. (a) Calculate the hydraulic power. (b) If the overall pump efficiency is 60%, what size of electric motor would be needed to drive the pump?	TLO4	L3	1.3.1
2. A gear pump has an outside diameter of 80mm, inside diameter of 55 mm and a width of 25mm. If the actual pump flow is 1600 RPM and the rated pressure is 95 LPM what is the volumetric displacement and theoretical discharge.	TLO5	L3	1.3.1

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **2. Hydraulic Actuators: Cylinders and Motors**	Planned Hours: **6 hrs.**

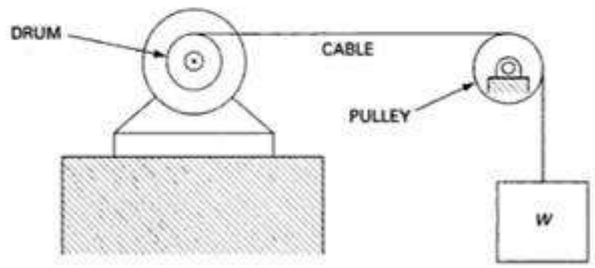
Learning Outcomes:-

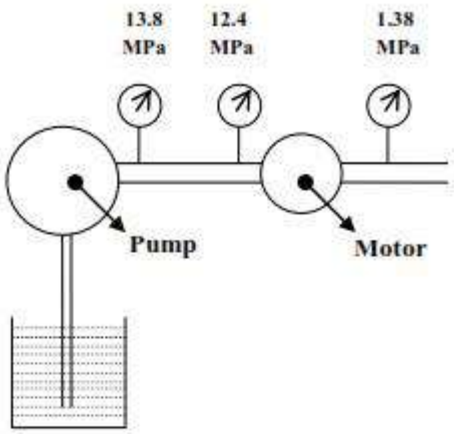
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Describe the construction, operation principles, and uses of hydraulic actuators	CO2	L2	1.3
2. Select actuators for fluid operated systems.	CO1	L3	1.3
3. Determine the performance of motors by calculating the volumetric, mechanical and overall efficiencies.	CO3	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Linear Hydraulic Actuators (cylinders)
2. Mechanics of Hydraulic Cylinder loading, Hydraulic Rotary Actuators,
3. Gear motors,
4. Piston motors,
5. Vane motors,
6. Hydraulic Motor Performance

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. The pressure rating of the components in a hydraulic system is 105 kPa. The system contains a hydraulic motor to turn a 0.3 m radius drum at 30 RPM to lift a weight of load 4000 N as shown in below Fig. Determine the flow rate and brake power if the motor efficiency is 90%. 	TLO3	L3	1.3.1
2. A hydraulic system contains a pump that discharges oil at 13.8 MPa and 0.00632 m^3 / s to a hydraulic motor shown in Fig. 1.15. The pressure at the motor inlet is 12.40 MPa due to pressure drop in the line. If oil leaves the motor at 1.38 MPa, determine the power delivery by the 100% efficient	TLO3	L3	1.3.1

motor.\n(a) What torque would a hydraulic motor deliver at a speed of 1750 RPM if it produces 3 kW?\n(b) If the pressure remains constant at 13.8 MPa, (i) what would be the effect of doubling the speed on the torque and (ii) what would be the effect of halving the speed on the torque?\n 			
3. A hydraulic motor has a displacement of 164 cm^3 and operates with a pressure of 70 bars and a speed of 2000 rpm. If the actual flow rate consumed by the motor is 0.006 m^3 and the actual torque delivered by the motor is 170 N – m. Compute i) vol. Efficiency ii) mechanical efficiency, iii) overall efficiency iv) The actual kW delivered by the motor.	TLO3	L3	1.3.1

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **3. Hydraulic Valves**	Planned Hours: **7 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Describe the construction, operation principles, and uses of various hydraulic control valves.	CO2	L2	1.3
2. Select control valves for fluid operated systems.	CO2	L2	1.3
3. Classify, draw and recognize the different types of control valves.	CO1	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Classification of Directional Control Valves (based Fluid Path)
2. Classification of Directional Control Valves(Design Characteristics)
3. Classification of Directional Control Valves(Control Method, Construction of Internal Moving Parts)
4. Direction control valves actuating Devices, Symbolic representation as per ISO 1219 and ISO 5599,
5. Pressure control valves,
6. Flow control valves,
7. Proportional valves, servo valves

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Explain pressure reducing valve with a neat figure.	TLO1	L2	1.3.1
2. Explain needle valve with a neat figure.	TLO3	L2	1.3.1

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **4. Hydraulic Circuit Design and Analysis**	Planned Hours: **6 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Construct hydraulic circuits to control single-acting and double-acting cylinders.	CO4	L3	2.1
2. Construct a regenerative circuit and determine the load-carrying capacities.	CO4	L3	2.1
3. Describe the working of a double-pump circuit, cylinder sequencing circuit, a counterbalancing circuit and locked cylinder using pilot check valve.	CO4	L3	2.1
4. Compare series and parallel synchronization circuits.	CO4	L3	2.1
5. Explain the three methods of speed control of a hydraulic cylinder - meter-in, meter-out and bleed-off circuits.	CO4	L3	2.1
6. Describe operation of complete hydraulic circuits drawn using graphical symbols for all components, for a given application.	CO1	L2	1.3
7. Calculate the speed, pressure and load-carrying capacity of hydraulic circuits.	CO4	L3	2.1
8. Describe construction and operation of various Ancillary Hydraulic Devices.	CO2	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Control of single acting and double acting Hydraulic Cylinder, regenerative circuit,
2. Pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application
3. Hydraulic cylinder sequencing circuits, cylinder using pilot check valve
4. Cylinder synchronizing circuits, speed control of hydraulic cylinder: Meter-in circuit, Meter-out circuit and Bleed-off circuit
5. Ancillary Hydraulic Devices: Reservoirs, Accumulators
6. Pressure Intensifiers, Sealing Devices

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Explain the regenerative circuit for a drilling machine.	TLO2	L2	2.1.1
2. Explain a double-pump hydraulic system with the help of a circuit	TLO3	L2	2.1.1

diagram.			
3. Design a car crushing system. The crushing force required is such that a 15 cm diameter cylinder is required at a working pressure of 126.5 kg/cm2. Time for crushing is about 10 s and the stroke required to flatten the car is 254 cm. Compare the power required by the circuit without and with accumulator.	TLO7	L3	2.1.1
4. A double-acting cylinder is hooked up in a regenerative circuit for drilling application. The relief valve is set at 75 bar. The piston diameter is 140 mm and the rod diameter is 100 mm. If the pump flow is 80 LPM, find the cylinder speed and load-carrying capacity for various positions of direction control valve.	TLO7	L3	2.1.1

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **5. Pneumatic Systems**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explain how the choice of medium depends on the application and explain the characteristics of compressed air.	CO2	L2	1.3
2. Classify and explain the working principle of pneumatic actuators.	CO2	L2	1.3
3. Explain the importance of cushioning and seals in air cylinders.	CO2	L2	1.3
4. Describe the cylinder mounting arrangements and cylinder sealing in a pneumatic system.	CO2	L2	1.3
5. Classify, draw and recognize the different types of pneumatic control valves.	CO1	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Structure of Pneumatic control system, Choice of working medium, characteristics of compressed air, Pneumatic Actuators: Types of Linear Actuator or Pneumatic cylinders
2. Types of Linear Actuator or Pneumatic cylinders, Cylinder mountings, Cylinder seals, End cushioning in pneumatic cylinders
3. Pneumatic Control Valves: Direction control valve- types of direction control valves
4. ISO designation of direction control valves, Non return valves, methods of actuation of pneumatic directional control valves
5. Flow control valves, and Pressure control valves

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Explain the working of 3/2 direction control valve with a neat sketch.	TLO5	L2	1.3.1
2. Compare pressure limiting valve and sequence valve.	TLO5	L2	1.3.1

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **6. Pneumatic Circuit Design and Hydraulic Control Systems**	Planned Hours: **9 hrs**

Learning Outcomes:-

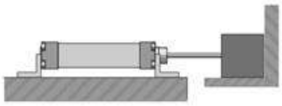
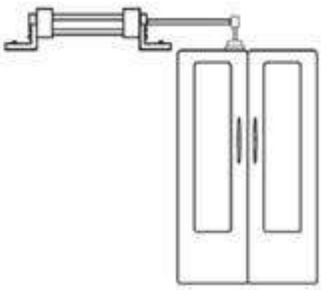
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explain the direct and indirect control of single acting cylinder by constructing the circuit diagram.	CO4	L3	2. 1
2. Explain the direct and indirect control of double acting cylinder by constructing the circuit diagram.	CO4	L3	2. 1
3. Explain memory, delay, OR, AND and NOT functions, pressure dependent controls, time dependent controls and construct the pneumatic circuit diagrams for given applications.	CO4	L3	2.2
4. Compare supply and exhaust air throttling and explain various methods of checking end positions of a cylinder.	CO4	L3	2. 1
5. Discuss valve laps, mechanical feedback, servo control system, system response and stability, pump servo systems, electro hydraulic servo valve system.	CO6	L2	1.3
6. Discuss the force control, force position control, spool positional control, proportional pressure control, and proportional flow control of proportional valves.	CO6	L2	1.3
7. Discuss electrical control of proportional valves.	CO6	L3	2. 2
8. Compare proportional valves and servo valves.	CO6	L2	1.3

Lesson Schedule Class No. - Portion covered per hour / per Class
1. Direct and indirect control of single acting cylinder, Control of single acting cylinder using “or” valve, control of single acting cylinder using “and” valve
2. Control of single acting cylinder using “not” valve, Direct control of a double acting cylinder, Indirect control of double acting cylinder using memory valve
3. Supply air throttling and exhaust air throttling, Various methods of checking end position of a cylinder, Pressure dependent controls and Time dependent controls
4. Servo Control, Valve servo systems: Valve lap, mechanical feedback, systems response
5. Pump servo systems,
6. Proportional valves: Force control, force position control, spool position control, proportional pressure control,
7. Two stage proportional valves, proportional flow control,

8. Electrical control of proportional valve, Proportional versus Servo valves,
9. Applications of proportional control valves.

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. A small single acting cylinder is to extend and clamp a work piece when a push button is pressed. As long as the push button is activated, the cylinder should remain in the clamped position. If the push button is released, the clamp is to retract. Use additional start button. Schematic diagram of the setup is shown in below figure. 	TLO1	L3	2.2.1
2. Pneumatic system is to be designed to operate a door of public transport vehicles. (See below figure) Assuming that the opening and closing of the doors are controlled by two button switches ON and OFF. When the button switch ON is pressed, the door will open. When the button switch OFF is pushed, the doors will close. 	TLO2	L3	2.2.1
3. Discuss how spool position is controlled in a proportional valve.	TLO6	L3	2.2.1
4. Compare proportional valves and servo valves.	TLO8	L2	1.3.1
5. Discuss various types of spool laps of a valve with the help of characteristics curve.	TLO5	L2	1.3.1
6. Derive the expression for system response to unit step input. (Input to the system:Z=1)	TLO5	L3	1.3.1
7. Derive the expression for system response to a ramp input and write the conclusion using the graph. (Input $Z = Vt$)	TLO5	L3	1.3.1
8. Discuss the points to increase the undamped natural frequency of a system.	TLO5	L3	1.3.1
9. Explain single stage proportional valve with a neat sketch.	TLO6	L2	1.3.1
10. Discuss the electrical control of proportional valves with the help of block diagram.	TLO7	L2	1.3.1
11. Explain proportional pressure-reducing valve with a neat sketch	TLO6	L2	1.3.1
12. Discuss the various controls of proportional valves	TLO6	L2	1.3.1
13. Explain the difference between force control and position control in proportional control valves.	TLO6	L2	1.3.1
14. Explain two-stage proportional directional control valves with a neat sketch.	TLO6	L2	1.3.1

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **7. Electro Pneumatics**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Describe the constructional details of solenoid valves and explain the operations of limit switches, sensors, timers, counters and pressure switches.	CO2	L2	1.3
2. Explain the direct and indirect control of single acting cylinder by constructing the electro pneumatic circuits.	CO4	L2	2.2
3. Explain the direct and indirect control of double acting cylinder by constructing the electro pneumatic circuits.	CO4	L2	2.2

Lesson Schedule Class No. - Portion covered per hour / per Class
1. Basic electrical devices - Manually actuated push button switches, Limit switches, Pressure switches, Solenoids
2. Solenoids, Relays, Timers, Temperature switches
3. Direct and indirect control of single acting cylinders using electro pneumatics
4. Direct and indirect control of double acting cylinders using electro pneumatics
5. Control of double acting cylinder OR logic (Parallel circuit), Control of double acting cylinder AND logic.

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Explain the function of a pressure switch with a neat sketch	TLO1	L2	1.3.1
2. Explain direct control of double acting cylinder with the electro pneumatic circuit diagram.	TLO3	L2	2.2.1
3. With electro pneumatic circuit diagram, discuss how a double acting cylinder is controlled using 5/2 way, double solenoid	TLO3	L2	2.2.1
4. Explain the working principle of an electromagnetic relay with a neat sketch.	TLO1	L2	1.3.1
5. Draw the electro pneumatic circuit diagram of indirect control of single acting cylinder.	TLO2	L2	2.2.1
6. Discuss direct control of automatic return of a double acting cylinder using double solenoid with electro pneumatic circuit diagram.	TLO3	L2	2.2.1
7. Discuss control of double acting cylinder using OR logic, with electro pneumatic circuit diagram.	TLO3	L2	2.2.1

Chapter wise Plan

Course Code and Title: **18EARC308 / Hydraulics and Pneumatics**	
Chapter Number and Title: **8. Hydraulic System Maintenance**	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explain the common faults in a hydraulic systems, causes and problems caused by contamination and contamination control.	CO5	L2	1.3
2. Explain how filters and pumps are maintained and discuss the guidelines for maintenance of hydraulic systems.	CO5	L2	1.3
3. Discuss the points for fault diagnosis of a hydraulic system.	CO5	L2	1.3

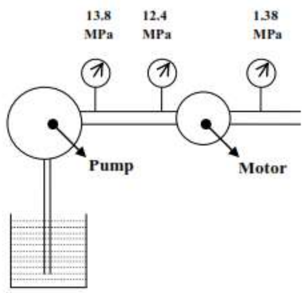
Lesson Schedule Class No. - Portion covered per hour / per Class
1. Common faults in a hydraulic systems
2. Filter and filter maintenance
3. Pump maintenance
4. Hydraulic system maintenance
5. Fault diagnosis of Hydraulic system

Review Questions

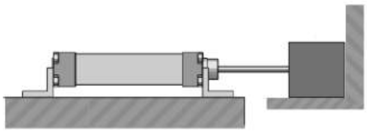
Sl.No. - Questions	TLOs	BL	PI Code
1. Explain common causes in a hydraulic system.	TLO2	L2	1.3.1
2. Discuss the points to enhance filter life.	TLO2	L2	1.3.1
3. Explain any five problems caused by contamination.	TLO1	L2	1.3.1
4. Explain any five causes of contamination	TLO1	L2	1.3.1
5. Discuss any ten guidelines for proper upkeep of the hydraulic system.	TLO3	L2	1.3.1

KLE Technological University
Creating Value Leveraging Knowledge
Department of Automation and Robotics

Question Paper Title: Model Question Paper for Minor-I (ISA-1)	
Course :Hydraulics and Pneumatics	**Course Code : 18EARC308**
Total Duration (H:M):1hr : 15 min	**Maximum Marks :40**
Note: Answer any two full questions	

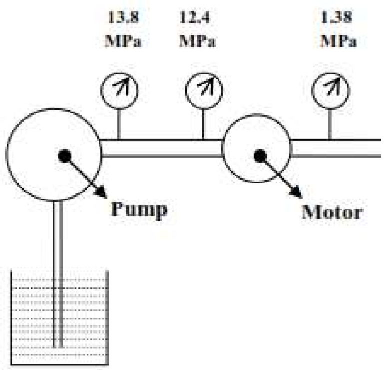
Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain the operation of an internal gear pump with a neat sketch.	5	CO2	L2	1	1.3.1
1b	What is a pressure-compensated vane pump and how does it work?	5	CO2	L2	1	1.3.1
1c	A pump has a displacement volume of 98.4 cm^3. It delivers 0.0152 m^3/s of oil at 1000 RPM and 70 bar. If the prime mover input torque is 124.3 Nm. What is the overall efficiency of pump? What is the theoretical torque required to operate the pump?	10	CO3	L3	1	1.3.1
2a	Explain the working of gear motor with a neat sketch.	5	CO2	L2	1	1.3.1
2b	Explain the operation of double acting cylinder with a piston rod on one side.	5	CO2	L2	1	1.3.1
2c	2. A hydraulic system contains a pump that discharges oil at 13.8 MPa and 0.00632 m^3 / s to a hydraulic motor shown in Fig. 1.15. The pressure at the motor inlet is 12.40 MPa due to pressure drop in the line. If oil leaves the motor at 1.38 MPa, determine the power delivery by the 100% efficient motor. (a) What torque would a hydraulic motor deliver at a speed of 1750 RPM if it produces 3 kW? (b) If the pressure remains constant at 13.8 MPa, (i) what would be the effect of doubling the speed on the torque and (ii) what would be the effect of halving the speed on the torque? 	10	CO3	L3	1	1.3.1
3a	Draw a schematic of 3/2 DCV that is manually operated and briefly explain its function.	5	CO1	L2	1	1.3.1
3b	Draw a schematic of 4/3 DCV that is direct operated electrically and briefly explain its function.	5	CO1	L2	1	1.3.1
3c	Discuss the application of a sequence valve used in hydraulic systems with circuit diagram.	10	CO2	L2	1	1.3.1

Question Paper Title: Model Question Paper for Minor-II (ISA-2)	
Course :Hydraulics and Pneumatics	**Course Code : 18EARC308**
Total Duration (H:M):1hr : 15 min	**Maximum Marks :40**
Note: Answer any two full questions	

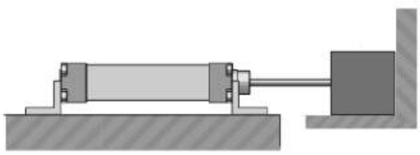
Q. No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain a double-pump hydraulic system with the help of a circuit diagram.	5	CO4	L2	1	2.1.1
1b	Explain the construction and operation of piston-type accumulators.	5	CO2	L2	1	1.3.1
2b	Two double-acting cylinders are to be synchronized by connecting them in series. The load acting on each cylinder is 4000 N. If one of the cylinders has the piston diameter 50 mm and rod diameter 28 mm, find the following: (a) The diameter of the second cylinder. (b) Pressure requirement of the pump. (c) Power of the pump in kW if the cylinder velocity is 4 m/s.	10	CO3	L3	1	1.3.1
1c	Explain the functions and working of basic components required for a pneumatic system with a simple sketch.	5	CO2	L2	1	1.3.1
2a	Explain the working of 3/2 Direction control valve with a neat sketch.	5	CO2	L2	1	1.3.1
2c	i. Explain with the help of neat sketch the construction and working of quick exhaust valves ii. How do 2/2 way differ from 4/2 way pneumatic Direction control valve.	10	CO2	L3	1	1.3.1
3a	Explain supply and exhaust air throttling with neat circuit diagrams.	5	CO4	L3	1	2.1.1
3b	With circuit diagram, discuss how single acting cylinder is controlled using OR valve.	5	CO4	L2	1	2.2.1
3c	A small single acting cylinder is to extend and clamp a work piece when a push button is pressed. As long as the push button is activated, the cylinder should remain in the clamped position. If the push button is released, the clamp is to retract. Use additional start button. Schematic diagram of the setup is shown in below figure. 	10	CO4	L3	2	2.2.1

Question Paper Title: Model Question Paper for End Semester Assessment	
Course :Hydraulics and Pneumatics	**Course Code : 18EARC308**
Total Duration (H:M):3 hr : 00 min	**Maximum Marks : 100**
Note :Answer Five Questions: Any two full questions from each Unit I & Unit II and one full question from Unit III	

UNIT - I

Q. No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain the operation of an internal gear pump with a neat figure.	5	CO2	L2	1	1.3.1
1b	What is a pressure-compensated vane pump and how does it work?	5	CO2	L2	1	1.3.1
1c	A pump has a displacement volume of 98.4 cm^3. It delivers 0.0152 m^3/s of oil at 1000 RPM and 70 bar. If the prime mover input torque is 124.3 Nm. What is the overall efficiency of pump? What is the theoretical torque required to operate the pump?	10	CO3	L3	1	1.3.1
2a	Explain the working of gear motor with a neat sketch.	5	CO2	L2	1	1.3.1
2b	Explain the operation of double acting cylinder with a piston rod on one side.	5	CO2	L2	1	1.3.1
2c	A hydraulic system contains a pump that discharges oil at 13.8 MPa and 0.00632 m^3 / s to a hydraulic motor shown in Fig. 1.15. The pressure at the motor inlet is 12.40 MPa due to pressure drop in the line. If oil leaves the motor at 1.38 MPa, determine the power delivery by the 100% efficient motor. (a) What torque would a hydraulic motor deliver at a speed of 1750 RPM if it produces 3 kW? (b) If the pressure remains constant at 13.8 MPa, (i) what would be the effect of doubling the speed on the torque and (ii) what would be the effect of halving the speed on the torque? 	10	CO3	L3	1	1.3.1

3a	Draw a schematic of 3/2 DCV that is manually operated and briefly explain its function.	5	CO2	L2	1	1.3.1
3b	Draw a schematic of 4/3 DCV that is direct operated electrically and briefly explain its function.	5	CO2	L2	1	1.3.1
3c	Discuss the application of a sequence valve used in hydraulic systems with circuit diagram.	10	CO2	L2	1	1.3.1

UNIT - II						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
4a	Explain a double-pump hydraulic system with the help of a circuit diagram.	5	CO4	L3	2	2.1.1
4b	Explain the construction and operation of piston-type accumulators.	5	CO2	L2	1	1.3.1
4c	Two double-acting cylinders are to be synchronized by connecting them in series. The load acting on each cylinder is 4000 N. If one of the cylinders has the piston diameter 50 mm and rod diameter 28 mm, find the following: (a) The diameter of the second cylinder. (b) Pressure requirement of the pump. (c) Power of the pump in kW if the cylinder velocity is 4 m/s.	10	CO3	L3	1	1.3.1
5a	Explain the functions and working of basic components required for a pneumatic system with a simple sketch.	5	CO2	L2	1	1.3.1
5b	Explain the working of 3/2 Direction control valve with a neat sketch.	5	CO2	L2	1	1.3.1
5c	i. Explain with the help of neat sketch the construction and working of quick exhaust valves ii. How do 2/2 way differ from 4/2 way pneumatic Direction control valve.	10	CO2	L2	1	1.3.1
6a	Explain supply and exhaust air throttling with neat circuit diagrams.	5	CO4	L2	2	2.1.1
6b	With circuit diagram, discuss how a single acting cylinder is controlled using OR valve.	5	CO4	L2	2	2.2.1
6c	A small single acting cylinder is to extend and clamp a work piece when a push button is pressed. As long as the push button is activated, the cylinder should remain in the clamped position. If the push button is released, the clamp is to retract. Use additional start button. Schematic diagram of the setup is shown in below figure. 	10	CO4	L3	2	2.2.1

UNIT - III						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
7a	Explain the function of a pressure switch with a neat sketch.	5	CO2	L2	1	1.3.1
7b	Explain the working principle of a limit switch.	5	CO2	L2	1	1.3.1
7c	With electro pneumatic circuit diagram, discuss how a double acting cylinder is controlled using 5/2 way, double solenoid.	10	CO4	L2	2	2.2.1
8a	Explain common causes in a hydraulic system.	5	CO5	L2	1	1.3.1
8b	Explain the problems caused by contamination.	5	CO5	L2	1	1.3.1
8c	i. Explain any five points to enhance filter life. ii. Explain the initial three tests to be run on hydraulic oil.	10	CO5	L2	1	1.3.1

FMTH0301/Rev.5.3

Course Plan

Semester: **5** Year: 2021-2022

Course Title: **Mechatronics System Design**	Course Code: 18EARC304
Total Contact Hours: **50 hours**	Duration of ESA: **3 hours**
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr. Doddabasappa Marebal	Date: 07-08-2021
Checked By: Prof. Arun C. Giriyapur	Date: 09-08-2021

Course Outcomes (COs):

At the end of the course the student should be able to:

I. Demonstrate knowledge of Mechatronic systems by identifying the basic elements and structure of integrated Mechanical-electronic systems and Methodology of Mechatronic system and design.

II. Demonstrate knowledge and skill of the basics of theoretical modelling and experimental modelling, the static and dynamic behaviour of lumped parameter processes in a general form and by a unified methodology for different physical domains by modelling the static and dynamic relations between the input, state, and output variables of components, subsystems, and systems.

III. Demonstrate knowledge of different types of electric drives and develop skill by selecting suitable motor for the application, size the motor in terms of power, torque and speed based on the load requirement and the characteristics of the motor and use them in model based designs.

IV. Demonstrate knowledge of model based methods for design and control of Mechatronic systems using UML and SysML as well as developing models of systems using the identification method.

V. Demonstrate knowledge of the recent trends and developments in the mechatronics system design process and the use of Artificial neural networks and Fuzzy-logic models and discussing modeling and control of case studies depicting the mechatronics system design process.

VI. Demonstrate the skill of designing a mechatronics application as a course project and should be able to model the system.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Mechatronics System Design														Semester: 5
Course Code: 18EARC304														Year: 2021 - 2022
Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Demonstrate knowledge of Mechatronic systems by identifying the basic elements and structure of integrated Mechanical-electronic systems and Methodology of Mechatronic system and design.	H													
2. Demonstrate knowledge and skill of the basics of theoretical modelling and experimental modelling, the static and dynamic behaviour of lumped parameter processes in a general form and by a unified methodology for different physical domains by modelling the static and dynamic relations between the input, state, and output variables of components, subsystems, and systems.	L													
3. Demonstrate knowledge of different types of electric drives and develop skill by selecting suitable motor for the application, size the motor in terms of power, torque and speed based on the load requirement and the characteristics of the motor and use them in model based designs.	M													
4. Demonstrate knowledge of model based methods for design and control of Mechatronic systems using UML and SysML as well as developing models of systems using the identification method.	H													
5. Demonstrate knowledge of the recent trends and developments in the mechatronics system design process and the use of Artificial neural networks and Fuzzy-logic models and discussing modeling and control of case studies depicting the mechatronics system design process.	L													
6. Demonstrate the skill of designing a mechatronics application as a course project and should be able to model the system.	L													

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.4 - Demonstrate the competence in engineering knowledge appropriate to automation and robotics program	1.4.1 - Apply discipline specific laws and principles to solve an interdisciplinary engineering problem

Eg: 1.2.3: Represents Program Outcome ‘1’, Competency ‘2’ and Performance Indicators ‘3’.

Course Assessment Plan

Course Title: Mechatronics System Design Code: 18EARC304				
Course outcomes (COs)	Weightage in Assessment	Assessment Methods		
		Minor Exam 1	Minor Exam 2	ESA
1. Demonstrate knowledge of Mechatronic systems by identifying the basic elements and structure of integrated Mechanical-electronic systems and Methodology of Mechatronic system and design.	16.6%	✓		✓
2. Demonstrate knowledge and skill of the basics of theoretical modelling and experimental modelling, the static and dynamic behaviour of lumped parameter processes in a general form and by a unified methodology for different physical domains by modelling the static and dynamic relations between the input, state, and output variables of components, subsystems, and systems.	16.6%	✓		✓
3. Demonstrate knowledge of different types of electric drives and develop skill by selecting suitable motor for the application, size the motor in terms of power, torque and speed based on the load requirement and the characteristics of the motor and use them in model based designs.	16.6%		✓	✓
4. Demonstrate knowledge of model based methods for design and control of Mechatronic systems using UML and SysML as well as developing models of systems using the identification method.	16.6%		✓	✓
5. Demonstrate knowledge of the recent trends and developments in the mechatronics system design process and the use of Artificial neural networks and Fuzzy-logic models and discussing modeling and control of case studies depicting the mechatronics system design process.	16.6%			✓
6. Demonstrate the skill of designing a mechatronics application as a course project and should be able to model the system.	16.6%			✓
Weightage	100%	25%	25%	50%

Course Code: 18EARC304	Course Title: Mechatronics System Design	
L-T-P : 4-0-0	Credits: 4	Contact Hrs: 50 hours
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50 hours		Exam Duration: 3 Hrs

Content	Hrs
Unit - I	
Chapter No. 1. Introduction to Mechatronics Systems and elements Introduction to Mechatronic Systems and Design, Mechatronic systems in Precision mechanics, Micromechanics and Process Engineering, Confinement of Mechatronic Systems, Functions, Distribution of Mechanical and Electronic Functions, Integration Forms of Processes and Electronics, Ways of Information Processing, Multi-level Control Systems, Special Signal Preprocessing, Design Procedures for Mechatronics Systems, V model	8
Chapter No. 2. Modeling of Processes Theoretical and Experimental Modeling, Classification of Process Elements , Process Elements with Lumped and Distributed Parameters, Mechanical System model, Mechanical Elements : Bars, Springs, Dampers, Mechanical Systems with Friction, Backlash, Electrical System model, Analogies between Mechanical and Electrical Systems, Dynamics of Mechanical Systems, Newton's Laws of Kinetics, Translational and Rotational Motion, Principles of Mechanics, d'Alembert's Principle, Lagrange's Equations, Problems.	12
Unit - II	
Chapter No. 3. Electrical Drives Types of Electrical Drives, Electromagnets, Direct Current Motors, Dynamic Behavior, Static Behavior, Special Types of DC Motors, Alternating Current Motors (AC), Induction Motors, Synchronous Motors, Single-phase Motors, Commutator Motors (Universal Motors), Squirrel-cage Motors, Power Electronics Circuits, Internally or Externally Commutated Electro-motors, Electrical Motor Sizing and Selection Procedure, Electric Motor Operational Conditions, Motion Profile, Load Torque Calculation, Motor Shaft Torque Calculation, Load Torque–Speed Profile, DC Motor Parameter Estimation, Process Dynamics Particularities, Electrical Binary Actuators.	10
Chapter No. 4. Model based Design of Systems & Identification Introduction to model based design ,Basic block diagrams, Model-based Methods of Control, Supervision and Fault Diagnosis, Intelligent Systems, Non-linear Control and Fault Detection, Model-based Compensation of Nonlinearities, Modeling and Fault Diagnosis, Examples for the Design of Mechatronic Systems using UML and SysML, Identification Methods, classification of Identification Methods,Test Signals, Closed-loop Identification, Type of Application, Parameter Estimation for Discrete Time-varying Systems, Non-linear Processes, Problems.	10
Unit - III	
Chapter No. 5. Recent trends in Mechatronics System Design process Mechatronics systems contributing to economic growth, Changes in technological processes and products, Tools and methods in mechatronics system design and development, Use of Artificial Neural Networks and Fuzzy-logic Models , Fields of application, Future Mechatronics systems.	5
Chapter No. 6. Case studies Dynamic Models of an Electromagnetic actuator, Control Prototyping and Hardware-in-the-loop Simulation, Rapid Control Prototyping for Engine Control, Hardware-in-the-loop Simulation for Industrial Robot, Process control system.	5

Text Books

1. Rolf Isermann, “Mechatronic Systems: Fundamentals”, Springer, 1st edition, 2005.
2. Alexandru Forrai, “Embedded Control System Design:A Model Based Approach”, Springer, 1st edition, 2013.
3. Patrick O.J. Kaltjob, “Mechatronic Systems and Process Automation: Model-Driven Approach and Practical Design Guidelines”, CRC Press, 1st edition, 2018.
4. Norman S. Nise, “Control Systems Engineering”, John Wiley & Sons Inc, Sixth Edition, 2011.

Reference Books

1. Devdas Shetty, Richard A. Kolk, “Mechatronics System Design”, Cengage Learning, Second edition, 2010.
2. “Mechatronics Handbook” Edited by Robert Bishop.CRC Press, 2002.
3. Loan D, Landau, Gianluca and Zito, “Digital Control Systems: Design, Identification and Implementation”, Springer, 2006.
4. George Pelz, “Mechatronic Systems: Modeling and Simulation with HDL”, Wiley, 2003
5. Wei Wu, “Model-Based Design for Effective Control System Development”, IGI Global, 1 edition, 2017.

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
Minor Exam-1	25
Minor Exam-2	25
Total	50

Course Unitization for Minor Exams and End Semester Assessment

Topics / Chapters	Teaching Hours	No. of Questions in Minor Exam-1	No. of Questions in Minor Exam-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
1.Introduction to Mechatronics Systems and elements	8	1.25	--	--	1.25
2.Modeling of Processes	12	1.75	--	--	1.75
Unit II					
3. Electric Drives	10	--	1.5	--	1.5
4.Model based Design of Systems & Identification	10	--	1.5		1.5
Unit III					
5.Recent trends in Mechatronics System Design process	5	--	--	--	1.00
6. Case studies	5	--	--	--	1.00

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in Minor I, II and ESA
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date: 08-08-2021

Head of Department

Chapter wise Plan

Course Code and Title: **18EARC304/ Mechatronics System Design**	
1. Chapter Number and Title: 1**.** Introduction to Mechatronics Systems and elements	Planned Hours: **8**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLO)	COs	BL	CA Code
1. Describe the development of Mechatronic systems from mechanical systems, considering the domains of mechanical engg. and precision mechanics	CO1	L2	1.4
2. Explore the development of intelligent and adaptive mechatronic systems	CO1	L2	1.4
3. Describe the design procedures for Mechatronics systems	CO2	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to Mechatronic Systems and Design 2. Mechanical Systems in Precision Mechanics, Micromechanics and process Engineering 3. Confinement of Mechatronic Systems, Functions 4. Distribution of Mechanical Functions 5. Distribution of Electronic Functions 6. Ways of Information Processing , Multi-level Control Systems 7. Design Procedures for Mechatronic Systems 8. V model

Review Questions

Sl.No. - Questions	TLO	BL	PI Code
1. Describe the evolution of mechanical systems into mechatronics systems	1	L2	1.4.1
2. Explain the integration strategies used in Mechatronics systems	1	L2	1.4.1
3. Explain the interrelation between design and construction of mechatronics system	1	L2	1.4.1
4. Explain the classification of mechatronics systems with examples.	2	L2	1.4.1
5. Describe the design procedures for building Mechatronics systems.	3	L2	1.4.1

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **2.**Modeling of Processes	Planned Hours:**12**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Describe the need and role of theoretical /mathematical modeling of technical processes belonging to mechanics, electrical, electronics.	CO2	L3	1.4
2. Describe the mathematical models of mechanical system using Spring-mass-damper systems and of electrical systems, using R,L,C elements, lumped and distributed parameters with examples.	CO2	L3	1.4
3. Describe the analogy between mechanical and electrical systems with examples.	CO2	L3	1.4
4. Explore the mathematical modeling of mechanical systems with mobile masses to explain their dynamic behavior using d'Alembert's Principle, Lagrange's Equations.	CO2	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
9. Theoretical and Experimental Modeling 10. Classification of Process Elements 11. Process Elements with Lumped and Distributed Parameters 12. Mechanical System model 13. Mechanical Elements 14. Mechanical Systems with Friction, Backlash 15. Electrical System model 16. Analogies between Mechanical and Electrical Systems 17. Dynamics of Mechanical Systems 18. Newton's Laws of Kinetics, Translational and Rotational Motion 19. Principles of Mechanics, d'Alembert's Principle 20. Lagrange's Equations, Problems.

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. An undamped spring-mass system oscillates at 1 kHz. The mass is 0.1 g. Calculate the spring constant c. Design an electrical inductance-capacitance system with the same frequency by using coils from loud speakers with L = 3 mH.	1	L3	1.4.1
2. State the analogies between an electrical RLC element and a mechanical element (mass-damper-spring) for the signals and the parameters and the	2	L3	1.4.1

across-through classification.			
3. What are the differences between constitutive and phenomenological equations? To which type of equations belong: Ohm's law, induction law, heat conduction, Newton's laws?	3	L3	1.4.1
4. Derive the equations of motion of the torsional system, consisting of two rotational masses, for the given example, by applying Lagrange equations.	4	L3	1.4.1
5. Two masses m_1 and m_2 are coupled together by a linear spring (C_l) and a linear damper (d_l) (dashpot). Mass m_2 is connected by a linear second spring (C_2) and damper (d_2) with a wall. Derive the equations for the positions $z_1(t)$ and $z_2(t)$ for the masses if a force $F_1(t)$ acts on mass m_1 by applying Lagrange equations.	4	L3	1.4.1
6. A robot arm of length l = 1 m carries a load of m = 100 kg with an angle of ϕ = 30 ° to the horizontal axis. Derive the equations of motion with torque $T_1(t)$ as input and $\phi_1(t)$ as output signal. Linearize the equations around the operation point (mass and damping of robot arm is negligible).	4	L3	1.4.1
7. Calculate the torsional spring stiffness c of a steel rod with length l = 1 m and diameter d = 0.01 m.	4	L3	1.4.1
8. Determine the force-displacement characteristics of an air spring for d=0.1 m and l = 0.3 m.	4	L3	1.4.1

Model Question Paper for Minor - I Examination (ISA)						
Course Code: 18EARC304	Course Title: Mechatronics System Design					
Duration: 1hr : 15 Min	Max. Marks: 40					
Note: Answer any two full questions						
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Describe the evolution of mechanical systems into mechatronics systems with a neat block diagram.	8	CO1	L2	1	1.4.1
1b	Explain the interrelation between design and construction of mechatronics systems	6	CO1	L2	1	1.4.1
1c	Explain the salient features of mechatronics systems	6	CO1	L2	1	1.4.1
2a	Discuss the V design model for mechatronics systems.	8	CO1	L2	1	1.4.1
2b	An un-damped spring-mass system oscillates at 1 kHz. The mass is 0.1 g. Calculate the spring constant c. Design an electrical inductance-capacitance system with the same frequency by using coils from loud speakers with L = 3 mH.	6	CO2	L3	1	1.4.1
2c	State the analogies between an electrical RLC element and a mechanical element (mass-damper-spring) for the signals and the parameters and the across-through classification.	6	CO2	L3	1	1.4.1
3a	Two masses m_1 and m_2 are coupled together by a linear spring (C_l) and a linear damper (d_l) (dashpot). Mass m_2 is connected by a linear second spring (C_2) and damper (d_2) with a wall. Derive the equations for the positions $z_1(t)$ and $z_2(t)$ for the masses if a force $F_1(t)$ acts on mass m_1 by applying Lagrange equations.	8	CO2	L3	1	1.4.1
3b	A robot arm of length l = 1 m carries a load of m = 100 kg with an angle of ϕ = 30° to the horizontal axis. Derive the equations of motion with torque $T_1(t)$ as input and $\phi_1(t)$ as output signal. Linearize the equations around the operation point (mass and damping of robot arm is negligible).	6	CO2	L3	1	1.4.1
3c	A mass m follows a parabolic trajectory $y = cx^2$ under the influence of gravity. Derive the equation of motion for $x(t)$ by using the Lagrange equation.	6	CO2	L3	1	1.4.1

Chapter wise Plan

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **3.** Electrical Drives	Planned Hours: **10**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Describe the construction and mathematical modeling of electromagnets, DC and AC motor types.	CO3	L3	1.4
2. Describe the role of power electronic circuits used in electric drive systems.	CO3	L3	1.4
3. Explain the motor sizing and selection procedures with examples.	CO3	L3	1.4
4. Explore the static and dynamic behavior of mechatronics systems using the mathematical models of electromagnetic components	CO3	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
21. Types of Electrical Drives, Electromagnets , Direct Current Motors 22. Dynamic Behavior , Static Behavior 23. Special Types of DC Motors, Alternating Current Motors (AC) 24. Induction Motors, Synchronous Motors , Single-phase Motors 25. Commutator Motors (Universal Motors) ,Squirrel-cage Motors 26. Power Electronics Circuits , Internally or Externally Commutated Electro-motors 27. Electrical Motor Sizing and Selection Procedure, Operational Conditions 28. Motion Profile, Load Torque Calculation 29. DC Motor Parameter Estimation, Process Dynamics Particularities 30. Electrical Binary Actuators

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. For the DC motor with the given datasheet, calculate the torque-speed characteristic for *V*, = 50 V and 100 V.	3	L3	1.4.1
2. Calculate the parameters for the dynamic model of the DC motor. Determine the armature and the mechanical time constant.	4	L3	1.4.1
3. A shunt-wound motor supplied with 200 V runs at 1000 rpm with an armature current of 20 A. The armature resistance is 0.6.	4	L3	1.4.1
4. Calculate the required armature voltage, neglecting friction. Calculate the armature voltage for 500 rpm and the current 10A.	4	L3	1.4.1

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: 4**.**Model based Design of Systems & Identification	Planned Hours: **10**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explore the model based design of systems with examples.	CO4	L3	1.4
2. Describe the non-linear control and Fault detection in Electromagnetic actuator	CO4	L2	1.4
3. Describe the model-based compensation of non-linearities and fault diagnosis	CO4	L3	1.4
4. Discuss Control Prototyping and Hardware-in-the-loop Simulation	CO4	L2	1.4
5. Explain the Identification methods for system or process, test signals, parameter estimation using standard techniques using ANN and Fuzzy Logic models	CO4	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
31. Introduction to model based design ,Basic block diagrams, Model-based Methods of Control 32. Supervision and Fault Diagnosis, Intelligent Systems, 33. Non-linear Control and Fault Detection , Model-based Compensation of Non-linearities, 34. Modeling and Fault Diagnosis 35. Design of Mechatronic Systems using UML and SysML 36. Identification Methods 37. classification of Identification Methods ,Test Signals , 38. Closed-loop Identification , Type of Application, 39. Parameter Estimation for Discrete Time-varying Systems, 40. Non-linear Processes and Problems

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Discuss the example block diagrams to illustrate model based design.	1	L3	1.4.1
2. Write a note on Model-based Methods of Control.	2	L3	1.4.1
3. Explain the scheme for model based supervision and Fault diagnosis	3	L3	1.4.1

4. Explain the general procedure for Identification of systems.	4	L2	1.4.1
5. How are the Identification methods classified? Explain each of them.	4	L2	1.4.1
6. Explain the identification process using Closed Loop configuration.	4	L3	1.4.1
7. Discuss about the non-linear processes using examples and the model based compensation of non-linearities.	5	L3	1.4.1

Model Question Paper for Minor -II Examination (ISA)							
Course Code: 18EARC304		Course Title: Mechatronics System Design					
Duration: 1hr : 15 Min		Duration: 1hr : 15 Min					
Max. Marks: 40		Max. Marks: 40					
Note: Answer any two full questions							
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**	
1a	Discuss the example block diagrams to illustrate model based design.	10	CO4	L2	1	1.4.1	
1b	Write a note on Model-based Methods of Control.	05	CO4	L2	1	1.4.1	
1c	Explain the scheme for model based supervision and Fault diagnosis	05	CO4	L3	1	1.4.1	
2a	Discuss the design of example mechatronics systems using UML/SysML.	10	CO4	L2	1	1.4.1	
2b	Discuss the need for compensation of Non-linearity.	05	CO3	L2	1	1.4.1	
2c	Explain the general procedure for Identification of systems	05	CO4	L3	1	1.4.1	
3a	How are the Identification methods classified? Explain each of them.	05	CO4	L2	1	1.4.1	
3b	Explain the identification process using Closed Loop configuration.	05	CO4	L2	1	1.4.1	
3c	Discuss about the non-linear processes using examples and the model based compensation of non-linearity.	10	CO4	L3	1	1.4.1	

Chapter wise Plan

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **5.** Recent trends in Mechatronics System Design process	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explore the role of mechatronics systems in economic growth.	CO5	L2	1.4
2. Discuss the recent trends in tools ,methods, processes and products associated with mechatronics system design	CO5	L3	1.4
3.List and explain the fields of application of mechatronics systems and future trends in mechatronics systems design	CO5	L2	1.4

Lesson Schedule Class No. - Portion covered per hour
41. Mechatronics systems contributing to economic growth 42. Changes in Technological processes and products 43. Tools and methods in mechatronics system design and development 44. Use of Artificial Neural Networks(ANN) and Fuzzy-logic Models 45. Fields of application, Future Mechatronics systems

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Write a note on the impact of mechatronics systems in the economic growth of the nation as a whole.	1	L2	1.4.1
2. Explain the recent trends in technological processes and products.	2	L2	1.4.1
3. Explain the future of mechatronics system design using ANN and Fuzzy logic based technologies.	3	L2	1.4.1

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **6.**Case studies	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explain the non-linear control and fault detection of Electromagnetic actuator.	CO6	L2	1.4.1
2. Describe the dynamics of Industrial Robot.	CO6	L3	1.4.1

Lesson Schedule Class No. - Portion covered per hour
46. Non-linear Control of Electromagnetic actuator 47. Fault detection of Electromagnetic actuator 48. Dynamics of Industrial Robot 49. Dynamics of Industrial Robot 50. Dynamics of Industrial Robot

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Explain the non-linearity present in an electromagnetic actuator and explain the need to control nonlinearity.	1	L3	1.4.1
2. Discuss the fault detection process of Electromagnetic actuator.	1	L3	1.4.1

Model Question Paper for End Semester Assessment (ESA)	
Course Code: 18EARC304	Course Title:Mechatronics System Design
Duration: 3 hrs	Max. Marks: 100
Note: Answer Five Questions: Any two full questions from each Unit I & Unit II and one full question from Unit III	

UNIT - I

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Describe the evolution of mechanical systems into mechatronics systems with a neat block diagram.	8	CO1	L2	1	1.4.1
1b	Explain the interrelation between design and construction of mechatronics systems	6	CO1	L2	1	1.4.1
1c	Explain the salient features of mechatronics systems	6	CO2	L3	1	1.4.1
2a	Discuss the V design model for Mechatronics systems.	8	CO2	L2	1	1.4.1
2b	An un-damped spring-mass system oscillates at 1 kHz. The mass is 0.1 g. Calculate the spring constant c. Design an electrical inductance-capacitance system with the same frequency by using coils from loud speakers with L = 3 mH.	6	CO2	L2	1	1.4.1
2c	State the analogies between an electrical RLC element and a mechanical element (mass-damper-spring) for the signals and the parameters and the across-through classification.	6	CO2		1	1.4.1
3a	Two masses $m_1$and m_2 are coupled together by a linear spring (C_l) and a linear damper (d_l) (dashpot). Mass m_2 is connected by a linear second spring (C_2) and damper (d_2) with a wall. Derive the equations for the positions $z_1(t)$ and $z_2(t)$ for the masses if a force $F_1(t)$ acts on mass m_1 by applying Lagrange equations.	8	CO2	L3	1	1.4.1
3b	A robot arm of length l = 1 m carries a load of m = 100 kg with an angle of $\phi = 30°$ to the horizontal axis. Derive the equations of motion with torque $T_1(t)$ as input and $\phi_1(t)$ as output signal. Linearize the equations around the operation point (mass and damping of robot arm is negligible).	6	CO2	L3	1	1.4.1
3c	A mass m follows a parabolic trajectory $y = cx^2$under the influenceof gravity. Derive the equation of motion for $x(t)$ by using the Lagrange equation.	6	CO2	L3	1	1.4.1

UNIT - II

Q.No.	Questions	Marks	CO	BL	PO	PI Code
4a	Discuss the example block diagrams to illustrate model based design.	10	CO3	L3	1	1.4.1
4b	Write a note on Model-based Methods of Control.	05	CO3	L3	1	1.4.1
4c	Explain the scheme for model based supervision and Fault diagnosis	05	CO3	L3	1	1.4.1

5a	Discuss the design of example mechatronics systems using UML/SysML.	10	CO3	L2	1	1.4.1
5b	Discuss the need for compensation of Non-linearity.	05	CO3	L2	1	1.4.1
5c	Explain the general procedure for Identification of systems	05	CO4	L3	1	1.4.1
6a	How are the Identification methods classified? Explain each of them.	05	CO4	L2	1	1.4.1
6b	Explain the identification process using Closed Loop configuration.	05	CO4	L2	1	1.4.1
6c	Discuss about the non-linear processes using examples and the model based compensation of non-linearity.	10	CO4	L3	1	1.4.1
UNIT - III						
7a	Explain the recent trends in technological processes and products.	10	CO5	L3	1	1.4.1
7b	Explain the future of mechatronics system design using ANN and Fuzzy logic based technologies.	10	CO5	L3	1	1.4.1
8a	Discuss the fault detection process of Electromagnetic actuator.	10	CO6	L4	1	1.4.1
8b	Discuss the dynamics of Industrial robot.	10	CO6	L4	1	1.4.1

Corrections Note

Sl. No	Changes made in Syllabus	Topic No/ Chapter No

FMTH0301/Rev.5.3

Course Plan

Semester: **V Sem** Year: 2019-20

Course Title: **Programming Industrial Automation Systems**	Course Code: 18EARC302
Total Contact Hours: **50**	Duration of ESA Hours: 3
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr Shridhar T Doddamani	Date: 16-07-2020
Checked By: Prof. A C Giriyapur	Date: 17-07-2020

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Demonstrate knowledge of basic terminologies and configurations of Programmable logic Controllers (PLC) along with signal conditioning circuitry, networking, and error checking and diagnostics facility available with PLC.
2. Demonstrate the knowledge of standards IEC 61131 and IEC61499 and solve problems using PLC programming methods such as Instruction List (IL), Ladder diagram (LD), Function Block (FB), Sequential Function Chart (SFC), Structured Text (ST) as per IEC61131-3 standard.
3. Demonstrate the ability to use advanced PLC functions to implement sequencing, flow control, arithmetic operation, data handling, data transfer, network communication and analog operation.
4. Explain the steps in building PLC based control application using development cycle by designing the PLC system layout, follow up of Start-Up and Checking Procedures, estimating power requirements , analyzing voltage , heat and noise considerations, incorporating of safety and fault diagnosis methods, following systematic wiring methods, acquiring knowledge of safety standards like NEMA & NEC and maintenance procedures.
5. Describe the technologies and advantages of using PC based automation, Programmable Automation Controllers (PAC), Supervisory Digital Control and Data Acquisition (SCADA) system and Distributed Control Systems (DCS).
6. Discuss the factors affecting PLC system selection, classifying PLCs based on sizes and scopes of applications, use of electrical relay diagram symbols and systematic documentation procedures.
7. Present a group wise demo by simulating the PLC logic solution by solving PLC based control system case studies like automatic material handling mechanisms, robotic applications and process control applications etc.
8. Select in teams through literature survey, the real world problems that can be solved using PLC logic control, prepare a survey report based on literature survey and present the report.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: Programming Industrial Automation Systems	Semester: V Sem
Course Code: 18EARC302	Year: 2019-20

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
i. Demonstrate knowledge of basic terminologies and configurations of Programmable logic Controllers (PLC) along with signal conditioning circuitry, networking, and error checking and diagnostics facility available with PLC.	**L**												**M**	
ii. Demonstrate the knowledge of standards IEC 61131 and IEC61499 and solve problems using PLC programming methods such as Instruction List (IL), Ladder diagram (LD), Function Block (FB), Sequential Function Chart (SFC), Structured Text (ST) as per IEC61131-3 standard.	**M**	**M**											**M**	
iii. Demonstrate the ability to use advanced PLC functions to implement sequencing, flow control, arithmetic operation, data handling, data transfer, network communication and analog operation.	**M**	**M**	**M**										**M**	
iv. Explain the steps in building PLC based control application using development cycle by designing the PLC system layout, follow up of Start-Up and Checking Procedures, estimating power requirements , analyzing voltage , heat and noise considerations, incorporating of safety and fault diagnosis methods, following systematic wiring methods, acquiring knowledge of safety standards like NEMA & NEC and maintenance procedures.	**M**					**M**							**M**	
v. Describe the technologies and advantages of using PC based	**M**												**M**	

automation, Programmable Automation Controllers (PAC), Supervisory Digital Control and Data Acquisition (SCADA) system and Distributed Control Systems (DCS).														
vi. Discuss the factors affecting PLC system selection, classifying PLCs based on sizes and scopes of applications, use of electrical relay diagram symbols and systematic documentation procedures.	**M**												**M**	
vii. Present a group wise demo by simulating the PLC logic solution by solving PLC based control system case studies like automatic material handling mechanisms, robotic applications and process control applications etc.	**M**	**M**	**M**	**M**	**H**	**M**		**M**	**H**	**M**		**M**	**M**	**M**
viii. Select in teams through literature survey, the real world problems that can be solved using PLC logic control, prepare a survey report based on literature survey and present the report.	**M**	**M**	**M**	**M**	**M**	**M**		**H**	**H**	**H**	**M**	**H**	**M**	**M**

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3 Demonstrate competence in engineering fundamentals	1.3
	1.3
1.4 Demonstrate the competence in engineering knowledge appropriate to automation and robotics program	1.4
2.1 Demonstrate an ability to identify and characterize an engineering problem	2.1.2
	2.1.3
	2.1.4
6.1 Demonstrate the ability to describe engineering roles in a broader context, e.g. as pertains to the environment, health, safety, and public welfare	6.1
6.2 Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2
13.1 Demonstrate an ability to design and integrate simple automation systems	13.1
	13.1

Course Content

Course Code: 18EARC302	Course Title: Programming Industrial Automation Systems	
L-T-P-: 3-0-0	Credits: 4	Contact Hrs: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 hrs

Content	Hrs
Unit - 1	
Chapter No. 01. Programmable logic controllers(PLC) & its building blocks Internal architecture of Programmable Logic Controllers systems, Input/ Output devices, Memory Organization, I/O processing, Signal conditioning, Remote connections, Networks, Processor Scan cycle, Error Checking and Diagnostics.	6 hrs
Chapter No. 02. The IEC 61131 , IEC61499 standards & Ladder , FB, IL, SFC and ST programming IEC 61131-3: Building Blocks , Goals , benefits, , Programming Languages of IEC 61131-3, Ladder diagrams, Analogy with Boolean Algebra and Binary Logic , Function blocks, Instruction lists, Sequential function charts, State chart modelling, Structured text programming with example programs for each, IEC 61499 models: models ,concepts and industrial examples like Temperature control system, Conveyor test station	9 hrs
Chapter No. 03.Advanced PLC functions PLC Sequencer, Shift registers, Program / Flow Control Instructions, Arithmetic Instructions, Data handling Instructions like FIFO, FAL, ONS, Data Transfer Instructions PLC MOVE, PLC Matrix functions, Network Communication Instructions, Analog PLC operation, PID control of continuous processes.	5 hrs
Unit - 2	
Chapter No. 04.Designing systems, PLC Start-up & Maintenance PLC Core application development, Development Cycle, Safe systems, Commissioning, Fault finding, PLC System Layout , Power Requirements and Safety Circuitry , Noise, Heat, and Voltage Considerations,, I/O Installation, System wiring strategies, and Precautions ,Safety Standards like NEMA & NEC, Electrical wiring diagrams PLC Start-Up and Checking Procedures , PLC System Maintenance & Troubleshooting	10 hrs
Chapter No. 05. PC based Automation, SCADA Technologies and advantages of PC based Automation, Programmable Automation Controller systems (PACs) for Industrial control , Comparison of PLC with PAC Supervisory Digital Control and Data Acquisition (SCADA) system & Distributed Control Systems(DCS): SCADA Hardware and software ,Open SCADA protocols like DNP3 and IEC60870,	10 hrs
Unit - 3	
Chapter No. 06. DCS & Field Bus Overview of DCS, Network Standards: Device net, CAN bus, Control Net, Profibus, Sercos, EtherCAT, Ethernet Powerlink, Comparison of each of them with other network standard.	5 hrs

Chapter No. 07. System Selection Guidelines & Commissioning PLC Selection process ,estimation of program memory and time requirements, PLC Sizes and Scope of applications, Special I/O modules, Electrical relay diagram symbols, Fail Safe Design, IEC 61508/61511 safety standards, Process modeling, Programming for large systems ,Control system documentation & Commissioning	5 hrs

Text Book (List of books as mentioned in the approved syllabus)

- John W. Webb & Ronald A Reis , "Programmable Logic Controllers: Principles and Applications ", Fifth Edition, PHI, 2012
- W. Bolton , Programmable Logic Controllers , Fourth Edition, ELSEVIER, 2009

References

- Frank D. Petruzella , Programmable Logic Controllers , McGraw- Hi, 1989
- Siemens , PLC Handbook,

Evaluation Scheme

CIE Scheme

Assessment	Weightage in Marks
Minor Exam1	15
MInor Exam 2	15
Class work/Assignment	20
Total	50

Course Unitization for Minor Exams and End Semester Assessment

Topics / Chapters	Teaching hours	No. of Questions in Minor Exam1	No. of Questions in MInor Exam 2	No. of Questions in Survey paper activity	No. of Questions in Case study presentation
Unit I					
01.Programmable logic controllers(PLC) & its building blocks	4	0.5	--	--	--
02. The IEC 61131 , IEC 61499 standards & Ladder , FB, IL, SFC and ST programming	6	1.5	--	--	--
03.Advanced PLC functions	5	1.00	--	--	--
Unit II					
04.Designing systems, PLC Start-up & Maintenance	7	--	1.50	--	--
05.PC based Automation, SCADA	8	--	1.50	--	--
Unit III					
06. DCS and Field Bus	5	--	--	--	--
07. System Selection Guidelines & Commissioning	5	--	--	1.00	1.00

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in Minor I, II and ESA
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date: 17/07/2020

Head of Department

Chapter wise Plan

Course Code and Title: **18EARC302 Programming Industrial Automation Systems**	
Chapter Number and Title: **01.Programmable logic controllers(PLC) & its building blocks**	Planned Hours: **4 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	CO's	BL	CA Code
1. Explain the basic terminologies, features of controller, Programmable Logic Controllers (PLC)	CO1	L2	13.1
2. Identify the various PLC Hardware units in functional block diagram, internal block diagram	CO1	L2	13.1
3. Explain the specifications, configurations of PLC and different means for programming.	CO1	L2	13.1
4. Describe the working principle of different types of input and output devices , their compatibility with input and output voltage levels of PLC and need for signal conditioning	CO1	L2	1.3
5. Explain the use of remote connections, standards for serial and parallel communication and networking with PLC	CO1	L2	13.1
6. Describe the working of PLC scan cycle, error checking and diagnostics facility	CO1	L2	13.1

Lesson Schedule Class No. - Portion covered per hour
1. Internal architecture of Programmable Logic Controllers systems
2. Input/ Output devices, Memory Organization I/O processing
3. Signal conditioning, Remote connections, Networks 4.0
4. Processor Scan cycle , Error Checking and Diagnostics

Review Questions

Sl.No. - Questions	TLO	BL	CA Code
1. Explain the terms Sourcing and Sinking with reference to PLC	TLO1	L2	1.3
2. Explain the functional components of PLC system with a neat block diagram	TLO1	L2	1.3
3. Explain the features and specification of Industrial PLC with examples	TLO2	L2	1.3

Assignment Questions
1. Explain the features and specification of Industrial PLC with examples 2. Explain the working of a) Proximity sensors b)Photoelectric sensors c) Encoders d) Temperature Sensors e) Position/Displacement sensors f) Strain Gauges g) Pressure sensors h) Liquid level detectors i) Fluid Flow measurement j) Smart Sensors with a neat diagram for each 3. Explain the process of Signal conditioning using example circuits How do input and output devices connected to PLC in remote fashion? 4. Write a note on various Protocols and Handshaking sequences List the features of Networks used with PLCs. 5. Explain with a block diagram about the Control Hierarchy of PLCs in Distributed systems

Course Code and Title: **18EARC302 Programming Industrial Automation Systems**	
Chapter Number and Title: **02. The IEC 61131 , IEC61499 standards & Ladder , FB, IL, SFC and ST programming**	Planned Hours: **6 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	CO's	BL	CA Code
1. Describe the terminology, guidelines , goals and the advantages of the IEC 61131 and IEC 61499 standard	CO2	L2	1.3
2. Explain the features of each PLC programming method and choose appropriate programming method for solving the given problem	CO2	L3	1.3, 1.4
3. Solve the stated problems on real time case studies using Ladder diagram ,Instruction List (IL), Sequential Function Chart (SFC) and Structured Text (ST) method	CO2	L3	1.4
4. Explain the relevance of using state chart modeling	CO2	L2	1.3
5. Demonstrate the conversion of logic circuits built to solve stated problems into ladder diagrams and other programming methods like IL,SFC and ST methods	CO2	L3	1.3,1.4

Lesson Schedule Class No. - Portion covered per hour
1. IEC 61131-3: Building Blocks , Goals , benefits

2. Programming Languages of IEC 61131-3, Ladder diagrams, Analogy with Boolean Algebra and Binary Logic
3. Function blocks, Instruction lists, Sequential function charts, State chart modeling
4. Structured text programming with example programs for each,
5. IEC 61499 models: models ,concepts
6. industrial examples like Temperature control system, Conveyor test station

Review Questions

Sr.No. - Questions	TLO	BL	CA Code
1. Explain the goals and benefits of the standard .	TLO1	L2	1.4
2. Explain the features of Sequential Function Chart and Structured Text programming methods	TLO3	L2	1.4

Assignment Questions

1. Explain about ladder diagrams and the various symbols used.
2. Explain how does a given logic circuit be converted into ladder diagram?
3. What do you mean by Instruction List? Give examples
4. Explain the features of Sequential Function Chart and Structured Text programming methods
5. Differentiate between Ladder program and Instruction List with examples
6. Draw the SFC for the given case study problem based on Industrial control strategies
7. Explain the steps involved in building PLC control logic solution for the stated case study problem
8. Compare the features of SFC and ladder diagram programming Explain the scope and requirements of IEC 61499 models

Course Code and Title: **18EARC302 Programming Industrial Automation Systems**	
Chapter Number and Title: **03.Advanced PLC functions**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	CO's	BL	CA Code
1. Describe the operation of PLC sequencer, shift registers, program/flow control instructions	CO3	L2	1.3
2. Demonstrate the function of FIFO,ONS,FAL functions through timing diagram	CO3	L2	1.3

3. Demonstrate the use of data transfer and network communication instructions	CO3	L2	1.3
4. Describe the operation of analog inputs and output modules of PLC along with supporting examples	CO3	L2	1.3
5. Describe the PID control strategy used for controlling continuous processes	CO3	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. PLC Sequencer, Shift registers, Program / Flow Control Instructions,
2. Arithmetic Instructions, Data handling Instructions like FIFO, FAL, ONS
3. Data Transfer Instructions PLC MOVE, PLC Matrix functions,
4. Network Communication Instructions, Analog PLC operation,
5. PID control of continuous processes.

Review Questions

Sr.No. - Questions	TLO	BL	CA Code
1. Write a note on operation and application of PLC sequencer and shift register	TLO1	L2	1.3
2. Explain about analog processing modules of PLC	TLO2	L2	1.3

Assignment Questions

1. Solve case study problems using program/flow control instructions, arithmetic instructions, data handling instructions
2. Solve case study problems using data handling and data transfer instructions
3. Explain about analog processing modules of PLC
4. Design a Ladder program to solve the given problem using special function instructions like battery backed relay, set – reset, one shot SR latch and master control relay
5. Solve the stated problems using control flow instructions of PLC like jump calls and subroutines
6. Solve the problems on sequencing applications based on timers and counters
7. Demonstrate applications that can be solved using shift registers
8. Solve problems using PLC instructions like Arithmetic and Data Manipulation Instructions ,Data Transfer Instructions , Network Communication Instructions
9. Design a ladder program to demonstrate latching, use of battery backed relays ,master control relay, Set-reset and one shot

10. How do you implement a PLC ladder program with multiple input conditions?
11. Explain the relevance of using Shift registers in any sequencing application of your choice
12. Explain the standard format used for Data handling operations by different manufacturers
13. Explain with a neat block diagram for Closed Loop control using PLC
14. Explain about IEC61131-3 standard symbol for PID control function
15. Demonstrate use of different types of timers for the given case study problem

Question Paper Title: Model Question Paper for ISA -I	
Course : Programming Industrial Automation Systems	**Course Code : 18EARC302**
Total Duration (H:M):1hr : 15	**Maximum Marks :40**
Note :Answer any two full questions	

Q.No.	Questions	Marks	CO	BL	PO	CA Code
1a	Explain the functionalities of individual blocks of PLC with a neat block diagram.	7	CO1	L2	1	1.3
1b	How does the PLC being used for Control Hierarchy in Distributed systems?	7	CO1	L2	1	1.3
1c	How do Sourcing and Sinking I/O modules of PLC interfaced to I/O devices? Explain with examples	6	CO1	L2	1	1.3
2a	Explain the operation of the following input devices, stating the form of the signal being sensed and the output: (a) reed switch, (b) incremental shaft encoder, (c) photoelectric transmissive switch, (d) diaphragm pressure switch.	5	CO2	L3	2	2.2
2b	Explain the scope and requirements of IEC61499 model	7	CO2	L2	13	13.1
2c	Draw the SFC for the given case study problem based on Industrial control strategies	8	CO2	L3	2	2.2
3a	Convert the given Sequential Function Chart to ladder diagram	6	CO3	L3	2	2.1
3b	Why there is a need to follow IEC611-3 standard? Justify.	6	CO3	L2	1	1.3
3c	Draw the function block diagrams to represent: (a) There is to be a motor startup when either switch A or switch B is activated. (b) A motor is to be started when two normally open switches are activated and remain on, even if the first of the two switches goes off but not if the second switch goes off. (c) A pump is to be switched on if the pump start switch is on or a test switch is operated.	8	CO3	L3	2	2.1

Course Code and Title: **18EARC302 Programming Industrial Automation Systems**	
Chapter Number and Title: **04. Designing systems, PLC Start-up & Maintenance**	Planned Hours: **7 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	CO's	BL	CA Code
1. Describe the issues on PLC core development and important stages in the development cycle	CO4	L2	13.1
2. Explain the safety requirements to be incorporated in Automated systems and appreciate the use of safety standards	CO4	L3	6.2
3. Discuss the steps involved in trouble shooting of automated system	CO4	L2	6.2,13.1
4. Explain the considerations with respect to noise, heat, voltage while building a PLC based automated system	CO4	L2	6.1,6.2
5. Discuss the precautions to be taken for system wiring	CO4	L2	6.2
6. Discuss the issues involved in PLC system maintenance and troubleshooting	CO4	L2	6.2

Lesson Schedule Class No. - Portion covered per hour
1. PLC Core application development, Development Cycle
2. Safe systems, Commissioning, Fault finding
3. PLC System Layout , Power Requirements and Safety Circuitry
4. Noise, Heat, and Voltage Considerations, I/O Installation
5. System wiring strategies, and Precautions
6. Safety Standards like NEMA & NEC, Electrical wiring diagrams
7. PLC Start-Up and Checking Procedures , PLC System Maintenance & Troubleshooting

Review Questions

Sr.No. - Questions	TLO	BL	CA Code
1. Enumerate the steps involved in systematic design approach to program development	TLO1	L2	1.3
2. What is “Pseudo code” ? Explain about its usage in sequential and looping sequences	TLO1	L2	1.3
3. Explain the need for power requirements and safety circuitry in PLCs	TLO2	L2	10.2

Assignment Questions
1.0 Identify basic Flow chart symbols and describe the relevance of each
2.0 Describe the importance of safety in PLC based systems with examples
3.0 How are Emergency Stop relays and safety functions used?
4.0 List the steps involved in commissioning of PLC
5.0 What is the need for software for Simulation and Testing of PLC?
6.0 What is the necessity of System documentation in PLC based systems, explain.
7.0 What are the methods of testing inputs and outputs in PLC?
8.0 Write a note on PLC system Layout
9.0 How do environmental factors affect design of system layout
10.0 Discuss the issues involved in wiring
11.0 Discuss the problems due to noise and heat in PLC based systems
12.0 Write a note on precautions to be taken while connecting I/O modules
13.0 Discuss in detail PLC start up and checking procedures
14.0 Explain the issues in PLC maintenance

Course Code and Title: **18EARC302** **Programming Industrial Automation Systems**	
Chapter Number and Title: **05.PC based Automation, SCADA**	Planned Hours: **8 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	CO's	BL	CA Code
1. Describe the scope of PC based Automation	CO5	L3	1.4
2. Compare the advantages of using Programmable Automation Controller systems (PACs) for Industrial control with that of PLC	CO5	L2	1.4
3. Describe the role of Supervisory Digital Control and Data Acquisition (SCADA) system	CO5	L2	1.4
4. Compare the features of Open SCADA protocols like DNP3 and IEC60870	CO5	L3	1.4,13.1

Lesson Schedule

Class No. - Portion covered per hour
1. Technologies and advantages of PC based Automation
2. Programmable Automation Controller systems (PACs) for Industrial control
3.Programmable Automation Controller systems (PACs) for Industrial control
4.Comparison of PLC with PAC Supervisory Digital Control and Data Acquisition (SCADA) system
5. Comparison of PLC with PAC Supervisory Digital Control and Data Acquisition (SCADA) system
6. SCADA Hardware and software
7. Open SCADA protocols like DNP3 and IEC60870
8. Open SCADA protocols like DNP3 and IEC60870

Review Questions

Sr.No. - Questions	TLO	BL	CA Code
1. Compare features of Programmable Automation Controller systems (PACs) with that of PLC.	TLO2	L2	13.1
2. Compare the features of Open SCADA protocols like DNP3 and IEC 60870 .	TLO4	L2	13.1

Question Paper Title: Model Question Paper for ISA-II	
Course : Programming Industrial Automation Systems	**Course Code : 18EARC302**
Total Duration (H:M):1hr : 15	**Maximum Marks :40**
Note :Answer any two full questions	

Q.No.	Questions	Marks	CO	BL	PO	CA Code
1a	Differentiate between Internal and external relay while building ladder logic solution for the given case study; A conveyor belt system that is driven by a three-phase motor is to start up with a delay of 3 seconds after it has been switched on. The conveyor belt is used for transporting packages. Once a certain number of packages has been transported, the system should switch off after a specified over travel time. In our example, the number of packages to be transported is five and an over travel time of 4 seconds is set. The system is switched on via S1, S2 switches off the system immediately and light barrier S3 is used to detect the number of packages that have been transported already	7	CO4	L3	13	13.1
1b	Design a ladder program to demonstrate any two functions a)Set-reset b) one shot c) master control relay d) jump	6	CO4	L2	13	13.1
1c	Suggest a way by which a spindle could be controlled to position a mechanism at 5° intervals. A range of opaque bottles of various sizes moves along a conveyor belt. Suggest a method that could be used to (a) detect the different sizes and (b) push bottles off the belt.	7	CO4	L3	13	13.1
2a	Design a ladder diagram to explain the action of Shift registers	6	CO5	L2	13	13.1
2b	Design a ladder program to implement Pulse Timer and retentive timer for given set of conditions	7	CO5	L3	13	13.1
2c	Describe the importance of safety in PLC based systems and the role of safety devices with examples	7	CO5	L2	13	13.1
3a	What is the necessity of System documentation in PLC based systems, explain	6	CO6	L2	13	13.1
3b	Discuss the problems due to noise and heat in PLC based systems	7	CO6	L2	13	13.1

3c	Discuss in detail PLC start up and checking procedures	7	CO6	L2	13	13.1

Course Code and Title: **18EARC302 Programming Industrial Automation Systems**	
Chapter Number and Title: **06. DCS & Field Bus**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	CO's	BL	CA Code
5. Distributed Control Systems(DCS): Overview of DCS	CO5	L2	1.4
6. Network Standards: Device net, CAN bus, Control Net	CO5	L3	1.4
7. Profibus, Sercos, Ethernet	CO5	L3	13.1
8. Comparison of each of them with other network standard.	CO5	L3	13.1

Lesson Schedule Class No. - Portion covered per hour
1.Overview of DCS
2.Network Standards: Device net, CAN bus
3.Control Net, Profibus
4.Sercos, EtherCAT, Ethernet Powerlink
5.Comparison of each of them with other network standard.

Review Questions

Sr.No. - Questions	TLO	BL	CA Code
Discuss Distributed control system with a neat block diagram.	CO5	L2	1.4
Explain the advantages of distributed control system.	CO5	L2	1.4
Discuss the DeviceNet protocol layers.	CO5	L3	1.4
Explain CAN bus data frame.	CO5	L2	1.4

Explain types of errors that may occur in CAN communication.	CO5	L3	1.4
Discuss Control Net media with a neat diagram	CO5	L2	1.4
Discuss EtherCAT frame structure	CO5	L2	13.1
Describe the salient Profibus features.	CO5	L2	13.1
Explain Ethernet POWERLINK communication architecture.	CO5	L3	13.1
Discuss the working of Sercos and list the advantages of Sercos.	CO5	L3	13.1

Assignment Questions
Explain the advantages of distributed control system. Discuss the DeviceNet protocol layers. Explain CAN bus data frame. Explain types of errors that may occur in CAN communication. Discuss Control Net media with a neat diagram Explain producer- consumer problem followed in Control Net. Describe the salient Profibus features.

Course Code and Title: **18EARC302 Programming Industrial Automation Systems**	
Chapter Number and Title: **07.System Selection Guidelines & Commissioning**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	CO's	BL	CA Code
1. Discuss the methods used for troubleshooting the PLC System	CO6	L2	13.1,13.1
2. Discuss the issues involved in PLC system selection, based on size, applications and control strategies	CO6	L2	13.1
3. Discuss about the special I/O modules available with PLC	CO6	L2	13.1
4. Demonstrate the use of symbols used in Electrical relay diagram and their significance	CO6	L2	13.1
5. Explain about fail safe design and the relevance of IEC 61508/61511	CO6	L2	13.1

safety standards			
6. Describe the steps in process modeling and the issues related to programming of large and complex systems	CO6	L2	13.1,13.1
7. Discuss the necessity for systematic documentation of control system	CO6	L2	13.1,13.1
8. Explain the steps involved in commissioning	CO6	L2	1.3,13.1,13.1

Lesson Schedule Class No. - Portion covered per hour
1. PLC Selection process ,estimation of program memory and time requirements,
2. PLC Sizes and Scope of applications, Special I/O modules,
3. Electrical relay diagram symbols, Fail Safe Design, IEC 61508/61511 safety standards,
4. Process modeling, Programming for large systems
5. Control system documentation & Commissioning

Review Questions

Sr.No. - Questions	TLO	BL	CA Code
1. Explain the techniques used for troubleshooting PLC	TLO1	L2	13.1
2. Discuss the issues involved in PLC system selection, based on size, applications and control strategies	TLO2	L2	13.1

Assignment Questions

1. Explain the techniques used for troubleshooting PLC
2. Discuss the important factors to be considered for PLC System Selection
3. Explain the classification of PLCs based on their sizes.
4. Discuss the different types of control strategies used with PLC
5. Write a note on selection of PLC system w.r.t memory, software, peripherals
6. Discuss the environmental and physical factors in system selection

Question Paper Title: Model Question Paper for End Semester Assessment	
Course : PIAS	**Course Code : 18EARC302**
Total Duration (H:M):1hr : 15	**Maximum Marks :**
Note :Answer Five Questions: Any two full questions from each Unit I & Unit II and one full question from Unit III	

UNIT - I

Q.No.	Questions	Marks	CO	BL	PO	CA Code
1a	Explain the functionalities of each of individual blocks of PLC with a neat block diagram.	7	CO1	L2	1	1.3
1b	Explain with the connection diagram, the interface circuitry for Sourcing and Sinking I/O modules of PLC with I/O devices.	6	CO1	L2	1	1.3
1c	State the characteristics of the relay, transistor and triac types of PLC output channels	7	CO1	L2	1	1.3
2a	Solve any three: i. Explain the operation of the following input devices, stating the form of the signal being sensed and the output: (a) reed switch, (b)incremental shaft encoder, (c) photoelectric transmissive switch, (d)diaphragm pressure switch (2 marks) ii. Write a structured text program to set the temperature of an enclosure by switches to the values 400, 500, 600, and 700, and switch on fan I ,when the temperature is 600 and fan II, when it is 700 (2 marks) iii) Convert the given SFC to ladder diagram (2 marks) iv) Convert the given ladder diagram to explain subroutine function given in figure(2 marks)	6	CO2	L3	2	2.2
2b	Explain the scope and requirements of IEC61131 and IEC61499 standards by comparing the two.	8	CO2	L2	13	1.4
2c	i) Select sensors that might be suitable for the following	6	CO2	L3	1	1.3

	applications: (a) counting boxes moving along a conveyor belt, (b) verifying the level of milk in a plastic bottle moving along a conveyor belt, (c) determining when the piston in a cylinder has reached a particular point in its extension; (d) determining when a metal plate has reached the right position under a tool. ii) Draw the function block diagrams to represent: (a) There is to be a motor startup when either switch A or switch B is activated. (b) A motor is to be started when two normally open switches are activated and remain on, even if the first of the two switches goes off but not if the second switch goes off. (c) A pump is to be switched on if the pump start switch is on or a test switch is operated.					
3a	Explain the operation of PLC sequencer and shift register functions with example	6	CO3	L2	1	1.3
3b	Design a algorithm and the timing diagram to demonstrate any two functions a) FIFO b) ONS c) master control relay d) jump	8	CO3	L3	1	1.3
3c	Explain the construction of Analog I/O module of PLC	6	CO3	L2	1	1.4

UNIT - II

Q.No.	Questions	Marks	CO	BL	PO	CA Code
4a	Describe the stepwise procedures to be followed in PLC development cycle.	6	CO4	L2	13	13.1
4b	How do safety features built into PLC based system in the designing stage using safety standards.	7	CO4	L2	6	6.2
4c	Discuss the problems due to noise and heat in PLC based systems. How can we overcome them?	7	CO4	L2	6	6.1
5a	Compare the advantages of PAC over PLC and justify with example case studies	7	CO5	L2	13	13.1
5b	Explain the advantages of using SCADA system in industrial control application	7	CO5	L2	13	13.1
5c	Write a note on automation bus standards	6	CO5	L2	13	13.1
6a	Explain the considerations of distributed network protocol	7	CO6	L2	13	13.1
6b	Write a note on essentials of SCADA systems	7	CO6	L2	13	13.1
6c	Describe why open systems and communication standards are important?	6	CO6	L3	13	13.1

UNIT - III						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**CA Code**
7a	Explain types of errors that may occur in CAN communication.	7	CO5	L2	1	1.4
7b	Discuss Control Net media with a neat diagram	6	CO5	L2	1	1.4
7c	Explain producer- consumer problem followed in Control Net.	7	CO5	L3	13	13.1
8a	Write a note on important factors to be considered for PLC System Selection	7	CO7	L2	13	13.1
8b	What is the necessity of System documentation in PLC based systems, explain.	6	CO7	L2	13	13.1
8c	Explain about the care to be taken while programming while building complex and larger systems.	7	CO7	L2	13	13.1

FMTH0301/Rev.5.3

Course Plan

Semester: **5** Year: 2021-2022

Course Title: **Mechatronics System Design**	Course Code: 18EARC304
Total Contact Hours: **50 hours**	Duration of ESA: **3 hours**
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr. Doddabasappa Marebal	Date: 07-08-2021
Checked By: Prof. Arun C. Giriyapur	Date: 09-08-2021

Course Outcomes (COs):

At the end of the course the student should be able to:

I. Demonstrate knowledge of Mechatronic systems by identifying the basic elements and structure of integrated Mechanical-electronic systems and Methodology of Mechatronic system and design.
II. Demonstrate knowledge and skill of the basics of theoretical modelling and experimental modelling, the static and dynamic behaviour of lumped parameter processes in a general form and by a unified methodology for different physical domains by modelling the static and dynamic relations between the input, state, and output variables of components, subsystems, and systems.
III. Demonstrate knowledge of different types of electric drives and develop skill by selecting suitable motor for the application, size the motor in terms of power, torque and speed based on the load requirement and the characteristics of the motor and use them in model based designs.
IV. Demonstrate knowledge of model based methods for design and control of Mechatronic systems using UML and SysML as well as developing models of systems using the identification method.
V. Demonstrate knowledge of the recent trends and developments in the mechatronics system design process and the use of Artificial neural networks and Fuzzy-logic models and discussing modeling and control of case studies depicting the mechatronics system design process.
VI. Demonstrate the skill of designing a mechatronics application as a course project and should be able to model the system.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Mechatronics System Design	Semester: 5
Course Code: 18EARC304	Year: 2021 - 2022

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Demonstrate knowledge of Mechatronic systems by identifying the basic elements and structure of integrated Mechanical-electronic systems and Methodology of Mechatronic system and design.	H													
2. Demonstrate knowledge and skill of the basics of theoretical modelling and experimental modelling, the static and dynamic behaviour of lumped parameter processes in a general form and by a unified methodology for different physical domains by modelling the static and dynamic relations between the input, state, and output variables of components, subsystems, and systems.	L													
3. Demonstrate knowledge of different types of electric drives and develop skill by selecting suitable motor for the application, size the motor in terms of power, torque and speed based on the load requirement and the characteristics of the motor and use them in model based designs.	M													
4. Demonstrate knowledge of model based methods for design and control of Mechatronic systems using UML and SysML as well as developing models of systems using the identification method.	H													
5. Demonstrate knowledge of the recent trends and developments in the mechatronics system design process and the use of Artificial neural networks and Fuzzy-logic models and discussing modeling and control of case studies depicting the mechatronics system design process.	L													
6. Demonstrate the skill of designing a mechatronics application as a course project and should be able to model the system.	L													

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.4 - Demonstrate the competence in engineering knowledge appropriate to automation and robotics program	1.4.1 - Apply discipline specific laws and principles to solve an interdisciplinary engineering problem

Eg: 1.2.3: Represents Program Outcome ‘1’, Competency ‘2’ and Performance Indicators ‘3’.

Course Assessment Plan

Course Title: Mechatronics System Design Code: 18EARC304				
Course outcomes (COs)	**Weightage in Assessment**	**Assessment Methods**		
		Minor Exam 1	**Minor Exam 2**	**ESA**
1. Demonstrate knowledge of Mechatronic systems by identifying the basic elements and structure of integrated Mechanical-electronic systems and Methodology of Mechatronic system and design.	16.6%	✓		✓
2. Demonstrate knowledge and skill of the basics of theoretical modelling and experimental modelling, the static and dynamic behaviour of lumped parameter processes in a general form and by a unified methodology for different physical domains by modelling the static and dynamic relations between the input, state, and output variables of components, subsystems, and systems.	16.6%	✓		✓
3. Demonstrate knowledge of different types of electric drives and develop skill by selecting suitable motor for the application, size the motor in terms of power, torque and speed based on the load requirement and the characteristics of the motor and use them in model based designs.	16.6%		✓	✓
4. Demonstrate knowledge of model based methods for design and control of Mechatronic systems using UML and SysML as well as developing models of systems using the identification method.	16.6%		✓	✓
5. Demonstrate knowledge of the recent trends and developments in the mechatronics system design process and the use of Artificial neural networks and Fuzzy-logic models and discussing modeling and control of case studies depicting the mechatronics system design process.	16.6%			✓
6. Demonstrate the skill of designing a mechatronics application as a course project and should be able to model the system.	16.6%			✓
Weightage	100%	25%	25%	50%

Course Code: 18EARC304	Course Title: Mechatronics System Design	
L-T-P : 4-0-0	Credits: 4	Contact Hrs: 50 hours
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50 hours		Exam Duration: 3 Hrs

Content	Hrs
Unit - I	
Chapter No. 1. Introduction to Mechatronics Systems and elements Introduction to Mechatronic Systems and Design, Mechatronic systems in Precision mechanics, Micromechanics and Process Engineering, Confinement of Mechatronic Systems, Functions, Distribution of Mechanical and Electronic Functions, Integration Forms of Processes and Electronics, Ways of Information Processing, Multi-level Control Systems, Special Signal Preprocessing, Design Procedures for Mechatronics Systems, V model	8
Chapter No. 2. Modeling of Processes Theoretical and Experimental Modeling, Classification of Process Elements , Process Elements with Lumped and Distributed Parameters, Mechanical System model, Mechanical Elements : Bars, Springs, Dampers, Mechanical Systems with Friction, Backlash, Electrical System model, Analogies between Mechanical and Electrical Systems, Dynamics of Mechanical Systems, Newton's Laws of Kinetics, Translational and Rotational Motion, Principles of Mechanics, d'Alembert's Principle, Lagrange's Equations, Problems.	12
Unit - II	
Chapter No. 3. Electrical Drives Types of Electrical Drives, Electromagnets, Direct Current Motors, Dynamic Behavior, Static Behavior, Special Types of DC Motors, Alternating Current Motors (AC), Induction Motors, Synchronous Motors, Single-phase Motors, Commutator Motors (Universal Motors), Squirrel-cage Motors, Power Electronics Circuits, Internally or Externally Commutated Electro-motors, Electrical Motor Sizing and Selection Procedure, Electric Motor Operational Conditions, Motion Profile, Load Torque Calculation, Motor Shaft Torque Calculation, Load Torque–Speed Profile, DC Motor Parameter Estimation, Process Dynamics Particularities, Electrical Binary Actuators.	10
Chapter No. 4. Model based Design of Systems & Identification Introduction to model based design ,Basic block diagrams, Model-based Methods of Control, Supervision and Fault Diagnosis, Intelligent Systems, Non-linear Control and Fault Detection, Model-based Compensation of Nonlinearities, Modeling and Fault Diagnosis, Examples for the Design of Mechatronic Systems using UML and SysML, Identification Methods, classification of Identification Methods,Test Signals, Closed-loop Identification, Type of Application, Parameter Estimation for Discrete Time-varying Systems, Non-linear Processes, Problems.	10
Unit - III	
Chapter No. 5. Recent trends in Mechatronics System Design process Mechatronics systems contributing to economic growth, Changes in technological processes and products, Tools and methods in mechatronics system design and development, Use of Artificial Neural Networks and Fuzzy-logic Models , Fields of application, Future Mechatronics systems.	5
Chapter No. 6. Case studies Dynamic Models of an Electromagnetic actuator, Control Prototyping and Hardware-in-the-loop Simulation, Rapid Control Prototyping for Engine Control, Hardware-in-the-loop Simulation for Industrial Robot, Process control system.	5

Text Books

1. Rolf Isermann, “Mechatronic Systems: Fundamentals”, Springer, 1st edition, 2005.
2. Alexandru Forrai, “Embedded Control System Design:A Model Based Approach”, Springer, 1st edition, 2013.
3. Patrick O.J. Kaltjob, “Mechatronic Systems and Process Automation: Model-Driven Approach and Practical Design Guidelines”, CRC Press, 1st edition, 2018.
4. Norman S. Nise, “Control Systems Engineering”, John Wiley & Sons Inc, Sixth Edition, 2011.

Reference Books

1. Devdas Shetty, Richard A. Kolk, “Mechatronics System Design”, Cengage Learning, Second edition, 2010.
2. “Mechatronics Handbook” Edited by Robert Bishop.CRC Press, 2002.
3. Loan D, Landau, Gianluca and Zito, “Digital Control Systems: Design, Identification and Implementation”, Springer, 2006.
4. George Pelz, “Mechatronic Systems: Modeling and Simulation with HDL”, Wiley, 2003
5. Wei Wu, “Model-Based Design for Effective Control System Development”, IGI Global, 1 edition, 2017.

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
Minor Exam-1	25
Minor Exam-2	25
Total	50

Course Unitization for Minor Exams and End Semester Assessment

Topics / Chapters	Teaching Hours	No. of Questions in Minor Exam-1	No. of Questions in Minor Exam-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
1.Introduction to Mechatronics Systems and elements	8	1.25	--	--	1.25
2.Modeling of Processes	12	1.75	--	--	1.75
Unit II					
3. Electric Drives	10	--	1.5	--	1.5
4.Model based Design of Systems & Identification	10	--	1.5		1.5
Unit III					
5.Recent trends in Mechatronics System Design process	5	--	--	--	1.00
6. Case studies	5	--	--	--	1.00

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in Minor I, II and ESA
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date: 08-08-2021 **Head of Department**

Chapter wise Plan

Course Code and Title: **18EARC304/ Mechatronics System Design**	
1. Chapter Number and Title: 1**.** Introduction to Mechatronics Systems and elements	Planned Hours: **8**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLO)	COs	BL	CA Code
1. Describe the development of Mechatronic systems from mechanical systems, considering the domains of mechanical engg. and precision mechanics	CO1	L2	1.4
2. Explore the development of intelligent and adaptive mechatronic systems	CO1	L2	1.4
3. Describe the design procedures for Mechatronics systems	CO2	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to Mechatronic Systems and Design 2. Mechanical Systems in Precision Mechanics, Micromechanics and process Engineering 3. Confinement of Mechatronic Systems, Functions 4. Distribution of Mechanical Functions 5. Distribution of Electronic Functions 6. Ways of Information Processing , Multi-level Control Systems 7. Design Procedures for Mechatronic Systems 8. V model

Review Questions

Sl.No. - Questions	TLO	BL	PI Code
1. Describe the evolution of mechanical systems into mechatronics systems	1	L2	1.4.1
2. Explain the integration strategies used in Mechatronics systems	1	L2	1.4.1
3. Explain the interrelation between design and construction of mechatronics system	1	L2	1.4.1
4. Explain the classification of mechatronics systems with examples.	2	L2	1.4.1
5. Describe the design procedures for building Mechatronics systems.	3	L2	1.4.1

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **2.**Modeling of Processes	Planned Hours:**12**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Describe the need and role of theoretical /mathematical modeling of technical processes belonging to mechanics, electrical, electronics.	CO2	L3	1.4
2. Describe the mathematical models of mechanical system using Spring-mass-damper systems and of electrical systems, using R,L,C elements, lumped and distributed parameters with examples.	CO2	L3	1.4
3. Describe the analogy between mechanical and electrical systems with examples.	CO2	L3	1.4
4. Explore the mathematical modeling of mechanical systems with mobile masses to explain their dynamic behavior using d'Alembert's Principle, Lagrange's Equations.	CO2	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
9. Theoretical and Experimental Modeling 10. Classification of Process Elements 11. Process Elements with Lumped and Distributed Parameters 12. Mechanical System model 13. Mechanical Elements 14. Mechanical Systems with Friction, Backlash 15. Electrical System model 16. Analogies between Mechanical and Electrical Systems 17. Dynamics of Mechanical Systems 18. Newton's Laws of Kinetics, Translational and Rotational Motion 19. Principles of Mechanics, d'Alembert's Principle 20. Lagrange's Equations, Problems.

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. An undamped spring-mass system oscillates at 1 kHz. The mass is 0.1 g. Calculate the spring constant c. Design an electrical inductance-capacitance system with the same frequency by using coils from loud speakers with L = 3 mH.	1	L3	1.4.1
2. State the analogies between an electrical RLC element and a mechanical element (mass-damper-spring) for the signals and the parameters and the	2	L3	1.4.1

across-through classification.			
3. What are the differences between constitutive and phenomenological equations? To which type of equations belong: Ohm's law, induction law, heat conduction, Newton's laws?	3	L3	1.4.1
4. Derive the equations of motion of the torsional system, consisting of two rotational masses, for the given example, by applying Lagrange equations.	4	L3	1.4.1
5. Two masses $m_1$and m_2 are coupled together by a linear spring (C_l) and a linear damper (d_l) (dashpot). Mass m_2 is connected by a linear second spring (C_2) and damper (d_2) with a wall. Derive the equations for the positions $z_1(t)$ and $z_2(t)$ for the masses if a force $F_1(t)$ acts on mass m_1 by applying Lagrange equations.	4	L3	1.4.1
6. A robot arm of length l = 1 m carries a load of m = 100 kg with an angle of $\phi = 30°$ to the horizontal axis. Derive the equations of motion with torque $T_1(t)$ as input and $\phi_1(t)$ as output signal. Linearize the equations around the operation point (mass and damping of robot arm is negligible).	4	L3	1.4.1
7. Calculate the torsional spring stiffness c of a steel rod with length l = 1 m and diameter d = 0.01 m.	4	L3	1.4.1
8. Determine the force-displacement characteristics of an air spring for d=0.1 m and l = 0.3 m.	4	L3	1.4.1

Model Question Paper for Minor - I Examination (ISA)						
Course Code: 18EARC304	Course Title: Mechatronics System Design					
Duration: 1hr : 15 Min	Max. Marks: 40					
Note: Answer any two full questions						
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Describe the evolution of mechanical systems into mechatronics systems with a neat block diagram.	8	CO1	L2	1	1.4.1
1b	Explain the interrelation between design and construction of mechatronics systems	6	CO1	L2	1	1.4.1
1c	Explain the salient features of mechatronics systems	6	CO1	L2	1	1.4.1
2a	Discuss the V design model for mechatronics systems.	8	CO1	L2	1	1.4.1
2b	An un-damped spring-mass system oscillates at 1 kHz. The mass is 0.1 g. Calculate the spring constant c. Design an electrical inductance-capacitance system with the same frequency by using coils from loud speakers with L = 3 mH.	6	CO2	L3	1	1.4.1
2c	State the analogies between an electrical RLC element and a mechanical element (mass-damper-spring) for the signals and the parameters and the across-through classification.	6	CO2	L3	1	1.4.1
3a	Two masses $m_1$and m_2 are coupled together by a linear spring (C_l) and a linear damper (d_l) (dashpot). Mass m_2 is connected by a linear second spring (C_2) and damper (d_2) with a wall. Derive the equations for the positions $z_1(t)$ and $z_2(t)$ for the masses if a force $F_1(t)$ acts on mass m_1 by applying Lagrange equations.	8	CO2	L3	1	1.4.1
3b	A robot arm of length l = 1 m carries a load of m = 100 kg with an angle of ϕ = 30° to the horizontal axis. Derive the equations of motion with torque $T_1(t)$ as input and $\phi_1(t)$ as output signal. Linearize the equations around the operation point (mass and damping of robot arm is negligible).	6	CO2	L3	1	1.4.1
3c	A mass m follows a parabolic trajectory $y = cx^2$under the influence of gravity. Derive the equation of motion for $x(t)$ by using the Lagrange equation.	6	CO2	L3	1	1.4.1

Chapter wise Plan

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **3.** Electrical Drives	Planned Hours: **10**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Describe the construction and mathematical modeling of electromagnets, DC and AC motor types.	CO3	L3	1.4
2. Describe the role of power electronic circuits used in electric drive systems.	CO3	L3	1.4
3. Explain the motor sizing and selection procedures with examples.	CO3	L3	1.4
4. Explore the static and dynamic behavior of mechatronics systems using the mathematical models of electromagnetic components	CO3	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
21. Types of Electrical Drives, Electromagnets , Direct Current Motors 22. Dynamic Behavior , Static Behavior 23. Special Types of DC Motors, Alternating Current Motors (AC) 24. Induction Motors, Synchronous Motors , Single-phase Motors 25. Commutator Motors (Universal Motors) ,Squirrel-cage Motors 26. Power Electronics Circuits , Internally or Externally Commutated Electro-motors 27. Electrical Motor Sizing and Selection Procedure, Operational Conditions 28. Motion Profile, Load Torque Calculation 29. DC Motor Parameter Estimation, Process Dynamics Particularities 30. Electrical Binary Actuators

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. For the DC motor with the given datasheet, calculate the torque-speed characteristic for *V,* = 50 V and 100 V.	3	L3	1.4.1
2. Calculate the parameters for the dynamic model of the DC motor. Determine the armature and the mechanical time constant.	4	L3	1.4.1
3. A shunt-wound motor supplied with 200 V runs at 1000 rpm with an armature current of 20 A. The armature resistance is 0.6.	4	L3	1.4.1
4. Calculate the required armature voltage, neglecting friction. Calculate the armature voltage for 500 rpm and the current 10A.	4	L3	1.4.1

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: 4**.**Model based Design of Systems & Identification	Planned Hours: **10**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explore the model based design of systems with examples.	CO4	L3	1.4
2. Describe the non-linear control and Fault detection in Electromagnetic actuator	CO4	L2	1.4
3. Describe the model-based compensation of non-linearities and fault diagnosis	CO4	L3	1.4
4. Discuss Control Prototyping and Hardware-in-the-loop Simulation	CO4	L2	1.4
5. Explain the Identification methods for system or process, test signals, parameter estimation using standard techniques using ANN and Fuzzy Logic models	CO4	L3	1.4

Lesson Schedule Class No. - Portion covered per hour
31. Introduction to model based design ,Basic block diagrams, Model-based Methods of Control 32. Supervision and Fault Diagnosis, Intelligent Systems, 33. Non-linear Control and Fault Detection , Model-based Compensation of Non-linearities, 34. Modeling and Fault Diagnosis 35. Design of Mechatronic Systems using UML and SysML 36. Identification Methods 37. classification of Identification Methods ,Test Signals , 38. Closed-loop Identification , Type of Application, 39. Parameter Estimation for Discrete Time-varying Systems, 40. Non-linear Processes and Problems

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Discuss the example block diagrams to illustrate model based design.	1	L3	1.4.1
2. Write a note on Model-based Methods of Control.	2	L3	1.4.1
3. Explain the scheme for model based supervision and Fault diagnosis	3	L3	1.4.1

4. Explain the general procedure for Identification of systems.	4	L2	1.4.1
5. How are the Identification methods classified? Explain each of them.	4	L2	1.4.1
6. Explain the identification process using Closed Loop configuration.	4	L3	1.4.1
7. Discuss about the non-linear processes using examples and the model based compensation of non-linearities.	5	L3	1.4.1

Model Question Paper for Minor -II Examination (ISA)						
Course Code: 18EARC304	Course Title: Mechatronics System Design					
Duration: 1hr : 15 Min	Duration: 1hr : 15 Min					
Max. Marks: 40	Max. Marks: 40					
Note: Answer any two full questions						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Discuss the example block diagrams to illustrate model based design.	10	CO4	L2	1	1.4.1
1b	Write a note on Model-based Methods of Control.	05	CO4	L2	1	1.4.1
1c	Explain the scheme for model based supervision and Fault diagnosis	05	CO4	L3	1	1.4.1
2a	Discuss the design of example mechatronics systems using UML/SysML.	10	CO4	L2	1	1.4.1
2b	Discuss the need for compensation of Non-linearity.	05	CO3	L2	1	1.4.1
2c	Explain the general procedure for Identification of systems	05	CO4	L3	1	1.4.1
3a	How are the Identification methods classified? Explain each of them.	05	CO4	L2	1	1.4.1
3b	Explain the identification process using Closed Loop configuration.	05	CO4	L2	1	1.4.1
3c	Discuss about the non-linear processes using examples and the model based compensation of non-linearity.	10	CO4	L3	1	1.4.1

Chapter wise Plan

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **5.** Recent trends in Mechatronics System Design process	Planned Hours: **5 hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explore the role of mechatronics systems in economic growth.	CO5	L2	1.4
2. Discuss the recent trends in tools ,methods, processes and products associated with mechatronics system design	CO5	L3	1.4
3.List and explain the fields of application of mechatronics systems and future trends in mechatronics systems design	CO5	L2	1.4

Lesson Schedule Class No. - Portion covered per hour
41. Mechatronics systems contributing to economic growth 42. Changes in Technological processes and products 43. Tools and methods in mechatronics system design and development 44. Use of Artificial Neural Networks(ANN) and Fuzzy-logic Models 45. Fields of application, Future Mechatronics systems

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Write a note on the impact of mechatronics systems in the economic growth of the nation as a whole.	1	L2	1.4.1
2. Explain the recent trends in technological processes and products.	2	L2	1.4.1
3. Explain the future of mechatronics system design using ANN and Fuzzy logic based technologies.	3	L2	1.4.1

Course Code and Title: **18EARC304/ Mechatronics System Design**	
Chapter Number and Title: **6.**Case studies	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Explain the non-linear control and fault detection of Electromagnetic actuator.	CO6	L2	1.4.1
2. Describe the dynamics of Industrial Robot.	CO6	L3	1.4.1

Lesson Schedule Class No. - Portion covered per hour
46. Non-linear Control of Electromagnetic actuator 47. Fault detection of Electromagnetic actuator 48. Dynamics of Industrial Robot 49. Dynamics of Industrial Robot 50. Dynamics of Industrial Robot

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Explain the non-linearity present in an electromagnetic actuator and explain the need to control nonlinearity.	1	L3	1.4.1
2. Discuss the fault detection process of Electromagnetic actuator.	1	L3	1.4.1

Model Question Paper for End Semester Assessment (ESA)	
Course Code: 18EARC304	Course Title:Mechatronics System Design
Duration: 3 hrs	Max. Marks: 100
Note: Answer Five Questions: Any two full questions from each Unit I & Unit II and one full question from Unit III	

UNIT - I

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Describe the evolution of mechanical systems into mechatronics systems with a neat block diagram.	8	CO1	L2	1	1.4.1
1b	Explain the interrelation between design and construction of mechatronics systems	6	CO1	L2	1	1.4.1
1c	Explain the salient features of mechatronics systems	6	CO2	L3	1	1.4.1
2a	Discuss the V design model for Mechatronics systems.	8	CO2	L2	1	1.4.1
2b	An un-damped spring-mass system oscillates at 1 kHz. The mass is 0.1 g. Calculate the spring constant c. Design an electrical inductance-capacitance system with the same frequency by using coils from loud speakers with L = 3 mH.	6	CO2	L2	1	1.4.1
2c	State the analogies between an electrical RLC element and a mechanical element (mass-damper-spring) for the signals and the parameters and the across-through classification.	6	CO2		1	1.4.1
3a	Two masses $m_1$and m_2 are coupled together by a linear spring (C_l) and a linear damper (d_l) (dashpot). Mass m_2 is connected by a linear second spring (C_2) and damper (d_2) with a wall. Derive the equations for the positions $z_1(t)$ and $z_2(t)$ for the masses if a force $F_1(t)$ acts on mass m_1 by applying Lagrange equations.	8	CO2	L3	1	1.4.1
3b	A robot arm of length l = 1 m carries a load of m = 100 kg with an angle of ϕ = 30° to the horizontal axis. Derive the equations of motion with torque $T_1(t)$ as input and $\phi_1(t)$ as output signal. Linearize the equations around the operation point (mass and damping of robot arm is negligible).	6	CO2	L3	1	1.4.1
3c	A mass m follows a parabolic trajectory $y = cx^2$under the influenceof gravity. Derive the equation of motion for $x(t)$ by using the Lagrange equation.	6	CO2	L3	1	1.4.1

UNIT - II

Q.No.	Questions	Marks	CO	BL	PO	PI Code
4a	Discuss the example block diagrams to illustrate model based design.	10	CO3	L3	1	1.4.1
4b	Write a note on Model-based Methods of Control.	05	CO3	L3	1	1.4.1
4c	Explain the scheme for model based supervision and Fault diagnosis	05	CO3	L3	1	1.4.1

5a	Discuss the design of example mechatronics systems using UML/SysML.	10	CO3	L2	1	1.4.1
5b	Discuss the need for compensation of Non-linearity.	05	CO3	L2	1	1.4.1
5c	Explain the general procedure for Identification of systems	05	CO4	L3	1	1.4.1
6a	How are the Identification methods classified? Explain each of them.	05	CO4	L2	1	1.4.1
6b	Explain the identification process using Closed Loop configuration.	05	CO4	L2	1	1.4.1
6c	Discuss about the non-linear processes using examples and the model based compensation of non-linearity.	10	CO4	L3	1	1.4.1
UNIT - III						
7a	Explain the recent trends in technological processes and products.	10	CO5	L3	1	1.4.1
7b	Explain the future of mechatronics system design using ANN and Fuzzy logic based technologies.	10	CO5	L3	1	1.4.1
8a	Discuss the fault detection process of Electromagnetic actuator.	10	CO6	L4	1	1.4.1
8b	Discuss the dynamics of Industrial robot.	10	CO6	L4	1	1.4.1

Corrections Note

Sl. No	Changes made in Syllabus	Topic No/ Chapter No

DEPARTMENT OF AUTOMATION & ROBOTICS

Laboratory Plan **FMTH0303-3.1**

Semester: V **Year: 2021-2022**

Laboratory Title: **Mini project (Engineering Design Project)**	Lab. Code: **18EARW301**
Total Hours: **30**	Duration of Exam: 2 hrs
Total Exam Marks: 5**0**	Total ISA Marks: **50**
Lab. Plan Author: Arunkumar C.Giriyapur	Date: 05-08-2021
Checked By: Mrs Shilpa Tanvashi	Date: 05-08-2021

Theme: *Product development through Engineering Design and Rapid Prototyping*

Course Objective: To apply engineering design process to develop a simple product and build it using rapid prototyping.

Task Details:

The project should include usage of engineering design principles, agile methodology and rapid prototyping. The product should be used to automate a process or perform a set of useful tasks.

Course Outcomes - CO

At the end of the course student will be able to:

1. Carry out need analysis and identify suitable problems.
2. Apply the principles of engineering design to scope, plan and implement the project, continuously evaluate progress, navigate uncertainty and adversity, and iterate as needed.
3. Think critically while analyzing, evaluating, synthesizing, and applying diverse information and experiences to support decision-making during the design process.
4. Develop and apply creativity to generate novel ideas taking into account real constraints that lead to innovative outcomes.
5. Develop schematics and select appropriate components.
6. Prototype the product using rapid prototyping and test it.
7. Collaborate successfully with other team members to achieve the desired outcome.
8. Consider the individual, social and environmental impacts of their decisions to produce positive transformations while minimizing unintended consequences.
9. Communicate effectively through oral, written, and visual media and listen actively to comprehend the meaning of others.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program outcomes (PO)

Laboratory (Course) Title: **Mini project** Laboratory (Course) code: 18EARW301

Semester: V Year: 2021-2022

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1. Carry out need analysis and identify suitable problems.	**H**	**H**								
2. Apply the principles of engineering design to scope, plan and implement the project, continuously evaluate progress, navigate uncertainty and adversity, and iterate as needed.		**H**	**H**							
3. Think critically while analyzing, evaluating, synthesizing, and applying diverse information and experiences to support decision-making during the design process.		**H**	**H**							
4. Develop and apply creativity to generate novel ideas taking into account real constraints that lead to innovative outcomes.			**H**							
5. Develop schematics and select appropriate components.			**H**							
6. Prototype the product using rapid prototyping and test it.					**H**					
7. Collaborate successfully with other team members to achieve the desired									**H**	
8. Consider the individual, social and environmental impacts of their decisions to produce positive transformation while minimizing unintended consequences						**H**	**H**	**H**		
9. Communicate effectively through oral, written, and visual media and listen actively to comprehend the meaning of others										**H**

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 Demonstrate the competence in mathematical modeling	1.1.1 Apply mathematical techniques to solve problems
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply elements of mechanical engineering principles and laws to solve problems
	1.3.2 Apply basic electrical & electronics engineering principles and laws to solve problems
	1.3.3 Apply computer programming skills to solve problems by building algorithms, flow charts and debugging
2.1 Demonstrate an ability to identify and characterize an engineering problem	2.1.3 Identifies all relevant constraints and requirements and formulate an accurate description of the problem
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions
3.1 Demonstrate an ability to define a complex open-ended problem in engineering terms	3.1.3 Recognizes that good problem definition assists in the design process
	3.1.2 Elicit and document, engineering requirements from stakeholders
	3.1.3 Synthesize engineering requirements from a review of the State of the Art
	3.1.4 Extract engineering requirements from relevant engineering Codes and Standards
	3.1.5 Explore and synthesize engineering requirements from larger social and professional concerns
	3.1.6 Determines design objectives, functional requirements and arrives at specifications
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1 Apply formal idea generation tools to develop multiple engineering design solutions
	3.2.2 Build models, prototypes, etc., to develop diverse set of design solutions
	3.2.3 Identify the suitable criteria for evaluation of alternate design solutions
3.3 Demonstrate an ability to select the optimal design scheme for further development	3.3.1 Apply formal multi-criteria decision making tools to select optimal engineering design solutions for further development
	3.3.2 Consult with domain experts and stakeholders to select candidate engineering design solution for further

	development
3.4 Demonstrate an ability to advance an engineering design to defined end state	3.4.1 Refine a conceptual design into a detailed design within the existing constraints (of the resources)
5.1 Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1 Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities.
5.3 Demonstrate an ability to evaluate the suitability and limitations of the tools used to solve an engineering problem	5.3.1 Discuss limitations and validate tools, techniques and resources
	5.3.2 Verify the credibility of results from tool use with reference to accuracy and limitations, and the assumptions inherent in their use.
6.2 Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
7.1 Demonstrate an understanding of the impact of engineering and industrial practice on social, environmental and economic contexts	7.1.2 Demonstrate an understanding of the relationship between the technical, socio economic and environmental dimensions of sustainability
8.1 Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
9.2 Demonstrate effective individual and team operations-- communication, problem solving, conflict resolution and leadership skills	9.2.1 Demonstrate effective communication, problem solving, conflict resolution and leadership skills
9.3 Demonstrate success in a team-based project	9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
10.1 Demonstrate an ability to comprehend technical literature and document project work.	10.1.1 Read, understand and interpret technical and non-technical information
	10.1.2 Produce clear, well-constructed, and well-supported written engineering documents
	10.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
10.2 Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others
	10.2.2 Deliver effective oral presentations to technical and non-technical audiences
10.3 Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations

Experiment wise plan

List of activities planned to meet the requirements of the syllabus

Week No	Activities	Deliverables	ISA Marks out of 50
1&2	Need analysis, Identification of problem statement, Engineering Design process	Problem statement, Project plan, Process plan	10
3&4	Product development	Component designs & Integration, Modeling and simulation	10
5,6,7&8	Rapid prototyping, Testing and validation	Prototype (hardware and software)	20
9&10	Reporting	Test reports and Conclusion	10

Attributes for Final Evaluation of Mini project:

Sl. No	Activity	ESA Marks out of 50
1	Project Report	10
2	Poster & Paper Presentation	20
3	Demo of Project	10
4	Viva Voce(individual)	10
	Total Marks	**50**

Date:05-08-2021 Head of Department

FMTH0301/Rev.5.3

Course Plan

Semester: **VI** Year: 2022 –2023

Course Title: **Real-Time Embedded Systems**	Course Code: **18EARC303**
Total Contact Hours: **50**	Duration of ESA Hours: 3
ESA Marks: **50**	ISA Marks: **50**
Lesson Plan Author: Dr Jyoti .S. Bali	Date: 20-08-2022
Checked By: Prof. Arunkumar .C. Giriyapur	Date: 20-08-2022

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Explain the basic need for real-time and embedded systems, related terminologies, concepts, characteristics and configurations, and further the generic architectural features of controllers essential to building real-time embedded systems.
2. Write programs for a real-time controller to suit the needs of a real-time system design based on exception handling, interrupt handlers, multitasking and inter-task communication.
3. Draw state charts and write pseudocode on various strategies, task scheduling, Inter-task communication, and resource-sharing mimicking the real-time case studies.
4. Identify reference models by defining the workload model, resources model and algorithm attributes and further describes the real-time embedded systems design workflow by following the hardware-software co-design methodology during their course project activity.
5. Research literature on optimizing the performance optimization of real-time embedded systems during their project activity and estimating the real-time system performance characteristics of the built real-time system.

Course Articulation Matrix: Mapping of Course Outcomes with Program Outcomes

Course Title: Real-Time Embedded Systems	Semester: VI
Course Code: 18EARC303	Year: 2022 –2023

Course Outcomes (CO) / Program Outcomes (PO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.Demonstrate the knowledge of Real-Time Embedded Systems (RTES), by explaining the basic need for real-time and embedded systems along with related terminologies, concepts, characteristics and configurations, and further the generic architectural features of controllers essential to building real-time embedded systems.	M	M												
2.Demonstrate the knowledge of Real-Time Embedded Systems (RTES), by explaining the basic need for real-time and embedded systems along with related terminologies, concepts, characteristics and configurations, and further the generic architectural features of controllers essential to building real-time embedded systems	M	M												
3.Demonstrate the knowledge and skill in RTOS programming by writing state-charts and pseudocode on various strategies, namely, task scheduling, Inter-task communication and resource-sharing mimicking the real-time case studies	M	M												
4.Demonstrate knowledge and skill in identifying reference models by defining the workload model, resources model and algorithm attributes and further describe the real-time embedded systems design workflow by following the hardware-software co-design methodology during their course project activity.	M	M												
5.Demonstrate the knowledge of building, analyzing and optimizing the performance of real-time embedded systems during their project activity by reading the latest white papers from leading industries/surveying of research reports and finally estimating the real-time system performance characteristics of the built real-time system.	M	M								M				

The degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators.

Competency	Performance Indicators	Planned Activity
1.4 Demonstrate competence in specialized engineering knowledge to the program	1.4.1 Apply discipline-specific laws and principles to solve an engineering problem	Course Project & Case study presentation
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 - Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions 2.2.2 Partitions problems, processes, or systems into manageable elements for analysis, modeling or design	Course Project & Case study presentation
10.1 Demonstrate an ability to comprehend technical information	10.1.1 Read, understand and interpret technical and non-technical information 10.1.3 create a flow in a document or presentation, a logical progression of ideas so that the main point is clear	Case-study presentation, Survey Paper activity

E.g., 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: 18EARC303	Course Title: Real-Time Embedded Systems	
L-T-P-S: 4-0-0-0	Credits: 4	Contact Hrs: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Content	Hrs
Unit - 1	
1.0 Introduction to System Structures and Real-time Embedded System Real-time systems, Classification, Core and Supporting components of the embedded system, Embedded firmware, Example case studies with block diagrams, namely, Process control system, Modern car. Purpose, Quality attributes, Challenges and characteristics of Embedded Computing System Design, Embedded System Design Process with case studies and State chart modeling - Automatic Chocolate Vending Machine (ACVM)	6
2.0 Target Architectures : ARM Cortex M3 processors & its Programming Introduction to embedded computing with examples and ARM processors, The architectural features, Nested Vector Interrupt Controller(NVIC), Exceptions Programming, advanced programming Features. Memory Protection and Debug Architecture. Advanced Processor technologies for embedded system design. Case studies: Engine Control Unit, Antilock Brake System(ABS)	7
3.0 Real-Time Kernels and Operating Systems Introduction to Real-Time Kernels and Real-Time operating System(RTOS), key characteristics, services of RTOS, components in RTOS kernel, context switching, Task scheduling, Task communication and Synchronization, Multiprocessing and multitasking, Multi-Threading, Hyper-threading, Scheduling types: Preemptive priority-based scheduling, Round-robin and preemptive scheduling. First-come First-Serve scheduling, Shortest Job First scheduling, Examples for each type using State diagrams and timing diagrams, Device drivers and selection criteria of an RTOS. Case study on Mars Pathfinder mission.	7
Unit - 2	
4.0 Inter-task Communication in RTOS Tasks, Semaphores, mutual exclusion (MUTEX) semaphore, Mail Box and Message Queues with finite state machines, Synchronization between two tasks and multiple tasks, Single shared-resource-access Synchronization, Case-study on Weapons Dispense System	7
5.0 Tasks and Task Management RTOS - task creation and Management, task scheduling, kernel services, inter-task-communication, Demo and Problem solving on Task creation and management functions using Open source tools. Discussion of Case studies on Industrial Robot and Adaptive Cruise control	7
6.0 Handling Deadlocks Sharing Resources, Deadlock Model- Necessary Conditions, Resource Allocation Graph, Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Handling of deadlocks, through a case study: The Dynamic Dining	6

Philosopher problem.	
Unit - 3	
7.0 Performance Analysis and Optimization Performance or Efficiency Measures, Complexity Analysis of the methodology, Analyzing Code, algorithms, Response Time, Time Loading, Memory Loading, Evaluating Performance, Performance Optimization, optimizing for Power Consumption. Demonstration of concepts of Performance Analysis and Optimization through a case study.	5
8.0 Wired and Wireless Protocols used in Real-Time Embedded System: Bus communication protocol (USB, I2C, SPI), Wireless and mobile system protocol (Bluetooth, 802.11 and its variants, ZigBee), Examples of block diagrams to explain the working of each protocol with real-time case studies.	5

Text Books:

1. James K. Peckol, “ Embedded Systems A Contemporary Design Tool,” Wiley student edition
2. Joseph Yiu “ The Definitive Guide to the ARM Cortex–M3”
3. Silberschatz, Galvin, and Gagne, ”Operating system concepts,” 8th edition, WILEY Publication.

References:

1. Shibu K V, “Introduction to Embedded Systems Tata McGraw Hill, New Delhi, 6th reprint 2012.
2. Raj Kamal,” Embedded Systems,” McGraw-Hill Education
3. Steve Furber, “ARM System-on-Chip Architecture” LPE, Second Edition.

Evaluation Scheme

ISA Scheme

Assessment	**Weightage in Marks**
Minor Exam 1	15
Minor Exam 2	15
Survey paper activity	10
Quiz & Assignment	10
Total	50

Course Unitization for Minor Exams and End Semester Assessment

Unit	Chapter		Teaching Hours	No. of Questions			No. of Questions in ESA
				Minor Exam I	Minor Exam II	Activity	
I	1	Introduction to System Structures and Real-Time Embedded System	6	1			1
	2	Target Architectures: ARM Cortex M3 processors & its Programming	7	1		1	1
	3	Real-Time Kernels and Operating Systems	7	1		1	1
II	4	Inter-task Communication in RTOS	7		1		1
	5	Tasks and Task Management	7		1		1
	6	Handling Deadlocks	6		1		1
III	7	Performance Analysis & Optimization	5				1
	8	Wired and Wireless Protocols used in Real-Time Embedded System	5				1

Note:

- Each question carries 20 marks and may consist of sub-questions.
- Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ESA.

Date:20-08-2022 Head of Department

Course Title: Real-Time Embedded Systems		Code: 18EARC303			
Course outcomes (COs)	Weightage in Assessment	Assessment Methods			
		Minor Exam 1	Minor Exam 2	Activity	ESA
1. Introduction to System Structures and Real-Time Embedded System	12%	✓			✓
2. Target Architectures: ARM Cortex M3 processors & its Programming	14%	✓		✓	✓
3. Real-Time Kernels and Operating Systems	14%	✓		✓	✓
4. Inter-task Communication in RTOS	14%		✓		✓
5. Tasks and Task Management	14%		✓		✓
6. Handling Deadlocks	12%		✓		✓
7. Performance Analysis & Optimization	10%				✓
8. Wired and Wireless Protocols used in Real-Time Embedded System	10%				✓
Weightage		15%	15%	20%	50%

Chapter-wise Plan UNIT I

Course Code and Title: **18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **1. Introduction to System Structures, Embedded System and Operating System**	*Planned Hours:* ***7***

Learning Objectives

At the end of this chapter, the student should be able to:

S. No	TLO's	CO	BL	CA Code
1	Define the basic terminologies, system structures, Architectural features, types of classification, Core and Supporting components, Embedded firmware features related to Real-time Embedded systems (RTES).	1	L2	2.1
2	Develop the concept of imbibing the Real-time behaviour in the system by using the quality attributes and characteristics of Embedded Computing System Design while overcoming the challenges in building RTES.	1	L4	2.1
3	Explain the principle of operation of hardware and software components.	1	L2	1.4
4	Explain the processes involved in the case study, Automatic Chocolate Vending Machine (ACVM) and draw the equivalent state chart model.	1	L3	1.4

Lesson Schedule

Class No. The portion covered per hour

1. Real-time systems, classification
2. Core and Supporting components of the embedded system, Embedded firmware
3. Example case study: Process control system, Modern car.
4. Purpose, Quality attributes, Challenges in Embedded Computing
5. characteristics of Embedded Computing, System Design
6. Embedded System Design Process case study Automatic-Chocolate Vending Machine (ACVM)
7. State chart modeling (ACVM)

Review Questions

S. No	Questions	TLO	B L	PI Code
1	Write a note on the types of System structures used for system development	1	L2	2.1.1
2	Discuss the characteristics, classification of Operating systems	2	L2	2.1.1
3	How does a real-time system differ from an ordinary system	3	L3	2.2.2
4	Discuss the architecture of an Embedded system and the relevance of every block	4	L2	2.2.1
5	Explain the components of a typical embedded system in detail.	4	L2	1.4.1
6	Which are the components used as the core of an embedded system? Explain the metrics, drawbacks, if any, and the application/domain where they are commonly used.	5	L2	1.4.1
7	What are the advantages of FLASH over other program storage memory in Embedded system design?	6	L2	1.4.1
8	What are the different types of RAM used for Embedded System design?	3	L2	1.4.1
9	Explain in detail the chosen real-time case-study problem.	3	L2	4.1.1
12	Explain embedded firmware with an example problem.	2	L2	4.1.1

Course Code and Title: **18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **2. Target Architectures: ARM Cortex M3 processors & its Programming**	*Planned Hours:* ***7***

Learning Objectives

At the end of this chapter, the student should be able to:

S. No	TLO's	CO	BL	CA Code
1	Explain the features of Embedded computing using ARM processor architectural features and the supporting examples.	2	L2	2.1
2	Develop concepts on advanced programming features, namely, Nested Vector Interrupt Controller(NVIC) and Exceptions Programming.	2	L4	2.1
3	Explain the advanced Processor technologies for embedded system design, namely, Memory Protection and Debug Architecture.	2	L2	2.2
4	Describe the processes involved in the following case studies: Engine Control Unit and Antilock Brake System(ABS) using state charts..	2	L3	2.2

Review Questions

S.No	Questions	TLO	BL	PI Code
1	Describe the architecture of the ARM Cortex- M3 processor.	1	L2	2.1.1
2	Explain the modes of operation, memory mapping and bus interface systems in ARM CortexM3	2	L2	2.1.1
3	What do you mean by the term ‘Exception’? Explain exception handling capability ARM CortexM3	2	L2	2.1.1
4	Discuss how ARM CortexM3 helps build deterministic interrupt handling for a predictable response concerning a real-time case-study problem.	3	L3	2.1.1
5	Describe the advantages of target architectures DSP & FPGA used in real-time systems	4	L2	2.1.2
6	What is a PLD? Show its working by the AND-OR plane implementation of half adder circuit.	5	L3	2.1.2

Course Code and Title: **18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **3. Real-Time Kernels and Operating Systems**	*Planned Hours:* **7**

Learning Objectives

At the end of this chapter, the student should be able to:

S. No	TLO’s	CO	BL	CA Code
1	Define the basic terminologies and components in the Real-Time Operating System(RTOS) kernel and list RTOS's key characteristics and services.	2	L2	2.1
2	Develop the concepts of necessity for Real-Time Kernels and RTOS) and use of techniques, namely, context switching, task scheduling and task communication and Synchronization.	3	L3	2.1
3	Explain the selection criteria of an RTOS, use of scheduling Techniques and device drivers for a selected application.	3	L4	2.1
4	Analyze the real-time processes involved in the case study on the Mars Pathfinder mission using state chart models.	3	L4	2.1

Lesson Schedule

Class No. The portion covered per hour

15.0 Introduction to Real-time kernels and Operating system basics, Task scheduling
16.0 Task Scheduling types, Examples
17.0 Task communication and Synchronization,
18.0 Multiprocessing and multitasking, Kernel objects
19.0 Device drivers and Selection criteria of RTOS
20.0 Case study on Mars PathFinder Mission

Review Questions

S. No	Questions	TLO	B L	PI Code
1	Explain, What is an operating system? Where it is used, and what are its primary functions?	1	L2	2.1.1
2	Explain the difference between the memory management of the general-purpose kernel and a real-time kernel.	1	L2	2.1.1
3	What is a task control block (TCB)? Explain the structure of TCB.	2	L2	2.1.1
4	What is Inter-process communication (IPC)? Give an overview of different IPC mechanisms adopted by various operating systems? Explain using an example of a real-time case-study problem.	2	L2	2.1.1
5	Three processes with process IDs P1, P2, P3 with estimated completion times 8, 4, 7 ms respectively enter the ready queue in the order P3, P1, P2. P1 contains an I/O waiting time of 2ms when it completes 4ms of its execution. P2 and P3 do not contain any I/o waiting. Calculate the waiting time and Turn Around Time (TAT) for each process and the average waiting and Turn Around Time in the LIFO scheduling. All the estimated execution completion times is excluding I/O wait time.	3	L3	2.1.1
6	Explain the architecture of device drivers.	3	L2	2.1.1
7	Write a brief note on the selection of RTOS	4	L2	2.1.1
8	Bring out the differences between semaphore and mutex	4	L2	2.1.1
9	Differentiate between Preemptive and non-preemptive scheduling.	5	L2	2.1.1
10	Explain the single and recursive sharing of resources	5	L2	2.1.1

11	With an example, discuss the round-robin scheduling.	5	L2	2.1.1
12	What is a process? Describe the process states with the help of a process transition diagram?	6	L2	2.1.1
13	Explain the procedure involved in context switching while doing multitasking	6	L2	2.1.1
14	With a neat diagram, explain process states.	6	L2	2.1.1

Question Paper Title: Model Question Paper for Minor Exam I (ISA)						
Total Duration (H: M):1:15	**Course: Real-Time Embedded Systems Course Code: 18EARC303**		**Maximum Marks: 60**			
Note: Answer any two total questions						
Q. No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain the characteristic of an embedded system along with its architectural diagram.	10	1	L2	13	2.1.2
1b	Which are the components used as the core of an embedded system? Explain the metrics, drawbacks, if any, and the application/domain where they are commonly used.	10	1	L3	5	2.1.1
2a	Discuss how ARM CortexM3 helps in building deterministic interrupt handling for predictable responses in automobiles. Give an example of a real-time case-study problem.	10	2	L2	5	2.1.1
2b	Explain the following two techniques used by the NVIC of Cortex M3 to decrease the interrupt latency. Show the relevant timing diagrams (i) tail-chaining (ii) Late arrivals	10	2	L2	5	2.1.1
3a	Discuss the different functional and non-functional requirements that need to be addressed in the selection of RTOS	10	3	L2	13	2.1.1
3b	Discuss the essential kernel services of an operating system and give the classification of the operating system.	10	3	L3	13	2.1.1

Assignment Case study Presentation
Students in a team of 3 members shall present a real-world case study problem for the complete analysis and relation to real-time embedded system concepts

Chapter-wise Plan UNIT II

Course Code and Title: **18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **4.0 Inter-task Communication in RTOS**	*Planned Hours:* **7**

Learning Objectives

At the end of this chapter, the student should be able to:

S. No	TLO's	CO	B L	CA Code
1.	Define the basic terminologies related to Task, Task scheduling and Inter-task Communication.			
2.	Develop the concepts on RTOS objects for Inter-task Communication, namely, Semaphore, Buffer, Mailbox, Message Queue and writing of pseudocode etc.	4	L2	2.1
3.	Explain the procedures involved in Synchronization between two tasks and across multiple tasks and Single shared-resource-access Synchronization.	4	L2	2.1
4.	Demonstrate using a state chart model and Pseudocode program for implementing Inter-Task communication to demonstrate RTOS concepts for a real-time control system case study.	4	L2	2.1

Lesson Schedule

Class No. The portion covered per hour

21.0 Introduction to Tasks, Semaphores and Message Queues

22.0 A typical finite state machine with an example.

23.0 Semaphore structure types, Synchronization between multiple tasks, Examples

24.0 Shared-resource-access Synchronization, Message queue, its structure

25.0 Message Queue operations with Examples, Sending messages in FIFO or LIFO order, broadcasting messages

26.0 Demonstration of the objects of Inter-process communication

27.0 Case-study on Magnetic Resonance Imaging(MRI)

Review Questions

S.No	Questions	TLO	BL	PI Code
1	Discuss how a semaphore can be used for inter-task Synchronization, taking the example of a real-time case-study problem.	1	L2	2.1.1
2	Bring out the differences between a semaphore and a mutex.	1	L2	2.2.1
3	Discuss the use of message queues, mailboxes and pipes.	2	L2	2.2.1
4	Explain the single and recursive sharing of resources.	1	L2	2.2.1
5	Write a short note on Sending messages in FIFO or LIFO order, broadcasting messages.	2	L2	2.2.1
6	Develop an embedded system that takes analogue voice signal as input, converts it into a digital format using an ADC, converts the digital data into packets and sends the packet over a data network. List the various task in the embedded software. How do you assign priorities to the task? Do you need an embedded operating system? If so, what type of OS.	3	L3	2.2.1
7	Discuss how a semaphore can be used for inter-task Synchronization.	3	L2	2.2.1

Course Code and Title: **18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **5.0 Tasks & Task Management**	*Planned Hours:* **7**

Learning Objectives

At the end of this chapter, the student should be able to:

S No	TLO's	CO	BL	CA Code
1	Define the terminologies, namely, kernels, Microkernels, Nano kernels and the services offered by each of them.	5	L2	2.1
2	Develop the basics of concepts, namely, RTOS-task creation and task management.	5	L2	2.1
3	Describe the principles of task scheduling, inter-task-communication for real-time case studies, namely, Industrial Robot/ Adaptive Cruise control System.	5	L2	2.1
4	Solve problems on Task creation and task management functions using pseudocode and state chart modeling.	5	L2	2.1

Lesson Schedule
Class No. The portion covered per hour
28.0 RTOS- task creation and Management, Task scheduling, kernel services
29.0 Inter-task-communication, Task creation and Management using RTOS
30.0 Task scheduling, Kernel services
31.0 Demo on Task creation and management functions.
32.0 A case study on Industrial Robot
33.0 A case study on Weapons Dispense System
34.0 A case study on Adaptive Cruise control

Review Questions

S. No	Questions	TLO	BL	PI Code
1	Explain the exception handling mechanisms for tasks and interrupts under the RTOS kernel, taking an example of a real-time case-study problem.	1	L2	2.1.1
2	Create a POSIX based message queue under RTOS for communicating between two tasks as per given requirements for a given example of a real-time case-study problem.	2	L3	2.1.1
3	Explain the watch-dog timer operation under RTOS Kernel.	3	L2	2.1.1
4	Write a complete RTOS program for implementing multitasking as per the given requirements for a given example of a real-time case-study problem.	4	L3	2.1.1
5	Explain the different mutual exclusion mechanisms supported by the RTOS kernel. State the relative merits and limitations of each.	5	L2	2.1.1

Course Code and Title: **18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **6. Handling Deadlocks**	*Planned Hours:* ***6***

Learning Objectives

At the end of this chapter, the student should be able to:

Sr.No	TLO's	CO	B L	CA Code
1	Define the Deadlock scenario and list the conditions that describe the deadlock situation.	6	L2	2.1
2	Develop concepts of Deadlock occurrence, Resource	6	L2	2.1

	Management, and, Sharing of Resources.			
3	Explain the principles of Deadlock Avoidance, Deadlock Detection, Handling of deadlocks, and Resource Management.	6	L2	2.1
4	Draw the Resource allocation graph for the given case study problem.	6	L3	2.1
5	Explain the strategies of deadlock management, namely, Banker's algorithm and Dining Philosopher problem.	6	L2	2.1

Lesson Schedule

Class No. The portion covered per hour

35.0 Sharing Resources, Deadlock Model- Necessary Conditions,
36.0 A Graph-Theoretic Tool: The Resource Allocation Graph,
37.0 Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance,
38.0 Deadlock Detection, Demonstration on Handling of deadlocks
39.0 Demo on Deadlock identification through a case study
40.0 The Dynamic Dining Philosopher problem.

Review Questions

S.No	Questions	TLO	B L	PI Code
1	Explain what a deadlock is? What are the different conditions favouring deadlock?	1	L2	2.1.1
2	Explain the Dining Philosophers problem in the process synchronization context.	2	L2	2.1.1
3	Discuss various deadlock prevention methods.	3	L2	2.1.1
4	Explain Banker' algorithm for safe states using a resource allocation graph for a given real-time case-study problem.	4	L2	2.1.1
5	Describe what should be considered when using a termination strategy to recover from a deadlock with a real-time case-study problem.	5	L2	2.1.1

Survey Paper Activity
Students in a team of 3 members shall present a survey paper based on the overview of available state of the art technologies, standards and the recent research activity in the area of an identified case-study problem

<table>
<tr><th colspan="7">Question Paper Title: Model Question Paper for Minor Exam II (ISA)</th></tr>
<tr><th>Total Duration (H: M):1.15</th><th colspan="4">Course: Real-Time Embedded Systems
Course Code: 18EARC303</th><th colspan="2">Maximum Marks: 60</th></tr>
<tr><th colspan="7">Note: Answer any two full questions</th></tr>
<tr><td>Q.No</td><td>Questions</td><td>Marks</td><td>CO</td><td>BL</td><td>PO</td><td>PI Code</td></tr>
<tr><td>1a</td><td>Discuss the use of message queues, mailboxes, and pipes</td><td>10</td><td>4</td><td>L3</td><td>5</td><td>2.1.1</td></tr>
<tr><td>1b</td><td>Discuss how a semaphore can be used for inter-task Synchronization concerning any real-time case-study problem.</td><td>10</td><td>4</td><td>L3</td><td>13</td><td>2.1.1</td></tr>
<tr><td>2a</td><td>Write an RTOS multitasking application to create two tasks as per the following requirements
(i) The stack size for the tasks are 2000
(ii) priority for both the tasks are 100
(iii) Task 1 prints the message “Hell from Task 1” continuously with a delay of 500 timer ticks between successive printing
(iv) Task 2 prints the message “Hell from Task 2” continuously with a delay of 500 timer ticks between successive printing</td><td>10</td><td>5</td><td>L2</td><td>5</td><td>2.1.1</td></tr>
<tr><td>2b</td><td>Explain the state transition under RTOS with a state transition diagram. Give an example of the scenarios for each state transition.</td><td>10</td><td>5</td><td>L3</td><td>5</td><td>2.1.1</td></tr>
<tr><td>3a</td><td>What are the necessary conditions for a deadlock to occur? Give a real-world case-study example in which a deadlock can occur.</td><td>10</td><td>6</td><td>L3</td><td>13</td><td>2.1.1</td></tr>
<tr><td>3b</td><td>Two tasks are sharing a FIFO queue. Either task can write to or read from the FIFO.
(i) Hypothesize a situation in which deadlock can occur.
(ii) Use the resource allocation graph to illustrate the situation</td><td>10</td><td>6</td><td>L2</td><td>13</td><td>2.1.1</td></tr>
</table>

Course Code and Title: **18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **7. Performance Analysis and Optimization**	*Planned Hours:* ***5***

Learning Objectives
At the end of this chapter, the student should be able to:

S. No	TLO's	CO	B L	CA Code
1	Define the terms, namely, performance measures, efficiency, complexity, response time and associated terminologies.	7	L2	2.1
2	Develop concepts of performance or efficiency of the system, time loading, memory loading and optimization using case study problems.	7	L2	2.1
3	Discuss the when analyzing performance and for improving performance in time, power and memory access.	7	L2	2.1

Lesson Schedule	
Class No.	The portion covered per hour
41.0	Performance or Efficiency Measures, Complexity Analysis, The Methodology
42.0	Analyzing Code, algorithms, Response Time, Time Loading
43.0	Memory Loading, Evaluating Performance, Optimization of Performance and Power Consumption.
44.0	Performance Analysis and Optimization through a case study I
45.0	Performance Analysis and Optimization through a case-study II

Review Questions

S. No	Questions	TLO	BL	PI Code
1	Identify the primary criteria by which the performance of an embedded application may be measured.	1	L2	2.1.1
2	What is complexity analysis? What is the purpose of performing a complexity analysis of a software algorithm for a real-time case-study example?	2	L2	2.1.1

3	Identify the major factors that can affect the time performance of an instruction.	3	L2	2.1.1
4	Describe the methods by which we can perform a time loading analysis of an embedded application. Discuss the advantages and disadvantages of each.	4	L2	2.1.1
5	Describe each model used in analyzing the performance of an embedded application and elaborate on the kind of information we are trying to gain from each model for a real-time case-study example.	5	L2	2.1.1
6	What are "tricks of the trade"? Discuss the use of these techniques in reducing time loading and response times concerning a real-time case-study example.	5	L2	2.1.1

Course Code and Title**: 18EARC303, Real-Time Embedded Systems**	
Chapter Number and Title: **8. Wired and Wireless Protocols used in Real-Time Embedded System**	Planned Hours: **5**

Learning Objectives

At the end of this chapter, the student should be able to:

Sr.No	TLO's	CO	BL	CA Code
1	Define the basic terminologies related to different communication protocols used in real-time embedded systems.	8	L2	2.1
2	Develop the concepts of strategies used for communication using standard wired and wireless protocols.	8	L2	2.1
3	Compare the advantages and unique features of each of the protocols in the chosen real-time case-study examples.	8	L2	2.1

Lesson Schedule

Class No. The portion covered per hour

46. Wired Bus communication protocol (USB, I^2C)
47. Bus communication protocol (SPI)
48. Wireless and mobile system protocol, Bluetooth, 802.11 and its variants, ZigBee
49. Example block diagrams on the use of each protocol for a specified application.
50. Example block diagrams on the use of each protocol for a specified application.

Review Questions

S. No	Questions	TLO	BL	PI Code
1	Explain the Bluetooth and 802.11 and their variants	1	2	2.1.1
2	Develop a C code to perform memory read and write using SPI.	2	3	2.1.1
3	Develop a C code to program RTC to generate HOURS, MINUTES And SECONDS using I2C protocol.	2	3	2.1.1

III. Course Project Activity
Students in a team of 3 members shall present a plan for implementation of solution based on Survey paper activity for the chosen case-study problem through UML or state charts. The team shall follow the Embedded System Design cycle steps to implement the solution in the associated Lab.

Question Paper Title: Model Question Paper for End Semester Assessment						
Total Duration (H: M): 3	**Course: Real-Time Embedded Systems Course Code:18EARC303**			**Maximum Marks: 100**		
Note: Answer five questions; any two full questions from each unit-I and Unit-II and one full question from unit-III						
UNIT I						
Q. No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain the characteristic of an embedded system along with its architectural diagram.	10	1	L2	2	2.2.2
1b	Which are the components used as the core of an embedded system? Explain the metrics, drawbacks concerning a real-time case-study example.	10	1	L2	2	2.2.2
2a	Explain the following two techniques used by the NVIC of Cortex M3 to decrease the interrupt latency. Show the relevant timing diagrams:(i) tail-chaining (ii) Late arrivals	10	2	L2	2	2.2.2
2b	Realize switching function (2, 3, 4, 6, 7) using 2 input LUTs. Give the truth table implementation using FPGA.	10	2	L3	2	2.2.2
3a	What is task scheduling? Explain with example	10	3	L2	2	2.2.2
3b	Develop a C code to perform the following tasks i. Flashing of LED ii. Displaying 00 to 99 on seven segments .use RTOS scheduling algorithms. An embedded system has three processes with the following execution time and periods: P1(4,16), P2(3,8), P1(2,7).i) what is the CPU utilization for such a system? ii)can the set of tasks be scheduled using a monotonic rate schedule? (iii) if not, what changes would have to be made to enable the set of tasks to be scheduled in a rate monotonic schedule	10	3	L3	2	2.2.2
UNIT II						
4a	Discuss the use of message queues, mailboxes, and pipes	10	4	L3	2	2.2.2
4b	Discuss how a semaphore can be used for inter-task Synchronization	10	4	L3	2	2.2.2

5a	Write an RTOS multitasking application to create two tasks as per the following requirements. (i) The stack size for the tasks are 2000 (ii) priority for both the tasks are 100 (iii) Task 1 prints the message “Hello from Task 1” continuously with a delay of 500 timer ticks between successive printing (iv) Task 2 prints the message “Hello from Task 2” continuously with a delay of 500 timer ticks between successive printing	10	5	L2	2	2.2.2
5b	Explain the state transition under RTOS with a state transition diagram. Give an example of the scenarios for each state transition.	10	5	L3	2	2.2.2
6a	What are the necessary conditions for a deadlock to occur? Give a real-world example in which a deadlock can occur	10	6	L3	2	2.2.2
6b	Two tasks are sharing a FIFO queue. Either task can write to or read from the FIFO. (i) Hypothesize a situation in which deadlock can occur. (ii) Use the resource allocation graph to illustrate the situation	10	6	L2	2	2.2.2
UNIT III						
7a	Identify the significant criteria, using which the performance of an embedded application can be analyzed. Do these criteria apply to all embedded applications? Justify.	10	7	L3	2	2.2.2
7b	Describe the methods by which we can perform a time loading analysis of an embedded application. Discuss the advantages and disadvantages of each.	10	7	L3	2	2.2.2
8a	Discuss the different embedded communication protocols	10	8	L3	2	2.2.2
8b	Develop a C code to program RTC and generate a calendar using SPI protocol	10	8	L3	2	2.2.2

FMTH0301/Rev.5.3

Course Plan

Semester: **VI**	Year: **2021-22**
Course Title: **Power Electronics, Motors & Drives**	Course Code: 16EARE301
Total Contact Hours: **40**	Duration of ESA Hours: 3
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr. Rakesh P. Tapaskar	Date: 20-12-2021
Checked By: Mrs. Jyoti Bali	Date: 24-12-2021

Prerequisites:

Knowledge of basic electronics, semiconductors.

Course Outcomes (COs):

At the end of the course the student should be able to:

I. Identify the individual building blocks of an electric drive system, the requirements and constraints in choosing each of the blocks in the drive system using their electrical and mathematical equivalent model meeting the objectives for the specified application

II. Apply the basic laws of electrical and electronics engineering to explain the different working modes of power electronics devices like Power BJT and Power MOSFET, thyristors and triacs using their characteristics

III. Discuss the thyristor concepts involving its commutation theories in various application.

IV. Discuss the concept of static switch with their advantages over conventional switches.

V. Develop the concept of power DC – DC converters in context of motor drives.

VI. Analyze the working of power electronics for motor and drive applications

VII. Discuss the working of stepper motor and its application

VIII. Discuss the drives for industrial applications like Rolling mill drives, cement mill drives, electric traction drives, textile mill drives and machine tool drives.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: Power Electronics, Motors & Drives	Semester: VI
Course Code: **16EARE301**	Year: Jan2019 to June 2019

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1.0 Identify the individual building blocks of an electric drive system, the requirements and constraints in choosing each of the blocks in the drive system using their electrical and mathematical equivalent model meeting the objectives for the specified application	H													
2.0 Apply the basic laws of electrical and electronics engineering to explain the different working modes of power electronics devices like Power BJT and Power MOSFET, thyristors and triacs using their characteristics	M	**H**												
3.0 Discuss the thyristor concepts involving its commutation theories in various application.		H												
4.0 Discuss the concept of static switch with their advantages over conventional switches.		H												
5.0 Develop the concept of power DC – DC converters in context of motor drives.		M												
6.0 Analyze the working of power electronics for motor and drive applications		H												
7.0 Discuss the working of stepper motor and its application		H	M											
8.0 Discuss the drives for industrial applications like Rolling mill drives, cement mill drives, electric traction drives, textile mill drives and machine tool drives.	M													

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3 - Demonstrate competence in engineering fundamentals	1.3.2 - Apply basic electrical and electronics engineering principles and laws to solve problems
2.1 - Demonstrate an ability to identify and characterize an engineering problem	2.1.2 - Identifies the essential problems and objectives
	2.1.3 - Identifies all relevant constraints and requirements and formulate an accurate description of the problem
2.2 - Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 - Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions
	2.2.3 - Selects appropriate analysis tools and applies those proficiently to implement the model/solution
3.1 - Demonstrate an ability to define a complex open-ended problem in engineering terms	3.1.2 - Elicit and document, engineering requirements from stakeholders
6.2 - Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1 - Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
8.2 - Demonstrate an ability to apply the Code of Ethics	8.2.1 - Identify tenets of the IEEE professional code of ethics
	8.2.2 - Examine and apply moral & ethical principles to historically famous case studies
9.1 - Demonstrate an ability to form a team and define a role for each member	9.1.2 - Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal
10.1 - Demonstrate an ability to comprehend technical literature and document project work.	10.1.1 - Read, understand and interpret technical and non-technical information
	10.1.2 - Produce clear, well-constructed, and well-supported written engineering documents
	10.1.3 - Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
12.1 - Demonstrate an ability to identify gaps in knowledge and a strategy to close these gaps	12.1.1 - Describe the rationale for requirement for continuing professional development
12.2 - Demonstrate an ability to Identify changing trends in engineering knowledge and practice	12.2.2 - Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
13.1 - Demonstrate an ability to design and integrate simple automation systems	13.1.1 - Develop system specification, identify IO, control components and field devices, Identify integration technologies

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Assessment Plan

Course Title: Power Electronics, Motors & Drives
Code: **16EARE301**

Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		M 1	M 2	ASSIGNMENT	ESA
1.0 Identify the individual building blocks of an electric drive system, the requirements and constraints in choosing each of the blocks in the drive system using their electrical and mathematical equivalent model meeting the objectives for the specified application	12 %	✓			✓
2.0 Apply the basic laws of electrical and electronics engineering to explain the different working modes of power electronics devices like Power BJT and Power MOSFET, thyristors and triacs using their characteristics	15 %	✓			✓
3.0 Discuss the thyristor concepts involving its commutation theories in various application.	12 %	✓			✓
4.0 Discuss the concept of static switch with their advantages over conventional switches.	10 %		✓		✓
5.0 Develop the concept of power DC – DC converters in context of motor drives.	10 %		✓		✓
6.0 Analyze the working of power electronics for motor and drive applications	15 %		✓		✓
7.0 Discuss the working of stepper motor and its application	14 %			✓	✓
8.0 Discuss the drives for industrial applications like Rolling mill drives, cement mill drives, electric traction drives, textile mill drives and machine tool drives.	12 %			✓	✓
Weightage		20%	20%	10%	50%

Course Content

Course Code: 16EARE301	Course Title: Power Electronics, Motors & Drives		
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40	
ISA Marks: 50	ESA Marks: 50	Total Marks: 100	
Teaching Hrs: 50		Exam Duration: 3 hrs	

Content	**Hrs**
Unit - 1	
CHAPTER NO. 1. INTRODUCTION TO PE AND ELECTRIC DRIVE SYSTEMS - Power Electronics, Applications of Power Electronics, Types of Power Electronic Circuits, Peripheral Effects, Characteristics and Specifications of Switches. Basic components of an Electric drive system: Mechanical loads, electric motors, power sources, converters and controllers.	7 hrs
CHAPTER NO. 2. POWER DIODES, BJT, MOSFET AND RECTIFIERS: Introduction, Diode Characteristics, Reverse Recovery Characteristics, Power Diode Types, Freewheeling Diodes with Switched RL Load. power BJT, structure of BJT, MOSFET and IGBT, characteristics of BJT, MOSFET and IGBT, comparison of power devices. Introduction, Single-Phase Full-Wave Rectifiers, Single-Phase Full-Wave Rectifier with RL Load, Single-Phase Full-Wave Rectifier with a Highly Inductive Load.	7 hrs
CHAPTER NO. 3. THYRISTORS AND COMMUTATION THEORY Introduction, Principle of Operation of SCR, Static Anode-Cathode Characteristics of SCR, two transistor model of SCR, Gate Characteristics of SCR, Firing circuits for SCRs, Turn-On Methods, Turn-Off Mechanism, Turn-Off. Natural and Forced Commutation – Class A and Class B types, Gate Trigger Circuit: Resistance Firing Circuit, Resistance capacitance firing circuit.	6 hrs
Unit - 2	
CHAPTER NO. 4. STATIC SWITCHES AND POWER SUPPLIES Single phase ac static switches, three phase ac static switches, three phase reversing switches, Solid state relays, Design of static switches, DC power supplies, DC Switched Mode DC power supplies, bidirectional power supplies, Switched Mode AC power supplies.	7 hrs
CHAPTER NO. 5. DC-DC CONVERTERS - Introduction, principle of step-down operation and its analysis with RL load, principle of step-up operation, Step-up converter with a resistive load, Performance parameters, Converter classification, Switching mode regulators: Buck regulator, Boost regulator, Buck-Boost Regulators.	7 hrs
CHAPTER NO. 6. POWER ELECTRONICS FOR MOTOR AND DRIVE APPLICATIONS DC and AC motor control, Single phase SCR drive, Three phase SCR drive, Reversible SCR drive, Speed control of DC motor, chopper-controlled DC drives, Microprocessor-Controlled DC drives, AC motor characteristics, speed control methods of induction motor, commutator less DC motor and Electronic commutation.	6 hrs
Unit - 3	
CHAPTER NO. 7. STEPPER MOTOR Principle of Stepper motor, Classification of Stepper motor, Principle of variable reluctant stepper motor, Principle of Permanent magnet stepper motor, Principle of hybrid stepper motor, driver for stepper motor, Applications of Stepper motor.	5 hrs
CHAPTER NO. 8. DRIVES FOR INDUSTRIAL APPLICATIONS Rolling mill drives, cement mill drives, electric traction drives, textile mill drives and machine tool drives.	5 hrs

Text Book: (List of books as mentioned in the approved syllabus)

1. Gopal K Dubey, Fundamental of electric drives, Second, Narosa publication, 2005
2. P.S Bhimbhra, Power Electronics, Fourth, Khanna , 2007
3. Mohammed A Sharkawi, Fundamental of electric drives, Fourth, Brooks/Cole, 2000
4. Robert Boylestead and Louis Nashelsky "Electronic Devices and Circuit Theory, Eleventh edition, Pearson Publications
5. Rashid M H, Power Electronics Circuits,devices and applications, Second, PHI, 2000
6. P.C Sen, Power Electronics, Tata McGraw Hill, Ninth Edition.

References

1. P.S Bhimbhra, Power Electronics, Fourth, Khanna, 2007
2. Mohammed A Sharkawi, Fundamental of electric drives, Fourth, Brooks/Cole, 2000

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
Minor Exam1	20
Minor Exam II	20
Assignments	10
Total	50

Course Unitization for Minor Exams and Semester End Examination

Topics / Chapters	Teaching hours	No. of Questions in Minor Exam1	No. of Questions in Minor Exam II	No. of Questions in ESA	No. of Questions in Datasheet Reading Activity
Unit I					
1.Introduction to Power electronic devices	5	1.00	--	1.00	--
2.Power diodes, rectifiers	5	1.00	--	1.00	--
3.Thyristors and Commutation Theory	5	1.00	--	1.00	--
Unit II					
4. Static Switches and Power Supplies	5	--	1.00	1.00	--
5. DC-DC converters	5	--	1.00	1.00	--
6. Power electronics for motor and drive applications	5		1.00	1.00	
Unit III					
7.Stepper motor	5	--	--	1.00	--
8.Drives for industrial Applications	5	--	--	1.00	1.00

Note:

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in Minor I, II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date: 25-12-2021

Head of Department

Chapter-wise Plan

Course Code and Title: **16EARE301 / Power Electronics, Motors & Drives**	
Chapter Number and Title: **1.0 INTRODUCTION TO PE AND ELECTRIC DRIVE SYSTEMS**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Identify the individual building blocks in the functional block diagram of a power electronic and electric drive system	CO1	L2	2.1
2. Discuss the characteristics and specifications of power electronic based switching systems	CO1	L2	2.1
3. Discuss the constraints, requirements and selection criteria associated with each component of electric drives including motors, converters, controllers and transmission mechanism for any chosen application	CO1	L2	2.1

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to Power Electronics, 2. Applications of Power Electronics, 3. Types of Power Electronic Circuits, Peripheral Effects, 4. Characteristics and Specifications of Switches. 5. Basic components of an Electric drive system: 6. Mechanical loads, electric motors, 7. Power sources, converters and controllers.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain the constraints and requirements in choosing each component of electrical drives taking an example of hoist system	TLO3	L2	2.1.2
2. Discuss in specific the constraints in choosing the motors employed in variable speed drives	TLO3	L2	2.1.2
3. Discuss the criteria to select suitable power electronic converter for any given application.	TLO2	L2	2.1.2

Assignment Questions
1. How does the type of load decide the selection of drive for the specific application? Justify your answer. 2. Compare the different types of converters based on their functional performance 3. Discuss the factors deciding the choice of electrical drive for an application like rolling mill/traction load/cement mill etc.

Course Code and Title: **16EARE301 / Power Electronics, Motors & Drives**	
Chapter Number and Title: **2.0 POWER DIODES, BJT, MOSFET AND RECTIFIERS**	Planned Hours: **7 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Interpret the ratings and characteristics of each of power electronics devices	CO2	L3	1.3
2. Discuss the different working modes of power electronics devices like power BJT and power MOSFET using their characteristics and basic laws of electrical and electronics principles.	CO2	L2	1.3
3. Discuss the gate and base drives of the devices	CO2	L2	1.3
4. Discuss the rectification action of simple power electronic components and protection schemes	CO2	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction, Diode Characteristics, Reverse Recovery Characteristics, 2. Power Diode Types, Freewheeling Diodes with Switched RL Load. 3. Power BJT, structure of BJT, MOSFET and IGBT, 4. Characteristics of BJT, MOSFET and IGBT, 5. Comparison of power devices. 6. Single-Phase Full-Wave Rectifiers, Single-Phase Full-Wave Rectifier with RL Load, 7. Single-Phase Full-Wave Rectifier with a Highly Inductive Load.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain the switching characteristics of power BJT	TLO3	L2	2.1.2
2. Explain the switching characteristics of power MOSFET	TLO3	L2	2.1.2
3. Explain the switching characteristics of IGBT	TLO2	L2	2.1.2
4. Compare the characteristics and application of BJT, IGBT and MOSFET	TLO2	L2	2.1.2
5. What is di/dt and dv/dt, how devices are protected against di/dt and dv/dt?	TLO3	L3	2.1.2

Assignment Questions

1. Explain the switching characteristics of power BJT, IGBT and MOSFET
2. Compare the characteristics and application of BJT, IGBT and MOSFET and relevance of di/dt and dv/dt protection schemes.

Course Code and Title: **16EARE301 / Power Electronics, Motors & Drives**	
Chapter Number and Title: **3. THYRISTORS AND COMMUTATION THEORY**	Planned Hours: **6 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Explain the operating modes of thyristor and its operation	CO3	L3	2.2
2. Describe the voltage and current rating of thyristors with characteristics of gate requirements.	CO3	L3	2.2
3. Comparison of various commutation theories and its classifications	CO3	L2	2.2
4. Describe the commutation methods for thyristors	CO3	L3	2.2

Lesson Schedule Class No. - Portion covered per hour
1. Introduction, Principle of Operation of SCR, 2. Static Anode-Cathode Characteristics of SCR, 3. Two transistor model of SCR, Gate Characteristics of SCR, **4.** Firing circuits for SCRs, Turn-On Methods, Turn-Off Mechanism, Turn-Off. 5. Natural and Forced Commutation – Class A and Class B types, 6. Gate Trigger Circuit: Resistance Firing Circuit, Resistance capacitance firing circuit.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain the characteristics of thyristor	TLO1	L2	2.2.1
2. Explain turn on off characteristics of thyristor.	TLO1	L2	2.2.1
3. Explain I^2t, dv/dt and di/dt ratings	TLO4	L3	2.2.1
4. Explain different commutations with necessary diagrams	TLO4	L3	2.2.1

Assignment Questions
1. Discuss the latching and holding current of thyristor and compare the same 2. Explain I^2t, dv/dt and di/dt ratings 3. Explain the classification of commutation methods 4. What is impulse commutation

Course Code and Title: **15EARC201 / Analog and Digital Electronic Circuits**	
Chapter Number and Title: **04. STATIC SWITCHES AND POWER SUPPLIES**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Discuss the need of static switches	CO4	L2	2.1
2. Describe the use of various static switches depending on application	CO4	L2	2.1
3. Describe the various power supplies schemes	CO4	L2	2.1
4. Discuss the need and operation of single and bidirectional power supplies	CO4	L2	2.1

Lesson Schedule Class No. - Portion covered per hour
1. Single phase ac static switches, 2. Three phase ac static switches, 3. Three phase reversing switches, 4. Solid state relays, Design of static switches, 5. DC power supplies, DC Switched Mode DC power supplies, 6. Bidirectional power supplies, 7. Switched Mode AC power supplies.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What is static switch?	1	L2	2.1.4
2	What is the difference between AC and DC switches.	2	L3	2.1.4
3	What are the advantages of ststic switches over mechanical sawitches.	3	L2	2.1.4
4	What is the principle pof operation of SSR?	2	L3	2.1.4
5	What are the normal specification of power supplies	2	L3	2.1.4
6	Name three types of AC and DC power supplies	2	L3	2.1.4
7	What are the advantages and disadvantage of SMPS	4	L3	2.1.4

Course Code and Title: **16EARE301 / Power Electronics, Motors & Drives**	
Chapter Number and Title: **5. DC-DC CONVERTERS**	Planned Hours: **5hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1.0 Discuss the principles of DC DC converters	CO4	L2	2.2
2.0 Describe step down and step up mode of conversions	CO4	L2	2.2
3.0 Explain the control strategies of choppers	CO4	L3	2.2
4.0 Explain of classification of choppers according to their VI quadrant of operation	CO4	L2	2.2

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to DC DC Converters 2. principle of step-down operation and its analysis with RL load, 3. principle of step-up operation, 4. Step-up converter with a resistive load, 5. Performance parameters, Converter classification, 6. Switching mode regulators: Buck regulator, 7. Boost regulator, Buck-Boost Regulators.

Review Questions

Questions	TLO	BL	PI Code
1. What is chopper	TLO1	L2	2.2.3
2. Explain with relevant waveforms of A type chopper	TLO3	L3	2.2.3
3. What is two quadrant choppers	TLO3	L3	2.2.3
4. Give the classification of chopper	TLO3	L2	2.2.1
5. Discuss various types of chopper configuration	TLO4	L2	2.2.1
6. Distinguish between class A and Class B choppers	TLO4	L3	2.2.1
7. Explain how the DC choppers are classified with reference to load voltage and current	TLO5	L2	2.2.1

Assignment Questions
1. What is chopper? Explain how the DC choppers are classified with reference to load voltage and current 2. Give the classification of chopper with R and RL loads

Course Code and Title: **16EARE301 / Power Electronics, Motors & Drives**	
Chapter Number and Title: **6. POWER ELECTRONICS FOR MOTOR AND DRIVE APPLICATIONS**	Planned Hours: 6**hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1.0 Discuss the principles DC and AC motor control	CO4	L2	2.2
2.0 Describe various SCR based drives for DC and AC motors	CO4	L2	2.2
3.0 Explain the Microprocessor/Microcontroller based DC drives	CO4	L3	2.2

Lesson Schedule Class No. - Portion covered per hour
1. DC and AC motor control, Single phase SCR drive, 2. Three phase SCR drive, Reversible SCR drive, 3. Speed control of DC motor, chopper-controlled DC drives, 4. Microprocessor-Controlled DC drives, 5. AC motor characteristics, speed control methods of induction motor, 6. Commutator less DC motor and Electronic commutation.

Review Questions

Questions	TLO	BL	PI Code
1. Explain DC and AC motor control using Single phase SCR drive,	TLO1	L2	2.2.3
2. Explain the Speed control of DC motor with chopper-controlled DC drives	TLO3	L3	2.2.3
3. Explain the Microprocessor/Microcontroller based DC drives	TLO3	L3	2.2.3
4. Discuss the Commutator less DC motor and Electronic commutation.	TLO4	L2	2.2.1

Assignment Questions
1. Discuss the principles DC and AC motor control 2. Explain the Microprocessor/Microcontroller based DC drives

Course Code and Title: **16EARE301 / Power Electronics, Motors & Drives**	
Chapter Number and Title: **7. Stepper Motor**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1.0 Discuss the working principle of stepper motor	CO6	L3	2.2
2.0 Discuss the application of stepper motor along with its working characterstics	CO6	L2	2.2

Lesson Schedule Class No. - Portion covered per hour
1. Principle of Stepper motor. 2. Classification of Stepper motor. 3. Principle of variable reluctant stepper motor. 4. Principle of Permanent magnet stepper motor. 5. Principle of hybrid stepper motor. 6. Applications of Stepper motor.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain the working principle of stepper motor	TLO2	L2	2.2.1
2. Classify stepper motor with their applications	TLO2	L2	2.2.1

Assignment Questions
1. Describe the working of stepper motor with its classification 2. Mention the applications of Stepper motor. 3. Explain the driver circuit employed for stepper motor

Course Code and Title: **16EARE301 / Power Electronics, Motors & Drives**	
Chapter Number and Title: **8. Drives for industrial Applications**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

TLO's	CO's	BL	CA Code
1. Interpret industrial plant specifications and develop suitable control schemes.	CO7	L4	10.1
2. Select industrial drive specifications for a range of specified applications	CO7	L3	10.1
3. Analyze the operating conditions and protection arrangements for drives as per standard	CO7	L4	2.1
4. Analyze the selection, installation and configuration procedures of variable speed drives used for industrial applications.	CO7	L4	3.1

Lesson Schedule Class No. - Portion covered per hour
1. Rolling mill drives
2. Electric traction drives
3. Textile mill drives
4. Machine tool drives
5. Machine tool drives

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Describe briefly the process involved in a cement factory and the required features of electric drives employed there through oral presentation and a report.	TLO1	L4	2.2.1
2. Explain the different steps followed in a textile industry and give an account of the electric drives employed with proper reasoning.	TLO4	L4	2.2.1

Question Paper Title: In Semester Assessment (ISA)							
Total Duration (H:M):1hour 15	Course: Power Electronics, Motors & Drives (16EARE301)		Maximum Marks :60				
Note: Answer any two full questions							
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**	
1a	Identify the individual building blocks in the functional block diagram of a power electronic and electric drive system	5	CO1	L2	2	2.1.2	
1b	Discuss the characteristics and specifications of power electronic based switching systems	10	CO1	L2	2	2.1.2	
1c	Discuss the constraints, requirements and selection criteria associated with each component of electric drives including motors, converters, controllers and transmission mechanism for any chosen application	5	CO1	L2	2	2.1.2	
2a	Explain the switching characteristics of IGBT	5	TLO2	L2	1	1.3.2	
2b	Compare the characteristics and application of BJT, IGBT and MOSFET	10	TLO2	L2	1	1.3.2	
2c	What is di/dt and dv/dt, how devices are protected against di/dt and dv/dt?	5	TLO3	L3	1	1.3.2	
3a	Explain the characteristics of thyristor	5	TLO1	L2	2	2.2.1	
3b	Explain turn on off characteristics of thyristor.	10	TLO1	L2	2	2.2.1	
3c	Explain I^2t, dv/dt and di/dt ratings	5	TLO4	L3	2	2.2.1	

Question Paper Title: End Semester Assessment (ESA)							
Total Duration (H:M):1H 15 MI	**Course :Power Electronics, Motors & Drives (16EARE301)**		**Maximum Marks :60**				
Note :Answer any Two Full Questions							
Q.No.	Questions	Marks	CO	BL	PO	PI Code	
1a	What are the normal specification of power supplies	5	2	L3	2	2.1.4	
1b	Name three types of AC and DC power supplies	10	2	L3	2	2.1.4	
1c	What are the advantages and disadvantage of SMPS	5	4	L3	2	2.1.4	
2a	Discuss various types of chopper configuration	5	4	L2	2	2.2.3	
2b	Distinguish between class A and Class B choppers	10	4	L3	2	2.2.3	
2c	Explain how the DC choppers are classified with reference to load voltage and current	5	5	L2	2	2.2.3	
3a	Explain the Speed control of DC motor with chopper-controlled DC drives	5	2	L2	2	2.2.3	
3b	Explain the Microprocessor/Microcontroller based DC drives	10	2	L2	2	2.2.3	
3c	Discuss the Commutator less DC motor and Electronic commutation.	5	5	L2	2	2.2.1	

Question Paper Title: Model question paper for End Semester Assessment (ESA)						
Total Duration (H:M):3	Course :Power Electronics, Motors & Drives (16EARE301)		Maximum Marks :160			
Note :Attempt any two full questions from Unit I & II, and any one question from Unit III						
UNIT I						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Identify the individual building blocks in the functional block diagram of a power electronic and electric drive system	5	1	L2	2	2.1.2
1b	Discuss the characteristics and specifications of power electronic based switching systems	10	1	L2	2	2.1.2
1c	Discuss the constraints, requirements and selection criteria associated with each component of electric drives including motors, converters, controllers and transmission mechanism for any chosen application	5	1	L2	2	2.1.2
2a	Explain the switching characteristics of IGBT	5	2	L2	1	1.3.2
2b	Compare the characteristics and application of BJT, IGBT and MOSFET	10	2	L2	1	1.3.2
2c	What is di/dt and dv/dt, how devices are protected against di/dt and dv/dt?	5	3	L3	1	1.3.2
3a	Explain the characteristics of thyristor	5	1	L2	2	2.2.1
3b	Explain turn on off characteristics of thyristor.	10	1	L2	2	2.2.1
3c	Explain I^2t, dv/dt and di/dt ratings	5	4	L3	2	2.2.1
UNIT II						
4a	What are the normal specification of power supplies	5	2	L3	2	2.1.4
4b	Name three types of AC and DC power supplies	10	2	L3	2	2.1.4
4c	What are the advantages and disadvantage of SMPS	5	4	L3	2	2.1.4
5a	Discuss various types of chopper configuration	5	4	L2	2	2.2.3
5b	Distinguish between class A and Class B choppers	10	4	L3	2	2.2.3
5c	Explain how the DC choppers are classified with reference to load voltage and current	5	5	L2	2	2.2.3
6a	Explain the Speed control of DC motor with chopper-controlled DC drives	5	2	L2	2	2.2.3
6b	Explain the Microprocessor/Microcontroller based DC drives	10	2	L2	2	2.2.3
6c	Discuss the Commutator less DC motor and Electronic commutation.	5	5	L2	2	2.2.1
UNIT III						

7a	Describe the working of stepper motor with its classification	10	7	L2	2	2.2.1
7b	Mention the applications of Stepper motor. Explain the driver circuit employed for stepper motor	10	7	L2	2	2.2.1
8a	Describe briefly the processes involved in a cement factory and the essential features of electric drives employed there.	10	8	L4	13	13.1.1
8b	Explain the constraints and requirements associated with electric drives used in a textile industry and explain the selection strategy used for each of the drive system element there.	10	8	L4	13	13.1.1

Corrections Note

FMTH0301/Rev.5.3

Course Plan

Semester: **VI** Year: 2020-2021

Course Title: **Computer vision and digital image processing**	Course Code: 15EARE302
Total Contact Hours: 40	Duration of ESA : 3 Hours
ISA Marks: 50	ESA Marks: 50
Lesson Plan Author: Mr. Shridhar Doddamani	Date: 12/03/2021
Checked By: Mrs. Ashwini G K	Date: 12/03/2021

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Explain the working of camera, its calibration procedure, and the associated applications of computer vision and digital image processing.
2. Explain the working of Lambertian and specular model to demonstrate modeling of pixel brightness and reflection, specifically for dynamic range of images to infer on color finding specularities.
3. Apply pre-processing steps namely, sampling and quantization, followed by processing using gray level transformation, histogram processing in spatial domain and Fourier transform in frequency domain for the acquired images.
4. Explain the methods for image segmentation and feature analysis, namely, detection of discontinuities, degradation/restoration process for the reconstruction of images using spatial filtering and frequency domain filtering.
5. Design algorithms based on color image processing and image compression using the fundamentals of color models and image compression methods.
6. Implement morphological algorithms for an image to classify segmentation types.
7. Implement the classification algorithms for recognition and categorization of images using Bayesian modeling method.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: **Computer vision and digital image processing**	Semester: 6
Course Code: 15EARE302	Year: 2020-2021

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Explain the working of camera, its calibration procedure, and the associated applications of computer vision and digital image processing.	**M**	**M**												
Explain the working of Lambertian and specular model to demonstrate modeling of pixel brightness and reflection, specifically for dynamic range of images to infer on color finding specularities.		**M**												
Apply pre-processing steps namely, sampling and quantization, followed by processing using gray level transformation, histogram processing in spatial domain and Fourier transform in frequency domain for the acquired images.		**M**	**M**											
Explain the methods for image segmentation and feature analysis, namely, detection of discontinuities, degradation/restoration process for the reconstruction of images using spatial filtering and frequency domain filtering.		**M**	**H**											
Design algorithms based on color image processing and image compression using the fundamentals of color models and image compression methods.		**M**	**H**											
Implement morphological algorithms for an image to classify segmentation types.			**H**											
Implement the classification algorithms for recognition and categorization of images using Bayesian modeling method.			**H**											

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 - Demonstrate the competence in mathematical modeling.	1.1.2 - Apply discipline specific advanced mathematical techniques to modeling and problem solving
1.3 - Demonstrate competence in engineering fundamentals	1.3.3 - Apply computer programming skills to solve problems by building algorithms ,flow charts and debugging
2.1 - Demonstrate an ability to identify and characterize an engineering problem	2.1.3 - Identifies all relevant constraints and requirements and formulate an accurate description of the problem
	2.1.4 - Gathers engineering knowledge from the available literature and selects the most relevant
2.2 - Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.2 - Partitions problems, processes or systems into manageable elements for the purposes of analysis, modeling or design
	2.2.3 Selects the appropriate analysis tools and applies that proficiency to implement the model/solution.
2.3 - Demonstrate an ability to formulate and interpret a model	2.3.1 - Evaluates the analysis for accuracy and validity of assumptions made.
2.4-Demonstrate an ability to execute a solutions process and analyze results	2.4.1-Ability to validate and verify using various tools.
3.1. Demonstrate an ability to define a complex open ended problems in engineering terms	3.1.1-Recognizes that good problem definition assists in design process.
	3.1.5. Determine Design objectives, functional requirements and arrives at specifications.

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: 15EARE302	Course Title: **Computer vision and digital image processing**	
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration : 3 hours

Content	Hours
UNIT – 1	
CHAPTER 1: FUNDAMENTALS OF COMPUTER VISION AND DIGITAL IMAGE PROCESSING Introduction to computer vision system, Geometric Camera Models- Pinhole Perspective, Cameras with Lenses, the Human Eye, Intrinsic and Extrinsic Parameters, Geometric Camera Calibration. Digital image processing system, application of computer vision and digital image processing. Design of machine vision system.	6 hrs
CHAPTER 2: LIGHT AND SHADING, COLOR Modeling Pixel Brightness, Reflection at Surfaces, Sources and Their Effects, the Lambertian+SpecularModel, Inference from Shading, Radiometric Calibration and High Dynamic Range Images, the Shape of specularities, Inferring Lightness and Illumination, Color- Human Color Perception, The Physics of color, representing Color, Inference from Color Finding specularities Using Color Shadow removal, using Color Constancy: Surface Color from Image Color.	6 hrs
CHAPTER 3: IMAGE FORMATION AND PROCESSING Image Acquisition – Sampling and Quantization- Pixel Relationships, image enhancement Spatial Domain Gray level Transformations Histogram Processing Spatial Filtering – Smoothing and Sharpening, Introduction to the Fourier Transform and the Frequency Domain, DFT, FFT.	5 hrs
UNIT – 2	
CHAPTER 4: IMAGE SEGMENTATION AND FEATURE ANALYSI Detection of Discontinuities – Edge Operators – Edge Linking and Boundary Detection –Thresholding – Region Based Segmentation, A Model of the Image Degradation/Restoration Process, Noise Models, Restoration in the Presence of Noise Only–Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering	6hrs
CHAPTER 5: COLOR IMAGE PROCESSING AND IMAGE COMPRESSION Color Fundamentals, Color Models, Pseudo color Image Processing, Basics of Full-	6hrs

Color Image Processing Color Transformations, Smoothing and Sharpening, Color Segmentation, Noise in Color Images Color Image Compression, Image Compression-Fundamentals, Image Compression Models, Elements of Information Theory, Error-Free Compression, Lossy Compression	
UNIT – 3	
CHAPTER 6: MORPHOLOGICAL PROCESSING Dilation and Erosion, Opening and Closing, The Hit-or-Miss Transformation, Some Basic Morphological Algorithms.	6hrs
CHAPTER 7: RECOGNITION AND BAYESIAN MODELING Object detection, Face recognition. Instance recognition, Category recognition, Context and scene understanding, Recognition databases and test sets, Prior models and Bayesian inference. Gradient descent and simulated annealing, Graph cuts, Markov random fields	5 hrs

Text Book (List of books as mentioned in the approved syllabus)

1. David A. Forsyth and Jean Ponce- Computer vision A modern approach, 2nd Edition, Pearson publication, 2003.

2. Rafael C. Gonzalez and Richard E. Woods- Digital Image Processing-2nd Edition, Prentice Hall publication,2002

Reference book

1. Richard Szeliski , Computer Vision: Algorithms and Applications, Springer publication,2010

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
Minor Exam-1	20
Minor Exam- 2	20
Course project	10
Total	50

Course Unitization for Minor Exams and Semester End Examination

Topics / Chapters	Teaching hours	No. of Questions in Minor Exam-1	No. of Questions in Minor Exam -2	No. of Questions in ESA
UNIT I				
CHAPTER 1: FUNDAMENTALS OF COMPUTER VISION AND DIGITAL IMAGE PROCESSING	6	1	--	1
CHAPTER 2: LIGHT AND SHADING, COLOR	6	1	--	1
CHAPTER 3: IMAGE FORMATION AND PROCESSING	5	1	--	1
UNIT II				
CHAPTER 4: IMAGE SEGMENTATION AND FEATURE ANALYSIS	6		1.5	1.5
CHAPTER 5: COLOR IMAGE PROCESSING AND IMAGE COMPRESSION	6		1.5	1.5
UNIT III				
CHAPTER 6: MORPHOLOGICAL PROCESSING AND IMAGE SEGMENTATION	6			1
CHAPTER 7: RECOGNITION AND BAYESIAN MODELING	5			1

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA I, II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date:12/03/2021 **Head of Department**

Course Assessment Plan

Course Title: Computer vision and digital image processing		Code: 15EARE302			
Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		Minor Exam-1	Minor Exam-2	Course project	End semester assement
Explain the working of camera, its calibration procedure, and the associated applications of computer vision and digital image processing.	15%	✓		✓	✓
Explain the working of Lambertian and specular model to demonstrate modeling of pixel brightness and reflection, specifically for dynamic range of images to infer on color finding specularities.	15%	✓		✓	✓
Apply pre-processing steps namely, sampling and quantization, followed by processing using gray level transformation, histogram processing in spatial domain and Fourier transform in frequency domain for the acquired images.	13%	✓		✓	✓
Explain the methods for image segmentation and feature analysis, namely, detection of discontinuities, degradation/restoration process in the reconstruction of images using spatial filtering and frequency domain filtering.	15%		✓	✓	✓
Design algorithms based on color image processing and image compression using the fundamentals of color models and image compression methods.	15%		✓	✓	✓
Implement morphological algorithms for an image to classify segmentation types.	15%			✓	✓
Implement the classification algorithms for recognition and categorization of images using Bayesian modeling method.	12%			✓	✓
Weightage		20%	20%	10%	50%

Chapter-wise plan

Course Code and Title:**15EARE302 Computer vision and digital image processing**	
Chapter Number and Title **1: Fundamentals of computer vision and digital image processing**	Planned Hours: **6 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Explain the working of pinhole perspective method used in camera calibration and identify the features of cameras with different types of lenses .	CO1	L2	2.2
2. Describe the applications of computer vision and digital image processing.	CO1	L2	2.1

Lesson Schedule Class No. - Portion covered per hour
1.Introduction of computer vision system and digital image processing system.
2.Geometric Camera Models- Pinhole Perspective.
3.Cameras with Lenses. Human Eye perception
4.Intrinsic and Extrinsic Parameters of camera
5.Geometric Camera Calibration. Digital image processing system,
6.Application of computer vision and digital image processing and machine vision system

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1.Demonstrate geometrically that the projections of two parallel lines lying in some plane Φ appear to converge on a horizon line h formed by the intersection of the image plane Π with the plane parallel to Φ and passing through the pinhole.	TLO1	L2	2.2.2
2.Explain method of camera calibration.	TLO1	L2	2.2.2
3.Explain the procedure of perspective equation projections for a virtual image located at a distance d in front of the pinhole p.	TLO1	L2	2.1.3
4.Explain the applications of computer vision and digital image processing.	TLO2	L2	2.1.3

Course Code and Title:**15EARE302 Computer vision and digital image processing**	
Chapter Number and Title **2: light and shading, color**	Planned Hours: **6 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Explain modeling of pixel brightness and reflection effects with the help of Lambertian and specular model .	CO2	L2	2.1
2.Apply the method for high dynamic range of images and shape of specularities present in the image to check the effects of light .	CO2	L3	2.1
3.Explain the inference from color finding specularities using color shadow removal and color constancy method.	CO2	L2	2.3

Lesson Schedule Class No. - Portion covered per hour
1.Modeling Pixel Brightness, Reflection at Surfaces, Sources and Their Effects
2.Lambertian and Specular Model, Inference from Shading, Radiometric Calibration
3.High Dynamic Range Images ,the Shape of specularities
4.Inferring Lightness and Illumination, Color- Human Color Perception
5.The Physics of color, representing Color, Inference from Color Finding specularities
6. Color Shadow removal, using Color Constancy, Surface Color from Image Color.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. If one looks across a large bay in the daytime, it is often hard to distinguish the mountains on the opposite side; near sunset, they are clearly visible. This phenomenon has to do with scattering of light by air—a large volume of air is actually a source. Explain what is happening. We have modeled air as a vacuum and asserted that no energy is lost along a straight line in a vacuum. Use your explanation to give an estimate of the kind of scales over which that model is acceptable.	TLO2	L3	2.1.4

2. We see a diffuse sphere centered at the origin, with radius one and albedo ρ, in an orthographic camera, looking down the z-axis. This sphere is illuminated by a distant point light source whose source direction is (0, 0, 1). There is no other illumination. Show that the shading field in the camera is $\rho\sqrt{1-x^2-y^2}$	TLO2	L3	2.2.2
3. A small sphere casts a shadow on a larger sphere. Describe the possible shadow boundaries that occur	TLO3	L2	2.3.1
4. We have a square area source and a square occlude, both parallel to a plane. The edge length of the source is now half that of the occlude, and they are vertically above one another with their centers aligned. (a) What is the shape of the umbra? (b) What is the shape of the outside boundary of the penumbra?	TLO3	L2	2.3.1

Course Code and Title:**15EARE302 Computer vision and digital image processing**	
Chapter Number and Title**: 3. Image formation and processing**	Planned Hours: **5 hrs**

Learning Outcomes:

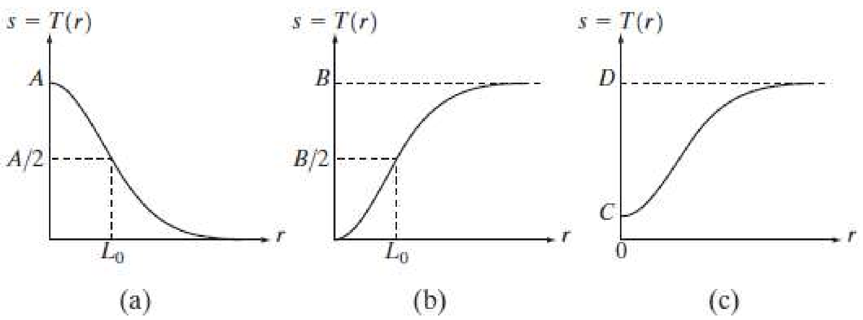
At the end of the course student should be able to:

TLO's	CO's	BL	CA Code
1. Apply pre-processing steps for the acquired image to perform sampling and quantization.	CO3	L3	2.2
2.Explain the spatial domain gray level transformations and histogram processing for spatial filtering.	CO3	L2	2.1
3. Apply Fourier transform for frequency domain.	CO3	L3	2.1

Lesson Schedule Class No. - Portion covered per hour
1.Image Acquisition – Sampling and Quantization
2.Pixel Relationships, image enhancement
3.Spatial Domain Gray level Transformations
4.Histogram Processing Spatial Filtering– Smoothing and Sharpening
5.Fourier Transform and the Frequency Domain, DFT, FFT.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. calculate image acquisition range in the given plane π using a single sensor.	TLO1	L3	2.1.3
2.Describe the procedure of image acquisition using a linear sensor strip, circular strip & single sensor with the necessary diagrams	TLO2	L2	2.1.4
3. Develop an algorithm for converting a one-pixel-thick 8-path to a 4-path.	TLO2	L3	2.1.3

4. Propose a set of gray-level-slicing transformations capable of producing all the individual bit planes of an 8-bit monochrome image. (For example, a transformation function with the property $T(r) = 0$ for r in the range $[0, 127]$, and $T(r) = 255$ for r in the range $[128, 255]$ produces an image of the 7th bit plane in an 8-bit image.)	TLO3	L3	2.3.1
5. Exponentials of the form $e^{-\alpha r^2}$, with α a positive constant, are useful for constructing smooth gray-level transformation functions. Start with this basic function and construct transformation functions having the general shapes shown in the following figures. The constants shown are *input* parameters, and your proposed transformations must include them in their specification. (For simplicity in your answers, L_0 is not a required parameter in the third curve.)  .	TLO3	L3	2.1.4
6. In some applications it is useful to model the histogram of input images as Gaussian probability density functions of the form $$p_r(r) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(r-m)^2}{2\sigma^2}}$$ where m and σ are the mean and standard deviation of the Gaussian PDF. The approach is to let m and σ be measures of average gray level and contrast of a given image. What is the transformation function you would use for histogram equalization?	TLO3	L3	2.3.1

Model Question Paper for Minor Examination – I (ISA)	
Course Code: 15EARE302	Course Title: : Computer vision and digital image processing
Duration(H:M): 1:15	Max. Marks:40
Note: Answer any two questions.	

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Write the equations perspective projections for a virtual image located at a distance d in front of the pinhole.	8	CO1	L3	2	2.1.3
1b	Write an algorithm for determining the lightness of image patches	8	CO2	L3	1	1.3.3
1c	Explain histogram processing for acquired image from camera.	4	CO3	L2	2	1.1.2
2a	Propose a set of gray-level-slicing transformations capable of producing all the individual bit planes of an 8-bit monochrome image. (For example, a transformation function with the property T(r)=0 for r in the range [0, 127], and T(r)=255 for r in the range [128, 255] produces an image of the 7th bit plane in an 8-bit image.)	8	CO3	L3	2	2.1.3
2b	Derive the equations for Intrinsic Parameters.	8	CO1	L3	2	2.3.1
2c	Explain linear color spaces.	4	CO1	L2	1	1.1.2
3a	What shapes can the shadow of a sphere take if it is cast on a plane and the source is a point source?	8	CO2	L3	2	2.1.4
3b	Explain the basic steps of filtering in frequency domain, with a neat diagram.	8	CO3	L3	2	2.2.2
3c	Explain machine vision system.	4	CO2	L2	2	1.2.2

Course Code and Title:**15EARE302 Computer vision and digital image processing**	
Chapter Number and Title: **4 : Image segmentation and feature analysis**	Planned Hours: **6hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Explain the detection of discontinuities using edge operators and edge linking.	CO4	L2	2.2
2.Describe the image degradation/restoration process to reconstruct an image without noise.	CO4	L2	2.4
3. Explain the method of restoration for noise only spatial filtering and periodic noise reduction by using frequency domain filtering.	CO4	L2	2.4

Lesson Schedule Class No. - Portion covered per hour
1.Detection of Discontinuities – Edge Operators – Edge Linking
2.Boundary Detection –Thresholding
3.Region Based Segmentation
4.Model of the Image Degradation/Restoration Process
5.Noise Models, Restoration in the Presence of Noise Only–Spatial Filtering
6. Periodic Noise Reduction by Frequency Domain Filtering.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain the noise probability density method.	TLO1	L2	2.2.3
2.Explain the gradient operators of image segmentation.	TLO3	L2	2.4.1
3. Explain restoration in the presence of noise only–spatial filtering.	TLO3	L2	2.4.1

Course Code and Title:**15EARE302 Computer vision and digital image processing**	
Chapter Number and Title: **5 Color image processing and image compression**	Planned Hours: **6hrs**

Learning Outcomes:

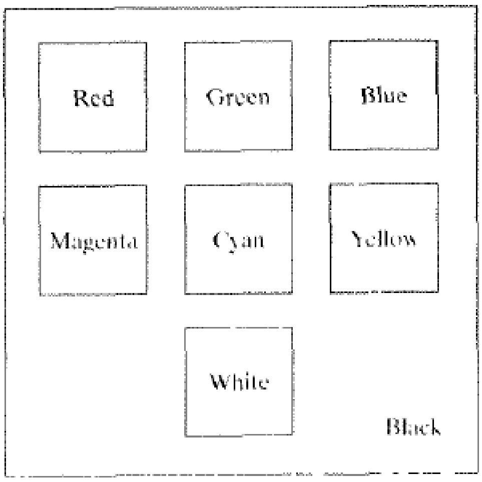
At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Apply the knowledge of color fundamentals and color models for pseudo color image processing of a colored image.	CO5	L3	2.2
2.Explain the smoothing and sharpening method for color segmentation and elimination of noise in color images.	CO5	L2	2.4
3. Distinguish among the image compression-fundamentals, image compression models.	CO5	L2	2.4

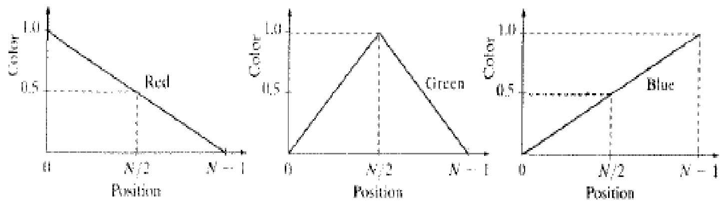
Lesson Schedule Class No. - Portion covered per hour
1.Color Fundamentals, Color Models
2.Pseudo color Image Processing, Basics of Full-Color Image Processing
3.Color Transformations, Smoothing and Sharpening
4.Color Segmentation, Noise in Color Images Color Image Compression
5.Image Compression-Fundamentals, Image Compression Models,
6. Elements of Information Theory, Error-Free Compression, Lossy Compression.

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1.What are the conceptual relationships present between the RGB & HSI color models? Explain.	TLO1	L2	2.2.2
2. In an automated assembly application, three classes of parts are to be color coded in order to simplify detection. However, only a monochrome TV camera is available to acquire digital images. Propose a technique for using this camera to detect the three different colors.	TLO1	L2	2.2.2.

3. In an automated assembly application, three classes of parts are to be color coded in order to simplify detection. However, only a monochrome TV camera is available to acquire digital images. Propose a technique for using this camera to detect the three different colors.	TLO2	L3	2.4.1
4.Explain lossy compression method with derivation.	TLO3	L2	2.4.1
5. Consider the following image composed of solid color squares. For discussing your answer, choose a gray scale consisting of eight shades of gray, 0 through 7, where 0 is black and 7 is white. Suppose that the image is converted to HSI color space. In answering the following questions, use specific numbers for the grade shades if they make sense. Otherwise, the relationships "same as," "lighter than," or "darker than" are sufficient. If you cannot assign a specific gray level or one of these relationships to the image you are discussing, give the reason. (a) Sketch the hue image. (b) Sketch the saturation image. (c) Sketch the intensity image. 	TLO2	L3	2.4.1

Model Question Paper for Minor Examination –II (ISA)	
Course Code: 15EARE302	Course Title: : Computer vision and digital image processing
Duration(H:M): 1:15	Max. Marks:40
Note: Answer any two questions.	

Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Derive equations for noise probability density functions.	8	CO4	L3	2	2.1.3
1b	Explain watershed segmentation algorithm.	8	CO4	L2	1	2.1.3
1c	Explain error-free compression for an image.	4	CO5	L2	2	2.1.3
2a	Explain RGB model with a neat diagram.	8	CO5	L2	2	2.1.4
2b	In a simple RGB image, the *R*, *G*, and *B* component images have the horizontal intensity profiles shown in the following diagram. What color would a person see in the middle column of this image?  .	8	CO4	L3	2	2.2.2
2c	Explain the types of segmentation.	4	CO4	L2	2	2.1.4
3a	Explain the gradient operators of image segmentation.	8	CO4	L2	2	2.1.3
3b	Explain transform coding system for lossy compression, with a neat diagram along with lossy compression algorithm.	8	CO5	L3	2	2.2.2
3c	What is color slicing? Explain how it is achieved?	4	CO5	L2	2	2.3.1

Course Code and Title:**15EARE302 Computer vision and digital image processing**	
Chapter Number and Title: **6. Morphological processing**	Planned Hours: **6 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1.Explain dilation and erosion process and hit/miss transformation of an image .	CO6	L2	2.1
2. Apply basic morphological algorithms.	CO6	L3	2.3

Lesson Schedule Class No. - Portion covered per hour
1.Dilation and Erosion,
2.The Hit-or-Miss Transformation
3.BASIC Transformation
4.Some Basic Morphological Algorithms
5.Morphological Algorithms
6.Opening and Closing

Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1. Explain Dilation and Erosion method.	TLO1	L2	2.1.3
2. Erosion of a set A by structuring element B is a subset of A as long as the origin of B is contained by B. Give an example in which the erosion $A \ominus B$ lies outside, or partially outside, A.	TLO2	L2	2.3.1
3. Write an algorithm Morphological processing.	TLO2	L3	2.3.1
4. How boundary extraction is accomplished in morphological processing? Explain	TLO2	L2	2.3.1

Course Code and Title:**15EARE302 Computer vision and digital image processing**	
Chapter Number and Title:**7 Recognition and Bayesian modeling**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of course student should be able to:

TLO's	CO's	BL	CA Code
1. Apply object detection procedure for classifying the face elements for recognition images.	CO7	L3	2.1
2. Apply context and scene understanding for an image recognition databases and test sets.	CO7	L3	2.4

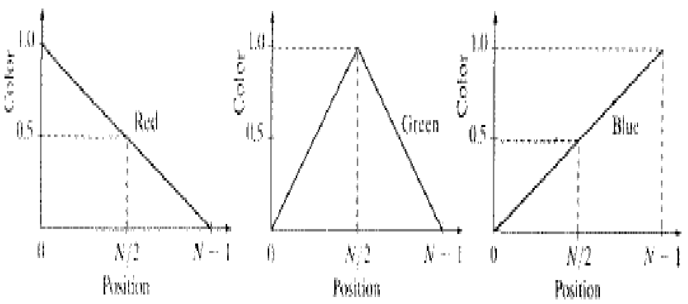
Lesson Schedule Class No. - Portion covered per hour
1.Object detection, Face recognition
2.Instance recognition, Category recognition
3.Context and scene understanding, Recognition databases and test sets,
4.Prior models and Bayesian inference
5.Gradient descent and simulated annealing, Graph cuts, Markov random fields

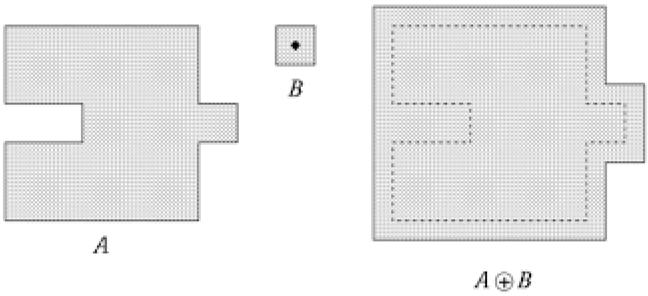
Review Questions

Sr.No. - Questions	TLO	BL	PI Code
1.Derive the procedure for face recognition in the given image having the coordinates(x,y).	TLO1	L3	2.1.3
3.Explain the recognition based on decision theoretic methods.	TLO1	L2	2.1.3
3. The following pattern classes have Gaussian probability density functions: ω_1: $\{(0,0)^T, (2,0)^T, (2,2)^T, (0,2)^T\}$ and ω_2: $\{(4,4)^T, (6,4)^T, (6,6)^T, (4,6)^T\}$. **(a)** Assume that $P(\omega_1) = P(\omega_2) = \frac{1}{2}$ and obtain the equation of the Bayes decision boundary between these two classes. **(b)** Sketch the boundary.	TLO2	L3	2.4.1

Model Question Paper for End Semester Assessment (ESA)	
Course Code : 15EARE302	**Course : Computer vision and digital image processing**
Duration :3 Hours	**Maximum Marks :100**
Note :Answer Five Questions: Any two full questions from each Unit I and Unit II and one full question from Unit III	

UNIT-I						
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Explain the perspective equation projections for a virtual image located at a distance d in front of the pinhole	8	CO1	L3	1	1.3.3
1b	If one looks across a large bay in the daytime, it is often hard to distinguish the mountains on the opposite side; near sunset, they are clearly visible. This phenomenon has to do with scattering of light by air—a large volume of air is actually a source. Explain what is happening. We have modeled air as a vacuum and asserted that no energy is lost along a straight line in a vacuum. Use your explanation to give an estimate of the kind of scales over which that model is acceptable.	8	CO2	L3	2	2.1.4
1c	Explain machine vision system.	4	CO1	L2	2	2.1.3
2a	Apply the equations for extrinsic parameters for camera calibration having the focal length as 1.2mm.	8	CO1	L3	2	2.1.3
2b	Apply an algorithm for Determining the Lightness of Image Patches	8	CO2	L3	1	1.3.3
2c	Explain is gray level transformation.	4	CO3	L2	1	1.1.2
3a	Propose a set of gray-level-slicing transformations capable of producing all the individual bit planes of an 8-bit monochrome image. (For example, a transformation function with the property T(r)=0 for r in the range [0, 127], and T(r)=255 for r in the range [128, 255] produces an image of the 7th bit plane in an 8-bit image.)	8	CO3	L3	2	2.1.3

3b	Propose a set of gray-level-slicing transformations capable of producing all the individual bit planes of an 8-bit monochrome image. (For example, a transformation function with the property $T(r) = 0$ for r in the range $[0, 127]$, and $T(r) = 255$ for r in the range $[128, 255]$ produces an image of the 7th bit plane in an 8-bit image.)	8	CO3	L3	2	2.1.1
3c	Explain linear color spaces.	4	CO2	L2	2	2.2.2
UNIT-II						
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
4a	Derive the equations for noise probability density functions.	8	CO4	L3	2	2.1.3
4b	Derive the gradient operators of image segmentation.	8	CO4	L3	1	1.3.3
4c	Explain the types of segmentation.	4	CO4	L2	2	2.2.2
5a	Explain the approach that incorporates both the degradation function statistical characteristics of noise into the restoration process.	8	CO4	L2	3	2.1.4
5b	What is image segmentation? Explain the detection of line discontinuity.	8	CO4	L2	2	2.2.2
5c	Explain error-free compression.	4	CO5	L2	3	2.1.3
6a	In a simple RGB image, the R, G, and B component images have the horizontal intensity profiles shown in the following diagram. What color would a person see in the middle column of this image? 	8	CO5	L3	2	2.1.3
6b	Explain conversion of RGB to HIS color model.	8	CO5	L3	2	2.2.2
6c	What is color slicing? Explain how it is achieved?	4	CO5	L2	2	2.3.1

UNIT-III						
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
7a	Explain the process of dilation and erosion.	8	CO6	L2	2	2.1.1
7b	Apply morphological algorithm for dilating the given image. 	8	CO6	L3	2	2.3.1
7c	Explain hit and mass transformation.	4	CO6	L2	2	2.1.1
8a	The following pattern classes have Gaussian probability density functions: ω_1: $\{(0,0)^T, (2,0)^T, (2,2)^T, (0,2)^T\}$ and ω_2: $\{(4,4)^T, (6,4)^T, (6,6)^T, (4,6)^T\}$. **(a)** Assume that $P(\omega_1) = P(\omega_2) = \frac{1}{2}$ and obtain the equation of the Bayes decision boundary between these two classes. **(b)** Sketch the boundary.	8	CO7	L3	2	2.2.2
8b	Explain gradient descent and simulated annealing.	8	CO7	L2	2	2.2.2
8c	Explain Bayesian inference methodology.	4	CO7	L2	2	2.2.2

FMTH0303-3.1

Laboratory Plan

Semester: 6th *Year:* 2021-2022

Laboratory Title: **Hydraulics And Pneumatics Laboratory**	*Lab. Code*: **16EARP302**
Total Hours: 24	*Duration of Exam*: 2 Hours
Total Exam Marks: 20	*Total ISA. Marks*: 80
Lab. Plan Author: Mrs. Shilpa V Tanvashi	Date: 27/12/2021
Checked By: Mr. Nagaraj B	*Date:* 29/12/2021

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Explain operating principle of various hydraulic and pneumatic components such as actuators, control valves and ancillary devices.
2. Identify various components and their specifications required to build hydraulic and pneumatic circuits.
3. Simulate and analyze fluid power circuit simulations using Automation Studio software.
4. Construct and test hydraulic and pneumatic circuits for given applications.
5. Demonstrate the knowledge of safety measures and maintenance of fluid power systems.
6. Implement a project on hydraulics and pneumatics for automation and robotics field.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: Hydraulics And Pneumatics Lab	Semester: 6th
Course Code:16EARP302	Year: 2021 - 2022

Course Outcomes / Program Outcomes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Explain operating principle of various hydraulic and pneumatic components such as actuators, control valves and ancillary devices.	**H**													
2. Identify various components and their specifications required to build hydraulic and pneumatic circuits.	**H**	**M**												
3. Simulate and analyze fluid power circuit simulations using Automation Studio software.		**M**			**H**									
4. Construct and test hydraulic and pneumatic circuits for given applications.		**H**												
5. Demonstrate the knowledge of safety measures and maintenance of fluid power systems.	**M**													
6. Implement a project on hydraulics and pneumatics for automation and robotics field.	**M**	**M**			**H**				**H**	**H**				

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency: 1.3	Demonstrate competence in engineering fundamentals
PI Code: 1.3.1	Apply elements of mechanical engineering principles and laws to solve problems
Competency: 1.4	Demonstrate the competence in engineering knowledge appropriate to automation and robotics program
PI Code: 1.4.1	Apply discipline specific laws and principles to solve an interdisciplinary engineering problem
Competency: 2.1	Demonstrate an ability to identify and characterize an engineering problem
PI Code: 2.1.1	Identifies known and unknown information, uncertainties, and biases when presented with a complex ill-structured problem
Competency: 2.2	Demonstrate an ability to formulate a solution plan and methodology for an engineering problem
PI Code: 2.2.1	Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions
Competency: 5.1	Demonstrate an ability to identify/ create modern engineering tools, techniques and resources
PI Code: 5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
Competency: 9.1	Demonstrate an ability to form a team and define a role for each member
PI Code: 9.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
Competency: 9.2	Demonstrate effective individual and team operations-- communication, problem solving, conflict resolution and leadership skills
PI Code: 9.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
Competency: 10.3	Demonstrate the ability to integrate different modes of communication
PI Code: 10.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations

Experiment wise Plan

List of experiments/jobs planned to meet the requirements of the course.

<table>
<tr><th colspan="2">Category: Demonstration</th><th colspan="2">Total Weightage: 30.00</th><th>No. of lab sessions: 6.00</th></tr>
<tr><th>Expt./ Job No.</th><th>Experiment / Job Details</th><th>No. of Lab Session(s) per batch (estimate)</th><th>Marks / Experiment</th><th>Correlation of Experiment with the theory</th></tr>
<tr><td>1</td><td>To study hydraulic pump, its characteristics and calculate the hydraulic power</td><td>1.00</td><td>5.00</td><td></td></tr>
<tr><td></td><td colspan="3">Learning Objectives:
The students should be able to:
1. Differentiate between types of pumps.
2. Plot and infer characteristic curve of the Pump.</td><td>Unit - I</td></tr>
<tr><td>2</td><td>A. To study concepts of Meter-in and Meter-out circuits using Single-rod cylinder and 4/2 DCV
B. Automation Studio Exercises-
Create the given circuits and simulate them to investigate their operation in Automation Studio</td><td>1.00</td><td>5.00</td><td></td></tr>
<tr><td></td><td colspan="3">Learning Objectives:
The students should be able to:
1. Identify hydraulic cylinders and various direction control valves.
2. Explain meter-in and meter-out circuits used to control the speed of a single acting cylinder using meter in/out throttle.</td><td>Unit I</td></tr>
<tr><td>3</td><td>To study pressure intensification of a single rod cylinder</td><td>1.00</td><td>5.00</td><td></td></tr>
<tr><td></td><td colspan="3">Learning Objectives:
The students should be able to:
1. Explain the physical basic principles of pressure intensification with single rod cylinders Demonstrate that double-acting hydraulic cylinders with different piston areas are pressure intensifiers</td><td>Unit - I</td></tr>
</table>

4	In a machining station, a hydraulic rotary drive is to swivel a drum from the horizontal to the vertical position after a welding process. The movement is to be performed by a hydraulic motor. Despite varying loads, the motor speed must remain constant.	1.00	5.00	
	Learning Objectives: The students should be able to: 1. Discuss the operating features of a hydraulic motor 2. Explain how a 4/3 directional valves can be used to implement clockwise and counter-clockwise running of the hydraulic motor.			Unit - I
5	**A.** Study of indirect control of a double-acting cylinder with a pneumatically operated 5/2 directional control valve. **B.** Experiments on AND, OR, Latch and Electric limit Switch.	2.00	10.00	
	Learning Objectives: The students should be able to: 1. Demonstrate how a 5/2 DCV can be used control a double acting cylinder 2. Understand the use of relay technology for various logical functions.			Unit - II
Category: Exercise		**Total Weightage: 20.00**		**No. of lab sessions: 5.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch**	**Marks / Experiment**	**Correlation of Experiment with the theory**
6	A. To study position dependent control of a double acting cylinder using mechanical limit switches. **B.** Verify the ladder diagram for AND, OR latch logic using 5/2 DCV and PLC kit.	1.00	5.00	
	Learning Objectives: The students should be able to: 1. Identify switches and push buttons and use them to build the circuits.			Unit - II
7	To study the application of different center configuration of 4/3 DCV. (Tandem and	1.00	5.00	

	closed center)			
	Learning Objectives: The students should be able to: 1. Demonstrate how a hydraulic cylinder is controlled by a 4/3 directional valve with different spool shapes (blocked and circulation position).			Unit - I
8	Study of Speed Control of Single Acting Cylinder - Slow Speed Extension and Rapid Retraction.	1.00	5.00	
	Learning Objectives: The students should be able to: 1. Explain how the speed of a single acting cylinder is controlled using a quick-exhaust valve			Unit II
9	Stop control, double-acting cylinder with 5/3 directional control valve, tensile load	1.00	5.00	
	Learning Objectives: The students should be able to: 1. Explain the use of a 5/3 directional control valve with closed mid-position for stopping a double-acting cylinder.			
Category: Structured Enquiry		**Total Weightage: 20.00**		**No. of lab sessions: 2.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch**	**Marks / Experiment**	**Correlation of Experiment with the theory**
10	On a machine tool the velocity of a feed cylinder is to be increased and thus the cycle time of the system shortened without changing the pump flow. The advance velocity (extending time of the hydraulic cylinder) is to be adjustable independently of the load.	1.00	5.00	
	Learning Objectives: The students should be able to: 1. Understand and record the table of the travel times 2. Calculate the velocity of the piston Identify different logic gates			Unit - I
11	Rotary machining station By using a 3/2 directional control valve with adjustable minimum pressure of response, a pressure-dependent (and in addition displacement) control of a double acting cylinder is put	1.00	10.00	

	into effect.			
	Learning Objectives: The students should be able to: 1. Demonstrate the use of a 2-way flow control valve. 2. To show how to assemble a counter-holding circuit			Unit - II
12	The sequential control with two pneumatic drives. The signal overlapping occurring during this exercise is constructively solved by use of rollers with idle return. Practice is obtained in developing sequential diagrams and pneumatic circuit diagrams.	1.00	5.00	
	Learning Objectives: The students should be able to: 1. Use double acting cylinders, appropriate DCVs, flow control valves and push buttons and construct the circuit diagram for sequential control of two pneumatic drives.			Unit - II
Category: Open Ended		**Total Weightage: 10.00**		**No. of lab sessions: 1.00**
Expt./ Job No.	**Experiment / Job Details**	**No. of Lab Session(s) per batch**	**Marks / Experiment**	**Correlation of Experiment with the theory**
13	A double-acting cylinder is used to press together glued components. Upon pressing a push-button, the clamping cylinder is to extend and trip the roller valve. Once the fully extended position of the cylinder has been reached and sufficient clamping force has been developed, the cylinder is to retract to the initial position. Develop a control circuit using a pressure sequence valve.	1.00	10.00	
	Learning Objectives: The students should be able to: 1. Construct a control circuit using a pressure sequence valve for a given application.			Unit - I, II and III

1. ***Evaluation*:**

Students Assessment through ISA (80%) + ESA (20%)

Type of Evaluation	Types of laboratory work	Assessment				
		Aim	Material	Method	Answer	**Weightage in Marks**
Internal Semester Assessment (80%)	Demonstration	Given	Given	Given	Given	**30**
	Exercise	Given	Given	Given	Open	**20**
	Structured Enquiry	Given	Open	Open	Open	**20**
	Open Ended	Given	Open	Open	Open	**10**
End Semester Assessment (20%)	Project	Open	Open	Open	Open	**20**
					Total	**100**

Date: *:* 29/12/2021

Head of Department

Laboratory Plan FMTH0303-3.3

Semester: **VI** *Year:* ***Jan2022- June2022***

Laboratory Title: **Real-Time Embedded Systems Lab**	*Lab. Code*: 16EARP307
Total Hours: **28**	*Duration of ESA Exam*: **3hrs**
Total ISA Marks: **80**	*Total ESA. Marks*: **20**
Lab. Plan Author: **Mrs. Jyoti S Bali**	*Date*: **29/12/2021**
Checked By: **Prof. Arunkumar .C. Giriyapur**	*Date*: **30/12/2021**

Prerequisites

Basics of Control Systems and microcontrollers

Course Learning Objectives – CLO

At the end of the course students will be able to:

I. Demonstrate the skills in solving Data acquisition based case-study problems related to Bio-Medical, Process control and Servo control applications using Energia IDE and TM4C1294NCPDT, TIVA C series microcontroller board

II. Implement Solutions using Code Composer Studio (CCS) compiler for the peripheral programming and data acquisition process with ARM Cortex M3/M4 boards.

III. Demonstrate the real time system features through multitasking approach, polling, Interrupt driven mechanisms, scheduling mechanisms and Inter-process communication using semaphores, queues, notifiers, mailbox, mutex etc. using keil uvision 4 with RTX Kernel

IV. Demonstrate the communication established between the controller and field devices using different communication protocols like I^2C,CAN,SPI & Ethernet using TIVA C series microcontroller board

V. Design using state machine architecture or Unified Modeling Language and implement a solution for a real world problem using IOT technology for applications related Smart Home, Energy Management, Smart Grid, Smart Agriculture ,Wearable Device, Smart Health Care , Connected Car, Smart Machine involving Inter-process communication, Resource sharing and an effective scheduling technique satisfying real time constraints.

LIST OF EXERCISES & ISA & ESA COMPUTATION

Sl. No	EXPERIMENTS	MAX MARKS
1	Demo on Energia IDE and TM4C1294NCPDT, TIVA C series microcontroller board & Solving problems on Data Acquisition for Bio Medical / Process control/Industrial control application	**05**
2	Demo on Code Composer Studio(CCS) and TIVA C series TM4C1294NCPDT microcontroller board and problem solving on ADC,TIMERS,INTERRUPTS	**10**
3	Demo on Introduction to Keil uvision4 and basic problem solving exercises	**10**
4	Demo on Raspberry Pi Programming and peripheral programming	**05**
5	Exercises on basic RTOS program , RTX Kernel using peripherals like RTC, TIMERS , UART, SEMAPHORES	**10**
6	Exercises on implementing scheduling algorithms like Preemptive /Round Robin / Interrupts/ and Multitasking operations in RTX Kernel of Keil uvision 4.	**10**
7	Structured Query : Implementing Communication Protocols like I2C / SPI / UART /CAN / ETHERNET with Energia /CCS & TM4C1294 TIVA board	**10**
	Attendance & Timely Submission of Journal, Synopsis, Reports of ESA Project	**20**
	TOTAL ISA MARKS	**80**
8.	**ESA Problem Statement** Design using state machine architecture or Unified Modeling Language and implement solution for a real world problem using IOT technology for applications related Smart Home, Energy Management, Smart Grid, Smart Agriculture ,Wearable Device, Smart Health Care, Connected Car, Smart Machine involving Inter-process communication, Resource sharing and an effective scheduling technique satisfying real time constraints.	**20**
	TOTAL MARKS	**100**

KLE Technological University, Hubballi
DEPARTMENT OF AUTOMATION & ROBOTICS

Course Articulation Matrix: Mapping of Course Learning Objectives (CLO) with Program outcomes

Course Title: **Real Time Embedded Systems lab**								Semester: VI						
Course Code: 16EARP307								Year: Jan. 2022 to June 2022						
Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1.0 Demonstrate the skills in solving Data acquisition based case-study problems related to Bio-Medical, Process control and Servo control applications using Energia IDE and TM4C1294NCPDT, TIVA C series microcontroller board	M	**M**	M											
2.0 Implement Solutions using Code Composer Studio (CCS) compiler for the peripheral programming and data acquisition process with ARM Cortex M3/M4 boards.	M	**M**	M											
3.0 Demonstrate the real time system features through multitasking approach, polling, Interrupt driven mechanisms, scheduling mechanisms and Inter-process communication using semaphores, queues, notifiers, mailbox, mutex etc. using keil uvision 4 with RTX Kernel	M	**M**	H											
4.0 Demonstrate the communication established between the controller and field devices using different communication protocols like I^2C,CAN,SPI & Ethernet using TIVA C series microcontroller board	H	**M**	H											
5.0 Design using state machine architecture or Unified Modeling Language and implement a solution for a real world problem using IOT technology for applications related Smart Home, Energy Management, Smart Grid, Smart Agriculture ,Wearable Device, Smart Health Care , Connected Car, Smart Machine involving Inter-process communication, Resource sharing and an effective scheduling technique satisfying real time constraints.	M	**H**	M											

Categorization of LAB activity and type of Evaluation

Type of Evaluation	Types of laboratory work	Given or open			
		Aim	Material	Method	Answer
ISA (80 Marks)	Demonstration	Given	Given	Given	Given
	Exercise	Given	Given	Given	open
	Structured Enquiry	Given	Given	open	open
	Open Ended Enquiry	Given	open	open	open
	Project Work	Open	open	open	open
ESA (20 Marks)	Final Project Demo ,Presentation and Viva-Voce				

Experiment wise plan

1. ***List of experiments/jobs planned to meet the requirements of the course.***

<table>
<tr><th colspan="2">Category: Demonstration</th><th>Total Weightage: 20</th><th colspan="2">No. of lab sessions: 4</th></tr>
<tr><th>Expt./Job No.</th><th>Experiment/job Details</th><th>No. of Lab. Session/s per batch (estimate)</th><th>Marks/Experiment</th><th>Correlation of Experiment with the theory</th></tr>
<tr><td rowspan="2">1.</td><td>Demo on Energia IDE and TM4c1294NCPDT, TIVA C series microcontroller board & Solving problems on Data Acquisition for Bio Medical / Process control/Industrial control application</td><td>2</td><td>10</td><td rowspan="2">Chapter 2</td></tr>
<tr><td colspan="3">Learning Objectives :
The students should be able to work with Energia IDE and TM4c1294NCPDT, TIVA C series microcontroller
To demonstrate the Data acquisition process for physiological signals like ECG,EEG, in Biomedical applications
To demonstrate the Data acquisition process for control parameters like temperature, pressure, flow rate etc in Process control applications
To demonstrate the Data acquisition process for parameters like speed, velocity, position,force etc for any Industrial control application</td></tr>
<tr><td>2.</td><td>Demo on Code Composer Studio(CCS) and TIVA C series TM4C1294NCPDT microcontroller board and problem solving on ADC,TIMERS,INTERRUPTS</td><td>2</td><td>10</td><td>Chapter 2&3</td></tr>
</table>

	Learning Objectives : *The students should be able to work with* Code Composer Studio(CCS) and TIVA C series TM4C1294NCPDT microcontroller • To demonstrate the Data acquisition process using on-chip ADC • To demonstrate the timed operations and time driven events using on-chip Timers • To demonstrate the interrupt driven mechanisms to service tasks or operations based on priority			
3.	Demo on Introduction to Keil uvision 4 & basic problem solving	*1*	*10*	*Chapter 3,4&5*
	Learning Objectives : *The students should be able to:* • Demonstrate inter task communication in an application using semaphores, Queue, notifier and mutex • Demonstrate the resource sharing in an application using inter task communication using Semaphore, Queue			
Category: Exercise type	***Total Weightage: 40***		***No. of lab sessions: 4***	
Expt./Job No.	***Experiment/job Details***	***No. of Lab. Session/s per batch (estimate)***	***Marks/ Expe riment***	***Correlation of Experiment with the theory***
4	Demo on Raspberry Pi Programming and peripheral programming		10	
	Learning Objectives : • *The students should be able to work with* Raspberry Pi Programming • To demonstrate the setting up of Raspberry Pi through the procedural steps • To demonstrate the programming of Raspberry Pi through basic problem solving and peripheral programming			

5	Exercises on basic RTOS program , RTX Kernel using peripherals like RTC, TIMERS , UART, SEMAPHORES	2	10	*Chapter 3&4*
	Learning Objectives : *The students should be able to use RTX Kernel of Keil uvision 4* • *To program* peripherals like RTC, TIMERS , UART, SEMAPHORES to i*mplement solutions to the given problems on Resource Sharing, Multi-tasking, Inter-task Communication with real time constraints on meeting deadline in terms of time*			
5.	Exercises on implementing scheduling algorithms like Preemptive /Round Robin / Interrupts/ and Multitasking operations in RTX Kernel of Keil uvision 4.	*2*	10	*Chapter 3,4&5*
	Learning Objectives : *The students should be able to do programming with* RTX Kernel of Keil uvision 4. • To demonstrate the Preemptive Scheduling Algorithms • To demonstrate the Round Robin Scheduling Algorithms			
Category: Structured Query		***Total Weightage: 10***		***No. of lab session:2***
7.	Implementing Communication Protocols like I2C/SPI/UART/CAN /ETHERNET with Energia & TM4C1294 TIVA board	*2*	*10*	*Chapter 8*

<table>
<tr>
<td></td>
<td colspan="3">Learning Objectives :
The students should be able to work with TM4C1294 TIVA board or Raspberry Pi 3 board
• To implement the solution based on a case study using any one of the communication protocols like I2C/SPI/UART/CAN /ETHERNET
•</td>
<td></td>
</tr>
<tr>
<td colspan="5">Category: Open Ended Query for ESA   Total Weightage for ISA: 10
Total Weightage for ESA: 20   No. of lab session: 2</td>
</tr>
<tr>
<td>8.</td>
<td>Design using state machine architecture or Unified Modeling Language and implement solution for a real world problem using IOT technology for applications related Smart Home, Energy Management, Smart Grid, Smart Agriculture ,Wearable Device, Smart Health Care, Connected Car, Smart Machine involving Inter-process communication, Resource sharing and an effective scheduling technique satisfying real time constraints.</td>
<td>2</td>
<td>10(ISA)
20(ESA)</td>
<td rowspan="2">Chapter 2,3,4,5,6,7&8</td>
</tr>
<tr>
<td></td>
<td colspan="3">Learning Objectives :
The students should be able work with ARM Cortex M3/M4 board or Raspberry Pi3 board:
• Choose a real world problem through literature survey
• Build the state chart model or UML model for the requirements and solution
• Demonstrate Resource sharing and Inter-task communication to optimize the coding
• Design the solution using to solve using the best possible scheduling mechanism
• Analyze the performance and efficiency of the system to address real time issues.</td>
</tr>
</table>

RUBRICS

Experiments	Rubrics & Marks Distribution
Demo Experiments	
Basic problem solving approach (60%) • Ability to list and follow the steps of problem solving (**30%**) • Briefing the plan of implementation **(30%)**	**Implementation Ability (40%)** • Ability to implement individually **(20%)** • Ability to implement in group & demonstrate the solution with documentation (**20%**)
Exercises	
Basic problem solving approach (50%) • Ability to list and follow the steps of problem solving • Briefing the plan of implementation	**Implementation Ability (25%)** • Ability to implement individually • Ability to implement in group & demonstrate the solution with documentation **Analyzing Ability (25%)** • Summarizing &Verification of the result • Analysis of result in terms of pros & cons
Structured Query	
Basic problem solving approach (50%) • Ability to list and follow the steps of problem solving **(25%)** • Briefing the plan of implementation **(25%)**	**Implementation Ability (25%)** • Ability to implement individually • Ability to implement in group & demonstrate the solution with documentation
	Analyzing Ability (25%) • Summarizing &Verification of the result • Analysis of result in terms of pros &
Open Ended Enquiry	
Basic problem solving approach (50%) • Defining the Problem • Planning the Steps –	**Submission of Documentation (50%)** • Synopsis – • Process Flow/Flow chart & Planning Action for finding solution

***Evaluation*:**

Course Assessment Plan

Type: ISA/ ESA	Course Outcomes	Assessment	Weightage in Marks
Continuous Internal Evaluation (80%)	• Demonstrate the skills in solving Data acquisition based case-study problems • Implement Solutions using Code Composer Studio (CCS) compiler • Demonstrate the real time system features through multitasking approach • Demonstrate the communication established between the controller and field devices	Demonstration Experiments	30
		Submission of solutions on Exercises	20
		Structured Query	10
		Open Ended Enquiry	10
		Lab Documentation , Attendance & Submission of work	10
		TOTAL ISA	**80**
ESA Examination (20%)	• Design using state machine architecture or Unified Modeling Language and implement a solution for a real world problem using IOT technology for applications	Final Evaluation of Open Ended Query Solution along with presentation	**20**
		TOTAL MARKS	**100**

.

Date: **Head of the Department**

Laboratory Plan

FMTH0303-3.1

Semester: VII Year: 2021-22

Laboratory Title: Senior Design Project	Lab Code: 19EARW401
Total Hours: 30	Duration of Exam: 3 Hrs
Total ESA Marks: 20	Total ISA. Marks: 80
Lab. Plan Author: Sachin Karadgi	Date: 10-Jan-2021
Checked By: Arunkumar C Giriyapur	Date: 10-Jan-2021

Prerequisites:

Subjects learnt up to VI semester.

Course Outcomes-CO

At the end of the course student will be able to:

1. Carry out market survey, do need analysis and identify suitable problems.
2. Write a project proposal, which will involve developing a complete solution for the identified problem from the real world.
3. Apply the principles of engineering design to plan and manage the project.
4. Apply suitable design processes and develop the best possible solution.
5. Develop proof of concepts and models for verification.
6. Prepare production drawings, bill of materials and process plans.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program outcomes (PO)

Laboratory (Course) Title: **Senior Design Project** Laboratory (Course) code: 19EARW401

Semester: VIII Year: 2021-22

Course Outcomes (CO) / Program Outcomes (PO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Carry out market survey, do need analysis and identify suitable problems.	H	H												
2. Write a project proposal, which will involve developing a complete solution for the identified problem from the real world.		H	H		M					H				
3. Apply the principles of engineering design to plan and manage the project.			H											
4. Apply suitable design processes and develop the best possible solution.			H		M		M							
5. Develop proof of concepts and models for verification.			H											
6. Prepare production drawings, bill of materials and process plans.			H							H				

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply elements of mechanical engineering principles and laws to solve problems
1.3 Demonstrate competence in engineering fundamentals	1.3.2 Apply basic electrical and electronics engineering principles and laws to solve problems
1.3 Demonstrate competence in engineering fundamentals	1.3.3 Apply computer programming skills to solve problems by building algorithms ,flow charts and debugging
1.4 Demonstrate the competence in engineering knowledge appropriate to automation and robotics program	1.4.1 Apply discipline specific laws and principles to solve an interdisciplinary engineering problem
2.1 Demonstrate an ability to identify and characterize an engineering problem	2.1.1 Identifies known and unknown information, uncertainties, and biases when presented with a complex ill-structured problem
2.1 Demonstrate an ability to identify and characterize an engineering problem	2.1.3 Identifies all relevant constraints and requirements and formulate an accurate description of the problem
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.2 Partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design.
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.3 Selects appropriate analysis tools and applies those proficiently to implement the model/solution
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1 Apply formal idea generation tools to develop multiple engineering design solutions
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.2 Build models, prototypes, etc., to develop diverse set of design solutions
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.3 Identify the suitable criteria for evaluation of alternate design solutions
5.1 Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1 Identify modern engineering tools, techniques and resources for engineering activities
7.1 Demonstrate an understanding of the impact of engineering and industrial practice on social, environmental and economic contexts	7.1 1 Identify risks/impacts in the life-cycle of an engineering product or activity
10.3 Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations

E.g.: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Evaluation Scheme

Students Assessment through ISA (50%) + ESA (50%)

Assessment	Weightage in Marks
ISA	80
ESA	20
Total	100

Date: Head of Department

FMTH0301/Rev.5.3

Course Plan

Semester: IV	Year: 2021-22
Course Title: Object-Oriented Programming and Database Management Systems	Course Code: 19EARC209
Total Contact hrs: 50	Duration of ESA: 3 hrs
ISA Marks: 50	ESA Marks: 50
Lesson Plan Author: Sachin Karadgi	Date: 18-03-2022
Checked By: Shilpa Tanvashi	Date: 18-03-2022

Course Outcomes (COs):

At the end of the course, the student should be able to:

.

1. Explain concepts of object-oriented programming.
2. Implement solutions to the real world problems using object oriented language concepts
3. Explain different software development lifecycles
4. Design object oriented solutions and present them using UML diagrams.
5. Design and implement database schema and database issues for a given ER model
6. Solve the problems related to data manipulation language to query, update, and manage a Database.
7. Apply the normalization rules to design well defined database.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Object-Oriented Programming and Database Management Systems	Semester: IV
Course Code: 19EARC209	Year: 2021-22

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Explain concepts of object-oriented programming.	**M**		**M**											
2. Implement solutions to the real world problems using object oriented language concepts	**H**													
3. Explain different software development lifecycles		**H**	**M**											
4. Design object oriented solutions and present them using UML diagrams.		**H**	**H**											
5. Design and implement database schema and database issues for a given ER model	**H**	**M**												
6. Solve the problems related to data manipulation language to query, update, and manage a Database.	**H**	**M**												
7. Apply the normalization rules to design well defined database.	**H**	**M**												

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.3 Demonstrate competence in engineering fundamentals	1.3.3 Apply computer programming skills to solve problems by building algorithms, flow charts and debugging
2.1 - Demonstrate an ability to identify and characterize an engineering problem	2.1.3 - Identifies all relevant constraints and requirements and formulate an accurate description of the problem.
	2.1.4 - Gathers engineering knowledge from the available literature and selects the most relevant
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.2 Partitions problems, processes or systems into manageable elements for the purposes of analysis, modelling or design.
3.1. Demonstrate an ability to define a complex open ended problems in engineering terms	3.1.1-Recognizes that good problem definition assists in design process
	3.1.5. Determine Design objectives, functional requirements and arrives at specifications

E.g., 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: 19EARC209	Course Title: Object Oriented Programming and Database Management Systems	
L-T-P: 4-0-0	Credits: 4	Contact Hrs: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Content	Hrs
UNIT I	
Chapter 1. Fundamental concepts of object oriented programming: Introduction to the principles of object-oriented programming ,classes, objects, messages, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers, Access Specifiers, Member Functions, Instance of a Class, Default Constructors, Destructors, Accessing Data Fields, Constructors with Parameters, Static Class Members, - Data Members and Member Functions	8
Chapter 2. Object-Oriented Programming - I Inheritance, Derived Class, Calling the Base Class Constructor, Overriding Member Functions, Polymorphism, Class Inheritance Hierarchies, Revisiting Class Diagrams, Abstract Classes, Run-Time Information, Early vs. Late Binding, Virtual Base Classes, Multiple Inheritance, Interfaces, Scope Resolution Operator, Nested Classes, Local Classes, Passing Objects to Functions, Return Objects, Object Assignment, Friend Function, Operator Overloading, Function Overloading, Copy Constructors.	8
Chapter 3 : Object-Oriented Programming-II Data types, program control, Functions, Numerical Computations in Python - NumPy arrays, SciPy for numerical methods, Data plotting with Matplotlib, Statistical modelling in Python -Pandas for DataFrame, SciPy and statsmodels for basic statistical data analysis, Image Processing in Python scikit-image, filtering, edge detection.	4
UNIT II	
Chapter 4:SDLC models, Object oriented analysis and structural modeling SDLC Models-waterfall model,v-model,spiral model and agile model, Requirement Engineering, System Modelling, UML and SysML Walkthrough, Class Diagram, Use Case Diagram, State Chart Diagram, Activity Diagram, Sequence Diagram.	8
Chapter 5 Introduction to database management system Introduction to DBMS and an example, Characteristics of Database approach; Actors On and Behind the Scene; Advantages and Disadvantages of using DBMS; Data models, schema and instances; Three-schema architecture and data independence; Database languages and interfaces; The database system environment.	8
Chapter 6: Data Models Using High-Level Conceptual Data Models for Database Design; An Example	4

Database Application; Entity Types, Entity Sets, Attributes and Keys; Relationship types, Relationship Sets. Roles and Structural Constraints; Weak Entity Types; Refining the ER Design; Relationship types of degree higher than two; ER Diagrams, Naming Conventions and Design Issues	
UNIT III	
Chapter No 7:Relational Database design and structured query language Relational Model Concepts; Relational Model Constraints and Relational Database Schemas; Update Operations, SQL Data Definition and Data Types; Specifying basic constraints in SQL,Insert, Delete and Update statements in SQL; Specifying constraints as Assertion and Trigger; Views in SQL; Basic queries in SQL	5
Chapter No 8 Normalization Informal Design Guidelines for Relation Schemas; Functional Dependencies; Normal Forms Based on Primary Keys; General Definitions of Second and Third Normal Forms; Boyce-Codd Normal Form.	5

Text Books (List of books as mentioned in the approved syllabus)

1. Herbert Schildt, “C++: The Complete Reference”, Tata McGraw-Hill, 2003.
2. Allen B. Downey *“Think Python” First Edition*, Green Tea Press ,2011
3. Ian Sommerville, “Software Engineering,” Pearson Publication, 9th edition, 2010.
4. Grady Booch, James Rumbaugh and Ivar Jacobson, “Unified Modeling Language User Guide,” Addison-Wesley, 1999.
5. Ramez Elmasri and Shamkant B. Navathe, “Fundamentals of Database Systems,” Pearson Education, 5th edition, 2008.

Reference Books:

1. Ramakrishnan S. and Gehrke J: “Database Management Systems”, 3rd edition, McGraw Hill, 2007
2. R. S. Pressman, “Software Engineering – A practitioner’s approach”, 3rd ed., McGraw Hill Int. Ed
3. Mark Lutz Programming Python, 4th Edition, O'Reilly Media, Inc., December 2010

Evaluation Scheme
ISA Scheme

Assessment	Weightage in Marks
ISA-1	20
ISA-2	20
Activity	10
Total	50

Course Unitization for ISA and ESA

Topics / Chapters	Teaching Credits	No. of Questions in ISA-1	No. of Questions in ISA-2	No. of Questions in ESA
Unit I				
Chapter 1. Fundamental concepts of object oriented programming:	8	✓	--	✓
Chapter 2. Object-Oriented Programming - I	8	✓	--	✓
Chapter 3 : Object-Oriented Programming-II	6	✓	--	✓
Unit II				
Chapter 4:SDLC models, Object oriented analysis and structural modeling	8	--	✓	✓
Chapter 5 Introduction to database management system	8	--	✓	✓
Chapter 6: Data Models	6	-	✓	✓
Unit III				
Chapter No 7:Relational Database design and structured query language	5	--	--	✓
Chapter No 8 Normalization	5	--	--	✓

Note :

1. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA I, ISA II and ESA
2. Answer 5 full questions of 20 marks each (two full questions from Unit I, and II, and one full question from Unit III) out of 8 questions in ESA.

Date:18/03/2022

Head of Department

Course Assessment Plan

Course Title: Object-Oriented Programming and Database Management Systems				Code: 19EARC209	
Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		ISA-I	ISA-II	Activity	ESA
1. Explain concepts of object-oriented programming.	16%	✓	--	✓	✓
2. Implement solutions to the real world problems using object oriented language concepts	28%	✓	--	✓	✓
3. Explain different software development lifecycles	8%	✓	--	✓	✓
4. Design object oriented solutions and present them using UML diagrams.	8%	--	✓	✓	✓
5. Design and implement database schema and database issues for a given ER model,	20 %	--	✓	✓	✓
6. Solve the problems related to data manipulation language to query, update, and manage a Database.	10%	--	--	✓	✓
7. Apply the normalization rules to design well defined database	10%			✓	✓
Weightage		20%	20%	10 %	50 %

Chapter wise Plan

Course Code and Title: 19EARC209 Object Oriented Programming and Database Management Systems	
Chapter Number and Title: **1. Fundamental concepts of object oriented programming**	Planned Hours: 8 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
1. Understand the basics of C++ - Different data types, operators, expressions, and statements, arrays and strings	CO1	L3	1.3
2. Write programs using user defined types. Class Specification and Class Objects, Scope resolution operator, Access members.	CO1	L3	1.3
3.Define member functions, Data hiding, Constructors, Destructors and parameterized constructors	CO1	L3	1.3

Lesson Schedule

Class No. - Portion covered per hour
1.basics of C++ - Different data types,
2. Operators, expressions, Statements, arrays and strings.
3.Pointers and user defined types
4.Class Specification, Class Objects,
5. Scope resolution operator, Access members.
6.Define member functions, Data hiding,
7.Constructors, Destructors
8.Parameterized constructors

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Assuming there are 7.481 gallons in a cubic foot, write a program that asks the user to enter a number of gallons, and then displays the equivalent in cubic feet.	TLO1	L2	1.3.3
2. A queue is a data storage device much like a stack. The difference is that in a stack the last data item stored is the first one retrieved, while in a queue the first data item stored is the first one retrieved. That is, a stack uses a last-in-first-out (LIFO) approach, while a queue uses first-in-first-out (FIFO). A	TLO2	L3	1.3.3

queue is like a line of customers in a bank: The first one to join the queue is the first one served. Rewrite the STAKARAY program from this chapter to incorporate a class called queue instead of a class called stack. Besides a constructor, it should have two functions: one called put() to put a data item on the queue, and one called get() to get data from the queue. These are equivalent to push() and pop() in the stack class.			

Chapter wise Plan

Course Code and Title: 19EARC209 Object-Oriented Programming and Database Management Systems	
Chapter Number and Title: 2 **Object-Oriented Programming - I**	Planned Hours: 8 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
1. Understand Base Class, Inheritance and protected members, Protected base class inheritance, Inheriting multiple base classes	CO2	L3	1.3
2. Implement the Virtual function, Calling a Virtual function through a base class reference, Virtual attribute is inherited,	CO2	L3	1.3
3. Use Virtual functions are hierarchical, pure virtual functions, Abstract classes, using virtual functions.	CO2	L3	1.3

Lesson Schedule

Class No. - Portion covered per hour
1.Base Class, Inheritance and protected members
2 Protected base class inheritance,
3. Inheriting multiple base classes
4.Virtual function, Calling a Virtual function
5. base class reference, Virtual attribute is inherited
6. Virtual functions are hierarchical
7. Pure virtual functions
8. Abstract classes, Using virtual functions

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Create a class that imitates part of the functionality of the basic data type int. Call the class Int (note different capitalization). The only data in this class is an int variable.Include member functions to initialize an Int to 0, to initialize it to an int value, to display it (it looks just like an int), and to add two Int values.Write a program that exercises this class by creating	TLO1	L3	1.3.3

one uninitialized and two initialized Int values, adding the two initialized values and placing the response in the uninitialized value, and then displaying this result			
2. Create a class that includes a data member that holds a “serial number” for each object created from the class. That is, the first object created will be numbered 1, the second 2, and so on. To do this, you’ll need another data member that records a count of how many objects have been created so far. (This member should apply to the class as a whole; not to individual objects. What keyword specifies this?) Then, as each object is created, its constructor can examine this count member variable to determine the appropriate serial number for the new object. Add a member function that permits an object to report its own serial number. Then write a main () program that creates three objects and queries each one about its serial number. They should respond I am object number 2, and so on.	TLO2	L3	1.3.3
3. Imagine a publishing company that markets both book and audiocassette versions of its works. Create a class publication that stores the title (a string) and price (type float) of a publication. From this class derive two classes: book, which adds a page count (type int), and tape, which adds a playing time in minutes (type float). Each of these three classes should have a getdata() function to get its data from the user at the keyboard, and a putdata() function to display its data.Write a main() program to test the book and tape classes by creating instances of them,asking the user to fill in data with getdata(), and then displaying the data with putdata().	TLO3	L3	1.3.3

Chapter wise Plan

Course Code and Title: 19EARC209 Object-Oriented Programming and Database Management Systems	
Chapter Number and Title: 3. **Object-Oriented Programming-II**	Planned Hours: 6 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
1.Write programs using Numerical Computations in Python - NumPy arrays, SciPy for numerical methods	CO2	L3	1.3
2.Solve real world problems by using libraries- Data plotting with Matplotlib, Statistical modelling in Python -Pandas for DataFrame, SciPy and statsmodels for basic statistical data analysis, Image Processing in Python scikit-image, filtering, edge detection.	CO2	L3	1.3

Lesson Schedule

Class No. - Portion covered per hour
1. Data types and variables,Numpy library
2. SciPy library
3. Statistical modelling in Python
4. Matplotlib library
5. Scikit library
6. scikit-image, filtering, edge detection

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Write a program in python to implement addition, division and multiplication on matrix using Numpy module.	TLO1	L3	1.3.3
2. How to print all the values of an array? Write a program for the same using python.	TLO1	L3	1.3.3
3. How to classify selecting of rows and values for a data frame using index and slicing [] operator?	TLO2	L3	1.3.3

Model Question Paper for Minor Examination – I (ISA)	
Course Code: 19EARC209	Course Title: **:** Object-Oriented Programming and Database Management Systems
Duration(H:M): 1:15	Max. Marks:40
Note: Answer any two questions.	

Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Write a C++ program to add ,subtract two complex numbers of the form a+ib	8	CO1	L3	1	1.3.3.
1b	Write a program that displays your favorite poem. Use an appropriate escape sequence for the line breaks. If you don't have a favorite poem, you can borrow this one by Ogden Nash:Candy is dandy, But liquor is quicker.	8	CO1	L3	1	1.3.3.
1c	Explain the following term with an example for each 1)Class 2)Object	4	CO1	L3	1	1.3.3.
2a	Create a class that imitates part of the functionality of the basic data type int. Call the class Int (note different capitalization). The only data in this class is an int variable. Include member functions to initialize an Int to 0, to initialize it to an int value, to display it (it looks just like an int), and to add two Int values. Write a program that exercises this class by creating one uninitialized and two initialized Int values, adding the two initialized values and placing the response in the uninitialized value, and then displaying this result.	8	CO1	L3	1	1.3.3.
2b	Imagine a publishing company that markets both book and audiocassette versions of its works. Create a class publication that stores the title (a string) and price (type float) of a publication. From this class derive two classes: book, which adds a page count (type int), and tape, which adds a playing time in minutes (type float). Each of these three classes should have a get data () function to get its data from the user at the keyboard, and a put data () function to display its data. Write a main () program to test the book and tape classes by creating instances of them, asking the user to fill in	8	CO1	L3	1	1.3.3.

	data with get data(), and then displaying the data with put data().					
2c	What is pure virtual function? Explain with an example.	4	L2	CO1	1	1.3.3.
3a	Write a program in python to implement addition,division and multiplication on matrix using Numpy module.	8	L3	CO2	1	1.3.3.
3b	How to print all the values of an array? Write a program for the same using python.	8	L3	CO2	1	1.3.3.
3c	How to classify selecting of rows and values for a data frame using index and slicing [] operator?	4	L2	CO2	1	1.3.3.

Chapter wise Plan

Course Code and Title: 19EARC209 Object-Oriented Programming and Database Management Systems	
Chapter Number and Title: 4 **SDLC models, Object oriented analysis and structural modeling**	Planned Hours: 8 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
2. Discuss different SDLC models, including understanding of advantages and disadvantages.	CO3	L2	2.1
3. Design system models using UML and SysML.	CO4	L2	2.2

Lesson Schedule

Class No. - Portion covered per hour
1. Software Development Lifecycle, SDLC Models
2. Agile Software Development
3. Requirement Engineering,
4. System Modelling
5. Architecture Design
6. Design and Implementation,
7. Software Testing
8. Software Evolution

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain the different stages of the software development process.	TLO1	L2	2.1.3
2.Create product backlog considering previously implemented engineering exploration project.	TLO2	L2	2.2.2
3.draw the UML diagrams for library management system.	TLO3	L2	2.1.4

Chapter wise Plan

Course Code and Title: 19EARC209 Object-Oriented Programming and Database Management Systems	
Chapter Number and Title: **5 Introduction to database management system**	Planned Hours: 8 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
1. Define a database and its characteristics, users on the scene, and behind the scene.	CO5	L2	2.1
2. Explain the three-schema architecture of a database.	CO5	L2	2.1
3. Describe the different database languages and interfaces, different database system components.	CO5	L2	2.2
4. Differentiate between the data models, schemas and instances, logical data independence, and physical data independence.	CO5	L2	2.2

Lesson Schedule

Class No. - Portion covered per hour
1. Introduction, Characteristics of Database Approach,
2. Actors on the Scene
3. Workers Behind the Scene,
4. Advantages and Disadvantages of using DBMS Approach
5. Data models, Schemas and Instances
6. Three-Schema Architecture and Data Independence
7. Database Languages and Interfaces,
8. Database System Environment

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Describe the three-schema architecture. Why do we need mappings between schema levels? How do different schema definition languages support this architecture?	TLO2	L2	2.1.3

2. Differentiate between data models, schema and instances.	TLO2	L2	2.1.4
3. Discuss the main characteristics of the database approach and how it differs from traditional file systems.	TLO3	L2	2.1.3
4. Explain the characteristics of the database approach.	TLO1	L2	2.2.2

Chapter wise Plan

Course Code and Title: 19EARC209 Object-Oriented Programming and Database Management Systems	
Chapter Number and Title: **6: Data Models**	Planned Hours: 6 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
1. Construct an ER Diagram for a given application and present the diagrams to stakeholders.	CO5	L2	2.1
2. Design database schema with all the required structured constraints	CO5	L3	3.1

Lesson Schedule

Class No. - Portion covered per hour
1. High-Level Conceptual Data Models for Database Design,
2. Entity Types, Entity Sets, Attributes and Keys, Relationship Types, Relationship Sets
3. Roles and Structural Constraints, Weak Entity Types
4. Relationship Types of Degree Higher than Two, ER Notations
5. Informal Design Guidelines for Relation Schemas
6. Functional Dependencies, Normal Forms Based on Primary Keys

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
Consider a movie database in which data is recorded about the movie industry. Design an entity-relationship diagram with the data requirements that are summarized as follows. (a)Each movie is identified by title and year of release. Each movie has a length in minutes. Each has a production company, and each is classified under one or more genres (such as horror, action, drama, and so forth). Each movie has one or more directors and one or more actors appear in it. Each movie also has a plot outline. Finally, each movie has zero or more quotable quotes, each of which is spoken by a particular actor appearing in the movie.	TLO1	L3	1.3.3

(b) Actors are identified by name and date of birth and appear in one or more movies. Each actor has a role in the movie. (c) Directors are also identified by name and date of birth and direct one or more movies. It is possible for a director to act in a movie (including one that he or she may also direct). (d) Production companies are identified by name and each has an address. A production company produces one or more movies.			
2..Consider the following relations for a database that keeps track of student enrollment in courses and the books adopted for each course: STUDENT(Ssn, Name, Major, Bdate) COURSE(Course#, Cname, Dept) ENROLL(Ssn, Course#, Quarter, Grade) BOOK_ADOPTION(Course#, Quarter, Book_isbn) TEXT(Book_isbn, Book_title, Publisher, Author) Specify the foreign keys for this schema, stating any assumptions you make	TLO4	L3	1.3.3

KLE Technological University
Creating Value
Leveraging Knowledge

DEPARTMENT OF AUTOMATION & ROBOTICS

Model Question Paper for Minor Examination – II (ISA)	
Course Code: 19EARC209	Course Title: **:** Object-Oriented Programming and Database Management Systems
Duration(H:M): 1:15	Max. Marks:40
Note: Answer any two questions.	

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain waterfall model.	8	CO3	L2	2	2.1.3
1b	Explain requirement engineering and analysis.	8	CO3	L2	2	2.1.3
1c	Propose the case study for modeling the control strategy action with suitable UML diagrams.	4	CO4	L2	2	2.2.2
2a	What are the responsibilities of the DBA and the database designers?	8	CO5	L2	2	2.1.3
2b	What four main types of actions involve databases? Briefly discuss each	8	CO5	L2	2	2.2.2
2c	What four main types of actions involve databases? Briefly discuss each	4	CO5	L2	2	2.1.3
3a	What is the difference between logical data independence and physical data independence? Which one is harder to achieve? Why?	8	CO6	L2	2	2.1.4
3b	Describe the three-schema architecture.Why do we need mappings between schema levels? How do different schema definition languages support this architecture	8	CO6	L2	2	2.1.3
3c	Define *foreign key*.What is this concept used for?	4	CO6	L2	2	2.1.4

Chapter wise Plan

Course Code and Title: 19EARC209 Object-Oriented Programming and Database Management Systems	
Chapter Number and Title: 7. **Relational Database design and structured query language**	Planned Hours: 5 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
1. List the different data types supported by SQL, commands available for retrieving and updating the database in SQL	CO6	L3	1.3.
2. Explain the basic data types available for attributes in SQL.	CO6	L3	1.3.
3. Discuss the different ways by which a join operation can be modeled using SQL, entity integrity and referential integrity constraints.	CO6	L2	3.1
4. Compose SQL statements for the given query.	CO6	L3	1.3

Lesson Schedule

Class No. - Portion covered per hour
1. SQL Data Definition and Data Types
2. Schema change statements in SQL,
3. Insert, Delete and Update statements in SQL
4. Specifying constraints as Assertion and Trigger,
5. Views in SQL, queries in SQL,More complex SQL Queries

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. How SQL supports the implementation of entity integrity and referential integrity constraints? Explain with an example.	TLO4	L2	3.1.1
2. Explain SQL database retrieval commands with examples.	TLO5	L2	3.1.1

Chapter wise Plan

Course Code and Title: 19EARC209 Object-Oriented Programming and Database Management Systems	
Chapter Number and Title: **8 Normalization**	Planned Hours: 5 hrs

Learning Outcomes

At the end of the topic, the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	PI Code
1. List the database design guidelines, functional dependency.	CO7	L2	2.2
2. Define normalization, 1NF, 2NF, 3NF and BCNF.	CO7	L2	2.1
3. Explain the concept of functional dependency.	CO7	L2	2.2

Lesson Schedule

Class No. - Portion covered per hour
1. Informal Design Guidelines for Relation Schemas,
2. Functional Dependencies,
3. Normalization rules
4. Normal Forms Based on Primary Keys,
5. General Definitions of Second and Third Normal Forms in DBMS, Boyce-Codd Normal Form

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Define 1NF, 2NF, 3NF and BCNF with an examples.	TLO3	L2	2.1.3
2. Design a Normalized database as BCNF database.	TLO6	L2	2.2.2

Model Question Paper for End Semester Assessment (ESA)	
Course Code : 19EARC209	**Course:** Object-Oriented Programming and Database Management Systems
Total Duration : 3 Hours	**Maximum Marks :100**
Note :Answer Five Questions: Any two full questions from each Unit I & Unit II and one full question from Unit III	

UNIT-I						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Write a C++ program to add ,subtract two complex numbers of the form a+ib	8	CO1	L3	1	1.3.3.
1b	Write a program that displays your favorite poem. Use an appropriate escape sequence for the line breaks. If you don't have a favorite poem, you can borrow this one by Ogden Nash:Candy is dandy, But liquor is quicker.		CO1	L3	1	1.3.3.
1c	Explain the following term with an example for each 1)Class 2)Object	8	CO1	L3	1	1.3.3.
2a	Create a class that imitates part of the functionality of the basic data type int. Call the class Int (note different capitalization). The only data in this class is an int variable. Include member functions to initialize an Int to 0, to initialize it to an int value, to display it (it looks just like an int), and to add two Int values. Write a program that exercises this class by creating one uninitialized and two initialized Int values, adding the two initialized values and placing the response in the uninitialized value, and then displaying this result.	8	CO1	L3	1	1.3.3.
2b	Imagine a publishing company that markets both book and audiocassette versions of its works. Create a class publication that stores the title (a string) and price (type float) of a publication. From this class derive two classes: book, which adds a page count (type int), and tape, which adds a playing time in minutes (type float). Each of these three classes should have a get data () function to	8	CO1	L3	1	1.3.3.

	get its data from the user at the keyboard, and a put data () function to display its data. Write a main () program to test the book and tape classes by creating instances of them, asking the user to fill in data with get data(), and then displaying the data with put data().					
2c	What is pure virtual function? Explain with an example.	8	L2	CO1	1	1.3.3.
3a	Write a program in python to implement addition, division and multiplication on matrix using Numpy module.	4	L3	CO2	1	1.3.3.
3b	How to print all the values of an array? Write a program for the same using python.	8	L3	CO2	1	1.3.3.
3c	How to classify selecting of rows and values for a data frame using index and slicing [] operator?	8	L2	CO2	1	1.3.3.
UNIT-II						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
4a	Explain waterfall model.	8	CO3	L2	2	2.1.3
4b	Explain requirement engineering and analysis.	8	CO3	L2	2	2.1.3
4c	Propose the case study for modeling the control strategy Action with suitable UML diagrams.	4	CO4	L2	2	2.2.2
5a	What are the responsibilities of the DBA and the database designers?	8	CO5	L2	2	2.1.3
5b	What four main types of actions involve databases? Briefly discuss each	8	CO5	L2	2	2.2.2
5c	What four main types of actions involve databases? Briefly discuss each	4	CO5	L2	2	2.1.3
6a	What is the difference between logical data independence and physical data independence? Which one is harder to achieve? Why?	8	CO6	L2	2	2.1.4
6b	Describe the three-schema architecture. Why do we need mappings between schema levels? How do different schema definition languages support this architecture	8	CO6	L2	2	2.1.3

6c	Define *foreign key*. What is this concept used for?	4	CO6	L2	2	2.1.4
UNIT-III						
Q.No.	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
7a	How to use INSERT, DELETE, and UPDATE Statements in SQL? Explain with an example.	8	CO6	L3	1	1.3.3
7b	List and Explain the commands available for retrieving and updating the database in SQL	8	CO6	L3	1	1.3.3
7c	List the data types that are allowed for SQL attributes.	4	CO6	L2	1	1.3.3
8a	What does the term *unnormalized relation* refer to? How did the normal forms develop historically from first normal form up to Boyce-Codd normal form	8	CO7	L3	1	1.3.3
8b	What is multivalued dependency? When does it arise?	8	CO7	L3	1	1.3.3
8c	What is a functional dependency? What are the possible sources of the information that defines the functional dependencies that hold among the attributes of a relation schema?	8	CO7	L2	1	1.3.3

FMTH0301/Rev.5.3

Course Plan

Semester: VII | Year: 2021-22

Course Title: Industrial Data Networks	Course Code: 16EARC401
Total Contact hrs: 50	Duration of ESA: 3 hrs
ISA Marks: 50	ESA Marks: 50
Lesson Plan Author: Mr. Nagaraj Benakanahalli	Date: 04-08-2021
Checked By: Dr. Sachin Karadgi	Date: 04-08-2021

Prerequisites:

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Demonstrate knowledge of serial communication, inter-networking concepts and operations of industrial Ethernet systems.
2. Explain the protocols of TCP/IP model and operation of TCP/IP.
3. Demonstrate knowledge of Modbus structures and functions
4. Explain the features of Profibus and its uses in various industries, and main features of Actuator-Sensor Interface.
5. Discuss different Ethernet based protocols, like EtherCAT, Ethernet POWERLINK and SERCOS III.
6. Describe fundamental operation of Highway Addressable Remote Transducer (HART) protocol and explain how data can be made accessed in OPC.
7. Demonstrate knowledge of CAN networks and few protocols based on CAN.
8. Demonstrate knowledge of FlexRay and MOST protocols.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Industrial Data Networks	Semester: VII
Course Code: 16EARC401	Year: 2021-22

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1.Demonstrate knowledge of serial communication, inter-networking concepts and operations of industrial Ethernet systems.	**H**													
2.Explain the protocols of TCP/IP model and operation of TCP/IP.	**H**													
3.Demonstrate knowledge of Modbus structures and functions	**M**													
4.Explain the features of Profibus and its uses in various industries, and main features of Actuator-Sensor Interface.	**M**													
5.Discuss different Ethernet based protocols, like EtherCAT, Ethernet POWERLINK and SERCOS III.	**M**													
6.Describe fundamental operation of Highway Addressable Remote Transducer (HART) protocol and explain how data can be made accessed in OPC.	**M**													
7.Demonstrate knowledge of CAN networks and few protocols based on CAN.	**L**													
8.Demonstrate knowledge of FlexRay and MOST protocols.	**L**													

Degree of compliance **L**: Low **M**: Medium **H**: High

Course Content

Course Code: 16EARC401	Course Title: Industrial Data Networks	
L-T-P : 4-0-0	Credits: 4	Contact Hrs: 50
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 50		Exam Duration: 3 hrs

Content	Hrs
Unit I	
Chapter No. 1. DATA NETWORK FUNDAMENTALS AND INDUSTRIAL ETHERNET Modern Instrumentation and Control Systems, Open Systems Interconnection (OSI) Model, Concepts of Parallelization, Sequential, Framing, Bit Encoding, Media Access Control, Error Correction, Time Division, Bit Rate, and Baud Rate, EIA-232, EIA-485, Fiber Optics Overview, Circuit Switching and Packet Switching, Network Topologies, Ethernet, Ethernet Topology, 10 Mbps Ethernet, 1 Gigabit Ethernet, Internetwork Connections Devices (Repeaters, Bridges, Hubs, Switches, Routers and Gateways)	8
Chapter No. 2. TCP/IP IP Version 4 (IPv4), IP Version 6 (IPv6), Address Resolution Protocol (ARP), Internet Control Message Protocol (ICMP), IP Routing, Transmission Control Protocol (TCP), User Datagram Protocol (UDP)	7
Chapter No. 3. MODBUS MODBUS: Protocol Structure, Function Codes	5
Unit II	
Chapter No. 4. FIELDBUS, PROFIBUS AND AS-INTERFACE FIELDBUS: Physical Layer, Data Link Layer and Application Layer of FOUNDATION Fieldbus PROFIBUS: PROFIBUS DP (Decentralized Periphery), PROFIBUS DP Communication Protocol, Application Profiles, PROFIBUS PA (Process Automation) AS-Interface: AS-Interface, Physical Layer, Data Link and Application Layer of the AS-Interface	7
Chapter No. 5. ETHERCAT, ETHERNET POWERLINK AND SERCOS III ETHERCAT: Architecture Model, Protocol, Topology, Distributed Clocks, Device Profiles, EtherCAT Master, EtherCAT Slave Ethernet POWERLINK: Slot Communication Network Management, Physical Layer, Data Link Layer, Transport and Application Layer of Ethernet POWERLINK, Ethernet POWERLINK Addressing, Frame Structures SERCOS III:OSI Layers of SERCOS III, Communication Cycle, Protocol Structure, Topology, Communication Network Infrastructure	8
Chapter No. 6. HART, BLUETOOTH AND OPC HART: HART Protocol, Physical Layer, Data Link Layer and Application Layer of HART. BLUETOOTH: Protocol Stack, Topologies, Generic Data Transport Architecture, Basic Rate/Enhanced Data Rate (BR/EDR) Radio Operation, Low Energy (LE) Operation, Operational Procedures and Modes, Profiles	5

OPC: Enterprise Integration, Manufacturing Execution Systems (MES), Process Analysis, Process Modeling, Data Modeling, Data Flow Diagrams (DFDs), Communication Patterns, Data Collection Technologies, OPC (OLE for Process Control)	
Unit III	
Chapter No. 7. CAN, CAN FD AND DEVICENET CAN: Physical Layer, Data Link Layer and Application Layer of CAN, Protocol, Bus Arbitration, Frames, Bit Stuffing, Bit Synchronization, Bit Timing CAN FD: Physical Layer, Data Link Layer and Application Layer of CAN FD, Protocol, Frames DEVICENET: Physical Layer, Data Link Layer, Network and Transport Layers, and Application Layer of DeviceNet	5
Chapter No. 8. FLEXRAY AND MOST FLEXRAY: Topologies, Protocol, Media Access Control (Communication Cycle), Frame Format, Clock Synchronization MOST: OSI Layers for MOST, Data Frame, Timing Master, Timing Slave, MOST Devices	5

Text Books (List of books as mentioned in the approved syllabus)

1. Steve Mackay, Edwin Wright, Deon Reynders, John Park, “Practical Industrial Data Networks: Design, Installation and Troubleshooting,” First edition, Newnes publication, Elsevier, 2004.
2. John Park, Steve Mackay, Edwin Wright, “Practical Data Communications for Instrumentation and Control,” First edition, Newnes publication, Elsevier, 2003.

References

1. Modbus, http://www.Modbus.org.
2. FOUNDATION Fieldbus, http://www.fieldbus.org.
3. FOUNDATION Fieldbus, https://www.fieldcommgroup.org/technologies/foundation-fieldbus/foundation-technology-overview.
4. ProfiBus, https://www.profibus.com.
5. AS-Interface, http://www.as-interface.net.
6. HART, https://www.fieldcommgroup.org/technologies/hart/hart-technology.
7. EtherCAT, https://www.ethercat.org.
8. Ethernet POWERLINK, https://www.ethernet-powerlink.org.
9. SERCOS, https://www.sercos.org.
10. OPC Foundation, https://opcfoundation.org.
11. Bluetooth, https://www.bluetooth.com.
12. CAN, https://www.can-cia.org/can-knowledge.
13. CAN FD, https://www.can-cia.org/can-knowledge/can/can-fd.
14. DeviceNet, https://www.odva.org.
15. FlexRay, http://www.ni.com/white-paper/3352/en.
16. Media Oriented Systems Transport (MOST), https://www.mostcooperation.com/cooperation/introduction.

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
ISA-1	25
ISA-2	25
Activity	--
Total	50

Course Unitization for ISA and ESA

Topics / Chapters	Teaching Hours	No. of Questions in ISA-1	No. of Questions in ISA-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
1.DATA NETWORK FUNDAMENTALS AND INDUSTRIAL ETHERNET	8	1.00	--	--	1.00
2.TCP/IP	7	1.00	--	--	1.00
3.MODBUS	5	1.00	--	--	1.00
Unit II					
4.FIELDBUS, PROFIBUS AND AS-INTERFACE	7	--	1.00	--	1.00
5.ETHERCAT, ETHERNET POWERLINKAND SERCOS III	8	--	1.00	--	1.00
6.HART, BLUETOOTH AND OPC	5	--	1.00	--	1.00
Unit III					
7.CAN, CAN FD AND DEVICENET	5	--	--	--	1.00
8.FLEXRAY AND MOST	5	--	--	--	1.00

Note:

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA- I, ISA-II and ESA.
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full question from Unit III) out of 8 questions in ESA.

Date: 04-09-2021 HOD

Course Assessment Plan

Course Title: Industrial Data Networks		Code: 16EARC401			
Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		ISA-1	ISA-2	Activity	ESA
1. Demonstrate knowledge of serial communication, inter-networking concepts and operations of industrial Ethernet systems.	12.5 %	✓			✓
2. Explain the protocols of TCP/IP model and operation of TCP/IP.	12.5 %	✓			✓
3. Demonstrate knowledge of Modbus structures and functions.	12.5 %	✓			✓
4. Explain the features of Profibus and its uses in various industries, and main features of Actuator-Sensor Interface.	12.5 %		✓		✓
5. Discuss different Ethernet based protocols, like EtherCAT, Ethernet POWERLINK and SERCOS III.	12.5 %		✓		✓
6. Describe fundamental operation of Highway Addressable Remote Transducer (HART) protocol and explain how data can be made accessed in OPC.	12.5 %		✓		✓
7. Demonstrate knowledge of CAN networks and few protocols based on CAN.	12.5 %				✓
8. Demonstrate knowledge of FlexRay and MOST protocols.	12.5 %				✓
Weightage		25 %	25 %		50 %

Chapter wise Plan

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **1. DATA NETWORK FUNDAMENTALS AND INDUSTRIAL ETHERNET**	Planned Hours: **8 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	CO's	BL	CA Code
1. Explain Open Systems Interconnection (OSI) model.	CO1	L3	1.3
2. Identify the interface standards and explain the main features of the EIA-232 standard.	CO1	L2	1.3
3. Explain media access control mechanisms.	CO1	L2	1.3
4. Explain standard Ethernet (10Base5) bus topology.	CO1	L2	1.3
5. Explain different internetwork connection devices.	CO1	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Modern Instrumentation and Control Systems, Open Systems Interconnection (OSI) Model
2. Concepts of Parallelization, Sequential, Framing, Bit Encoding
3. Media Access Control, Error Correction, Time Division, Bit Rate, and Baud Rate
4. EIA-232
5. EIA-485, Fiber Optics Overview
6. Circuit Switching and Packet Switching, Network Topologies, Ethernet
7. Ethernet Topology, 10 Mbps Ethernet, Gigabit Ethernet
8. Internetwork Connections Devices (Repeaters, Bridges, Hubs, Switches, Routers and Gateways)

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Identify the model which provides a universal framework for all communication systems and explain the same with a neat figure.	TLO1	L3	1.3.2
2. Which interface is used for the single purpose of interfacing data terminal equipment (DTE) and data circuit terminating equipment (DCE) employing serial binary data interchange, explain.	TLO2	L3	1.3.2
3. Compare circuit switched and packet switched networks.	TLO3	L2	1.3.2
4. Explain standard Ethernet bus topology with a neat figure.	TLO4	L2	1.3.2

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **2. TCP/IP**	Planned Hours: **7hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	CA Code
1. Map TCP/IP Protocol Suite onto OSI model.	CO2	L2	1.3
2. Explain IP version 4 (IPv4), including IPv4 addressing.	CO2	L3	1.3
3. Explain Address Resolution Protocol (ARP), Internet Control Message Protocol (ICMP), Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).	CO2	L2	1.3

Lesson Schedule Class No. – Portion covered per hour
1. IP Version 4 (IPv4)
2. IP Version 4 (IPv4), IP Version 6 (IPv6)
3. Address Resolution Protocol (ARP)
4. Internet Control Message Protocol (ICMP)
5. IP Routing
6. Transmission Control Protocol (TCP)
7. User Datagram Protocol (UDP)

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Which protocol is responsible for the delivery of packets/datagrams between hosts. Also, explain it with its header format.	TLO2	L3	1.3.2
2. Explain the connection-oriented protocol with a header format.	TLO3	L2	1.3.2
3. With header format explain the protocol which does not require a connection to be established between two machines prior to data transmission.	TLO3	L2	1.3.2

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **3. MODBUS**	Planned Hours:**5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	CA Code
1. Describe Modbus protocol structure.	CO3	L3	1.3
2. Demonstrate to build the request and response messages associated with various Modbus function codes.	C03	L2	1.3

Lesson Schedule Class No. – Portion covered per hour
1. Modbus – Protocol Structure
2. Modbus – Function Codes
3. Modbus – Function Codes
4. Modbus – Function Codes
5. Modbus – Function Codes

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain the Modbus protocol structure	TLO1	L2	1.3.2
2. Determine the request and response for Modbus function code Write Multiple Coils (15) with 16 coils starting at coil 35 in target device 15. Suitable assumption can be made about output values.	TLO2	L3	1.3.2

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **4. FIELDBUS, PROFIBUS AND AS-INTERFACE**	Planned Hours:**7hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	CA Code
1. Discuss different types of messages as part of data link layer in FOUNDATION Fieldbus.	C04	L2	1.3
2. Explain PROFIBUS DP communication stack.	CO4	L2	1.3
3. Explain the master call and slave response of AS-Interface network.	C04	L2	1.3

Lesson Schedule Class No. – Portion covered per hour
1. FOUNDATION Fieldbus – Physical Layer, Data Link Layer, Application Layer
2. PROFIBUS DP (Decentralized Periphery)
3. PROFIBUS DP Communication Stack
4. PROFIBUS DP Application Profiles
5. PROFIBUS PA
6. AS-Interface – Physical Layer, Data Link Layer
7. AS-Interface –Data Link Layer, Application Layer

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Describe the concept of cyclic and acyclic messages in FOUNDATION Fieldbus.	TL01	L2	1.3.2
2. Explain PROFIBUS DP communication stack with a figure.	TLO2	L2	1.3.2
3. Discuss master call and slave response of AS-Interface network.	TLO3	L2	1.3.2

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **5. ETHERCAT, ETHERNET POWERLINKAND SERCOS III**	Planned Hours: **8hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	CA Code
1. Discuss about the EtherCAT architecture model.	CO5	L2	1.3
2. Describe OSI layers of Ethernet POWERLINKand Ethernet POWERLINK's frame structures.	CO5	L2	1.3
3. Explain communication network infrastructure of SERCOS III.	C05	L2	1.3

Lesson Schedule Class No. – Portion covered per hour
1. EtherCAT – Architecture Model, Protocol, Topology, Distributed Clock
2. EtherCAT – Distributed Clock, Device Profiles
3. EtherCAT – EtherCAT Master, EtherCAT Slave
4. Ethernet POWERLINK – Slot Communication Network Management, Physical Layer, Data Link Layer
5. Ethernet POWERLINK – Transport and Application Layer
6. Ethernet POWERLINK – Ethernet POWERLINK Addressing, Frame Structures
7. SERCOS III – OSI Layers of SERCOS, Communication Cycle, Protocol Structure
8. SERCOS III – Protocol Structure, Topology, Communication Network Infrastructure

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain the EtherCAT data frame, and how does EtherCAT data frame differs from IEEE 802.3 data frame.	TLO1	L2	1.3.2
2. Explain Ethernet POWERLINK frame structure and also identify different message types.	TL02	L2	1.3.2
3. Describe SERCOS III communication cycle.	TL03	L2	1.3.2

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **6. HART, BLUETOOTH AND OPC**	Planned Hours:**5hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	CA Code
1. Discuss OSI layers of HART.	CO6	L2	1.3
2. Explain the working of Bluetooth devices.	CO6	L2	1.3
3. Describing different data collection technologies and explain the working of OPC (OLE for Process Control).	C06	L2	1.3

Lesson Schedule Class No. – Portion covered per hour
1. HART – Physical Layer, Data Link Layer, Application Layer, Protocol Stack, Topologies
2. Bluetooth – Generic Data Transport Architecture, Basic Rate/Enhanced Data Rate (BR/EDR) Radio Operation
3. Bluetooth – Low Energy (LE) Operation, Operational Procedures and Modes, Profiles
4. OPC – Enterprise Integration, Manufacturing Execution Systems (MES), Process Analysis, Process Modeling, Data Modeling, Data Flow Diagrams (DFDs), Communication Patterns, Data Collection Technologies
5. OPC – OPC (OLE for Process Control)

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain Bell 202 communication standard used in HART.	TLO1	L2	1.3.2
2. Describe generic data transport architecture of Bluetooth.	TL02	L2	1.3.2
3. Data has to be exchanged among various automation systems. How would this be realized using OPC (OLE for Process Control)?	TL03	L2	1.3.2

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **7. CAN, CAN FD AND DEVICENET**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	CA Code
1. Explain CAN networks.	CO7	L2	1.3
2. Differentiate between CAN and CAN FD.	CO7	L3	1.3
3. Explain the OSI layers of DeviceNet.	CO7	L2	1.3

Lesson Schedule Class No. – Portion covered per hour
1. CAN – Physical Layer, Data Link Layer, Application Layer
2. CAN – Frames
3. CAN – Bus Arbitration, Bit Stuffing, Bit Synchronization, Bit Timing
4. CAN FD – Physical Layer, Data Link Layer, Application Layer, Protocol, Frames
5. DeviceNet - Physical Layer, Data Link Layer, Network Layer, Application Layer

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Explain data frame – extended format (29 bits identifier) of CAN.	TLO1	L2	1.3.2
2. Explain different frames of CAN FD.	TLO2	L3	1.3.2
3. Discuss about different types of messaging of DeviceNet.	TLO3	L2	1.3.2

Course Code and Title: 16EARC401 / Industrial Data Networks	
Chapter Number and Title: **8. FLEXRAY AND MOST**	Planned Hours: **5 hrs**

Learning Outcomes:

At the end of the topic the student should be able to:

Topic Learning Outcomes (TLOs)	COs	BL	CA Code
1. Explain the communication cycle and frame format in FlexRay.	CO8	L2	1.3
2. Explain MOST layers and MOST frames.	CO8	L2	1.3

Lesson Schedule Class No. – Portion covered per hour
1. FlexRay – Topologies, Protocol
2. FlexRay – Media Access Control (Communication Cycle)
3. FlexRay – Frame Format, Clock Synchronization
4. MOST – Physical Layer, Data Link Layer, Application Layer
5. MOST – Data Frame, Timing Master, Timing Slave, MOST Devices

Review Questions

Sl. No. - Questions	TLOs	BL	PI Code
1. Discuss timing hierarchy within the communication cycle of FlexRay.	TLO1	L3	1.3.2
2. Explain frames corresponding to different MOST versions.	TL02	L2	1.3.2

Model Question Paper for In-Semester Assessment (ISA-1)						
Course Code: 16EARC401		Course Title: Industrial Data Networks				
Duration: 75 min						
Max. Marks: 40						
Note: Answer any 2 full questions.						
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Explain IEEE 802.3 frame format.	6	C02	L2	1	1.3.2
1b	What would be length of request and response message in case ofRead Input Register 04 (0X04) if the input register has to be read from 010 to 136 from device 254.	7	C03	L3	1	1.3.2
1c	Identify the model which provides a universal framework for all communication systems and explain the same with a neat figure.	7	C01	L3	1	1.3.2
2a	Explain Modbus protocol structure.	6	C03	L2	1	1.3.2
2b	Explain different types of handshaking mechanisms available in RS-232, if possible with neat figures.	7	C01	L2	1	1.3.2
2c	Which protocol reports errors and other useful information about the performance and operation of the network? Explain the protocol with the format.	7	C02	L3	1	1.3.2
3a	Explain the different states of RS-485.	6	C01	L2	1	1.3.2
3b	With header format explain the protocol which does not require a connection to be established between two machines prior to data transmission.	7	C02	L3	1	1.3.2
3c	Determine the request and response for function code Read Discrete Inputs – 02 (0X02) with read inputs 197-218 from target device 17.	7	C03	L3	1	1.3.2

Model Question Paper for In-Semester Assessment (ISA-2)		
Course Code: 16EARC401		Course Title: Industrial Data Networks
Duration: 75 min		
Max. Marks: 40		
Note: Answer any 2 full questions.		

Q.No	Questions	Marks	CO	BL	PO	PI Code
1a	Describe the protocol structure of SERCOS III.	6	C05	L2	1	1.3.2
1b	Explain Bell 202 communication standard used in HART.	7	C06	L2	1	1.3.2
1c	Discuss about various versions of master call and slave reply of AS-Interface.	7	C04	L2	1	1.3.2
2a	Illustrate Basic Rate/Enhanced Data Rate (BR/EDR) Bluetooth topologies with neat figures.	6	C06	L2	1	1.3.2
2b	Describe cyclic and acyclic messages in FOUNDATION Fieldbus.	7	C04	L2	1	1.3.2
2c	Explain EtherCAT communication types.	7	C05	L2	1	1.3.2
3a	Describe the encoding rules used in FOUNDATION Fieldbus.	6	C04	L2	1	1.3.2
3b	Explain the addressing of Ethernet POWERLINK.	7	C05	L2	1	1.3.2
3c	Data has to be exchanged between various higher-level applications and automation systems, and this require interfaces. How would you design interfaces on the automation system side?	7	C06	L3	1	1.3.2

Model Question Paper for End Semester Assessment (ESA)		
Course Code: 16EARC401		Course Title: Industrial Data Networks
Duration: 180 min		
Max. Marks: 100		

Note:
1. Answer 5 full questions of 20 marks each (two full questions from Unit-I and Unit-II, and one full question from Unit-III).
2. Missing data can be assumed with justification.

Q.No	Questions	Marks	CO	BL	PO	PI Code
	UNIT - I					
1a	Illustrate three-way handshake used to establish connection in TCP.	4	C02	L2	1	1.3.2
1b	Explain Modbus data model.	6	C03	L2	1	1.3.2
1c	Identify the model which provides a universal framework for all communication systems and explain the same with a neat figure.	10	C01	L3	1	1.3.2
2a	Describe Modbus protocol structure.	4	C03	L3	1	1.3.2
2b	Explain fiber optic cable components with the help of neat figure.	6	C01	L2	1	1.3.2
2c	With header format explain the protocol which does not require a connection to be established between two machines prior to data transmission.	10	C02	L3	1	1.3.2
3a	Explain the 5-4-3-2 rule as part of 10 Mbps Ethernet with a neat figure.	4	C01	L2	1	1.3.2
3b	Explain 802.3 data frame. Message with length of 40 bytes has to be transmitted. Determine the length of the message that will be transmitted using IEEE 802.3 data frame.	6	C02	L2	1	1.3.2
3c	Determine the request and response for Modbus function code Write Multiple Registers (16) with register values 566, 05, 1578, and 662 to be written in registers starting from register 188 in target device 16.	10	C03	L3	1	1.3.2
	UNIT - II					
4a	Explain the protocol structure of SERCOS III.	4	C05	L2	1	1.3.2
4b	Discuss about communication modes available in HART.	6	C06	L2	1	1.3.2
4c	Describe the concept of cyclic and acyclic messages in FOUNDATION Fieldbus.	10	C04	L3	1	1.3.2
5a	Illustrate Basic Rate/Enhanced Data Rate (BR/EDR) Bluetooth packet structure.	4	C06	L2	1	1.3.2

5b	Explain the (bus) access mechanism used in ProfiBus DP.	6	C04	L2	1	1.3.2
5c	Explain EtherCAT architecture model with a neat figure.	10	C05	L2	1	1.3.2
6a	Describe the encoding rules used in FOUNDATION Fieldbus.	4	C04	L3	1	1.3.2
6b	Explain the OSI layers associated with Ethernet POWERLINK.	6	C05	L2	1	1.3.2
6c	Data has to be exchanged among various automation systems. How would this be realized using OPC (OLE for Process Control)?	10	C06	L3	1	1.3.2
UNIT - III						
7a	Explain different types of messaging of DeviceNet.	4	C07	L2	1	1.3.2
7b	Discuss the operation modes of CAN FD device.	6	C07	L2	1	1.3.2
7c	Data 64574 has to be transmitted on CANBus. Draw the encoding diagram for the corresponding data.	10	C07	L3	1	1.3.2
8a	Explain MOST device model with a neat figure.	4	C08	L2	1	1.3.2
8b	Map MOST protocol layers onto OSI model and explain MOST protocol layers with a neat figure.	6	C08	L2	1	1.3.2
8c	Explain the possible topologies of FlexRay with neat figures.	10	C08	L2	1	1.3.2

KLE Technological University
Creating Value
Leveraging Knowledge

DEPARTMENT OF AUTOMATION & ROBOTICS

FMTH0301/Rev.5.3

Course Plan

Semester: **V** Year: 2021

Course Title: **Measurement Systems**	Course Code: 18EARC305
Total Contact Hours: **40**	Duration of ESA: 3 hours
ISA Marks: **50**	ESA Marks: **50**
Lesson Plan Author: Mr. Vinod Kumar V Meti	Date: 22-10-2021
Checked By: Mr. Amit Talli	Date: 22-10-2021

Mission Statement:

The mission of the measurement system course is to prepare students to select suitable sensors, model and design measurement systems for use in mechatronic systems, real world industrial applications and projects by educating them in the fundamental concepts of measurement systems, applications and design of measurement systems.

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Demonstrate broad knowledge of general concepts in measurement systems by discussing the need and requirements of measurement in general and specific to mechatronic systems, types of applications, general configuration and functions of measurement systems, functional elements in a measurement system and their performance characteristics.
2. Demonstrate broad knowledge and skill in identifying and selecting different measuring devices / sensors that can be used to measure different physical parameters, working principles, modelling and applicable standards and calibration.
3. Demonstrate broad knowledge of requirements of signal conditioning / manipulation, transmission and recording by identifying and discussing various device and techniques used for signal conditioning, transmission and recording while designing measurement systems.
4. Demonstrate knowledge of the requirements and configuration of a PC based data acquisition system and discuss different types of implementation in terms of hardware and software.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Program Outcomes

Course Title: **Measurement Systems**	Semester: 5^{th}
Course Code: 18EARC305	Year: 2021

Course Outcomes (CO) / Program Outcomes (PO)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Demonstrate broad knowledge of general concepts in measurement systems by discussing the need and requirements of measurement in general and specific to mechatronic systems, types of applications, general configuration and functions of measurement systems, functional elements in a measurement system and their performance characteristics.	**M**	**M**												
2. Demonstrate broad knowledge and skill in identifying and selecting different measuring devices / sensors that can be used to measure different physical parameters, working principles, modelling and applicable standards and calibration.	**H**													
3. Demonstrate broad knowledge of requirements of signal conditioning / manipulation, transmission and recording by identifying and discussing various device and techniques used for signal conditioning, transmission and recording while designing measurement systems.		**H**												
4. Demonstrate knowledge of the requirements and configuration of a PC based data acquisition system and discuss different types of implementation in terms of hardware and software.		**H**												

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 - Demonstrate the competence in mathematical modeling	1.1.2 - Apply discipline specific advanced mathematical techniques to modeling and problem solving
1.2 - Demonstrate the competence in basic sciences.	1.2.1 – Apply mathematical technique to solve the problems
1.3 - Demonstrate the competence in engineering fundaments.	1.3.1 – Apply elements of mechanical engineering principles and laws to solve problems.
	1.3.2 - Apply basic electrical and electronics engineering principles and laws to solve problems.
2.1 - Demonstrate an ability to identify and characterize an engineering problem	2.1.2 – Identify the essential problems and objectives
	2.1.3 – Identifies all relevant constraints and requirements and formulate an accurate description of the problem
2.2 - Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 - Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions
2.3 - Demonstrate an ability to formulate and interpret a model	2.3.1 - Evaluates the analysis for accuracy and validity of assumptions made
13.1 - Demonstrate an ability to design and integrate simple automation systems	13.1.1 - Develop system specification, identify IO, control components and field devices, Identify integration technologies

Eg: 1.2.3: Represents program outcome '1', competency '2' and performance indicator '3'.

Course Content

Course Code: 18EARC305	Course Title: Measurement Systems	
L-T-P: 3-0-0	Credits: 3	Contact Hrs: 40 hours
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Duration of ESA: 3 Hrs

Content	Hrs
Unit – I	
Chapter No. 1. Introduction to Measurement Systems Why study Measurement Systems, Classification of Types of Measurement Applications, Computer-Aided Machines and Processes, Functional Elements of an Instrument, Active and Passive Transducers, Analog And Digital Modes of Operation , Null and Deflection Methods, Input-Output Configuration of Instruments and Measurement Systems, Static Characteristics and Static Calibration, Dynamic Characteristics.	5 hrs
Chapter No. 2. Sensors and Signal conditioning Sensor characterization, Relations between physical quantities, Sensor Classification, Specifications, Error reduction techniques, Loading errors, Signal conditioning processes, The operational amplifier, Filtering, Wheatstone bridge, Pulse modulation.	5 hrs
Chapter No. 3. Motion Measurement Fundamental Standards, Relative Displacement: Translation and Rotational, Relative Velocity: Translation and Rotational, Relative-Acceleration Measurements, Displacement Pickups, Velocity Pickups, Acceleration Pickups, Calibration and Vibration Pickups, Jerk Pickups.	5 hrs
Unit – II	
Chapter No. 4. Force, Torque, and Shaft Power Measurement Standards and Calibration, Basic Methods of Force Measurement, Characteristics of Elastic Force Transducers, Torque measurement on Rotating shaft, Shaft Power Measurement (Dynamometers), Vibrating Wire Force Transducers.	5 hrs
Chapter No. 5. Pressure & Sound Measurement Standards and Calibration, Basic Methods of Pressure Measurement, Deadweight Gages and Manometers, Elastic Transducers, Vibrating-Cylinder and Other Resonant Transducers, Dynamic Testing of Pressure-Measuring Systems, High-Pressure Measurement, Low-Pressure Measurement, Sound Measurement.	5 hrs
Chapter No. 6. Flow and Temperature Measurement Local Flow Velocity, Magnitude and Direction, Gross Volume Flow Rate, Standards and Calibration of Temperature Measurement, Thermal-Expansion methods, Thermoelectric Sensors, Electrical-Resistance Sensors, Junction Semiconductor Sensors, Digital Thermometers, Radiation Methods.	5 hrs
Unit – III	
Chapter No.7. Data Acquisition Systems Data conversion devices, Signal sampling and aliasing, Sampling theorem, Quantization, Encoding, Digital to analog conversion methods, Analog to digital conversion methods,	5 hrs

Sample & Hold circuit, Flash ADC, Successive approximation ADC, Dual slope ADC, Sigma Delta ADC, Multiplexers.	
Chapter No. 8. Transmission and Recording of Data Cable Transmission of Analog Voltage and Current Signals, Cable Transmission of Digital Data, Fiber-Optic Data Transmission, Analog Voltmeters and Potentiometers, Electrical Instruments, Digital Voltmeters and Multimeters, Signal Generation, Electromechanical XT and XY Recorders, Fiber Optic Sensors.	5 hrs

Text Books:

1. Ernest O. Doebelin and Dhanesh N. Manik, “Measurement Systems”, Seventh Edition, McGraw Hill Education Pvt Ltd, 2019.
2. W. Bolton, “Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering”, Fourth Edition, PEARSON, 2010.

References:

1. Sabri Cetinkunt “Mechatronics with Experiments”, WILEY, Second Edition, 2015.
2. J. P. Holman, “Experimental Methods for Engineers”, Eighth Edition, McGraw Hill Education Pvt Ltd, 2012.

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
Minor Exam 1	25
Minor Exam 2	25
Assignment	00
Total	**50**

Course Unitization for Minor Exams and End Semester Assessment

Unit	Chapter		Teaching Hours	No. of Questions in Minor Exam-1	No. of Questions in Minor Exam-2	No. of Questions in ESA
I	1	Introduction to Measurement Systems	5	1	-	1
	2	Sensors and Signal conditioning	5	1	-	1
	3	Motion Measurement	5	1	-	1
II	4	Force, Torque, and Shaft Power Measurement	5	-	1	1
	5	Pressure & Sound Measurement	5	-	1	1
	6	Flow and Temperature Measurement	5	-	1	1
III	7	Data Acquisition Systems	5	-	-	1
	8	Transmission and Recording of Data	5	-	-	1

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in Minor I, II and ESA
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date: 22-10-2021 Head of Department

Course Assessment Pattern

Course Title: Measurement Systems						Code: 18EARC305
Course outcomes (COs)	Weightage in assessment	Assessment Methods				
		ISA-1	ISA-2	Quiz	Activity	ESA
1. Demonstrate broad knowledge of general concepts in measurement systems by discussing the need and requirements of measurement in general and specific to mechatronic systems, types of applications, general configuration and functions of measurement systems, functional elements in a measurement system and their performance characteristics.	20%	✓				✓
2. Demonstrate broad knowledge and skill in identifying and selecting different measuring devices / sensors that can be used to measure different physical parameters, working principles, modelling and applicable standards and calibration.	25%	✓	✓			✓
3. Demonstrate broad knowledge of requirements of signal conditioning / manipulation, transmission and recording by identifying and discussing various device and techniques used for signal conditioning, transmission and recording while designing measurement systems.	30%		✓			✓
4. Demonstrate knowledge of the requirements and configuration of a PC based data acquisition system and discuss different types of implementation in terms of hardware and software.	25%					✓
Weightage	100%	25%	25%			50%

Chapter wise Plan

UNIT I

Course Code and Title: **18EARC305 Measurement Systems**	
Chapter Number and Title: **1. Introduction to Measurement Systems**	*Planned Hours:* ***5 hrs***

Learning Objectives

At the end of this chapter, student should be able to:

Sr.No	TLO's	CO's	BL	CA Code
1	What is measurement system?	1	L1	1.2
2	Identify the importance of measurement system.	1	L1	1.2
3	Discuss the need and requirements of a measurement system.	1	L1	1.3
4	Identify the classification of types of a measurement applications.	1	L1	1.3
5	Describe the functional elements of a measurement system.	1	L2	1.3
6	Discuss active and passive transducers.	1	L2	1.3
7	Discuss analog and digital Modes of operation.	1	L2	1.3
8	Discuss the Null and Deflection methods of measurement	1	L2	1.3
9	Identify the performance characteristics of a measurement system.	1	L2	1.3
10	Solve the problems on calibration data of an instrument.	1	L3	2.1

Lesson Schedule

Class No. Portion covered per hour

1. Why study Measurement Systems, Classification of Types of Measurement Applications
2. Computer-Aided Machines and Processes, Functional Elements of an Instrument
3. Active and Passive Transducers, Analog And Digital Modes of Operation , Null and Deflection Methods
4. Input-Output Configuration of Instruments and Measurement Systems
5. Static Characteristics and Static Calibration, Dynamic Characteristics, Problems.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Define measurement system?	1	L1	1.2.1
2	Explain the importance of measurement systems.	2	L2	1.3.1
3	Explain the requirements of a measurement specific to mechatronics system.	3	L2	1.3.1
4	Discuss the types of measurement applications.	4	L2	1.3.1
5	Explain the functional elements of a pressure gage with the help of block diagram.	5	L2	1.3.1
6	Explain electronic amplifier with the help of neat diagram.	6	L2	1.3.1
7	Explain analog and digital modes of operation by considering the digital revolution counter as an example.	7	L2	1.3.1

<table>
<tr><td>8</td><td>Explain deadweight pressure gage with the help of neat diagram.</td><td>8</td><td>L2</td><td>1.3.1</td></tr>
<tr><td>9</td><td>Explain static and dynamic characteristics of a measurement system</td><td>9</td><td>L2</td><td>1.3.1</td></tr>
<tr><td>10</td><td>Consider the pressure readings of table 2. A) Determine the probability of pressure readings to be less than 10kPa. B) Determine the probability of obtaining pressure readings between 10kPa and 10.42kPa. The average value μ=10.11kPa and standard deviation σ=0.14.
Table 2. Pressure gage calibration data.
<table>
<tr><th>Trial Number</th><th>Scale Reading, kPa</th></tr>
<tr><td>1</td><td>10.02</td></tr>
<tr><td>2</td><td>10.20</td></tr>
<tr><td>3</td><td>10.26</td></tr>
<tr><td>4</td><td>10.20</td></tr>
<tr><td>5</td><td>10.22</td></tr>
<tr><td>6</td><td>10.13</td></tr>
<tr><td>7</td><td>9.97</td></tr>
<tr><td>8</td><td>10.12</td></tr>
<tr><td>9</td><td>10.09</td></tr>
<tr><td>10</td><td>9.90</td></tr>
<tr><td>11</td><td>10.05</td></tr>
<tr><td>12</td><td>10.17</td></tr>
<tr><td>13</td><td>10.42</td></tr>
<tr><td>14</td><td>10.21</td></tr>
<tr><td>15</td><td>10.23</td></tr>
<tr><td>16</td><td>10.11</td></tr>
<tr><td>17</td><td>9.98</td></tr>
<tr><td>18</td><td>10.10</td></tr>
<tr><td>19</td><td>10.04</td></tr>
<tr><td>20</td><td>9.81</td></tr>
</table></td><td>10</td><td>L3</td><td>2.1.3</td></tr>
</table>

Course Code and Title: **18EARC305 Measurement Systems**	
Chapter Number and Title: **2. Sensors and Signal conditioning**	*Planned Hours:* ***5 hrs***

Learning Objectives

At the end of this chapter, student should be able to:

Sr.No	TLO's	CO's	BL	CA Code
1	Define sensor?	2	L1	1.2
2	Identify the types of sensors used to measure different physical parameters.	2	L1	1.2
3	Identify various physical characteristics of sensors.	2	L1	1.2
4	Discuss the operational amplifier, filtering, wheatstone bridge and pulse modulation.	2	L2	1.3
5	Solve problems to find unknown resistance with a known resistance using Wheatstone bridge.	2	L3	2.1

Lesson Schedule

Class No. Portion covered per hour

6. Sensor characterization, Relations between physical quantities
7. Sensor Classification, Specifications, Error reduction techniques
8. Loading errors, Signal conditioning processes
9. The operational amplifier, Filtering
10. Wheatstone bridge, Pulse modulation.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What is sensor?	1	L1	1.2.1
2	Identify the various applications of sensors used to measure different physical parameters.	2	L1	1.2.1
3	Explain the important sensor performance characteristics.	3	L1	1.2.1
4	Explain the working principle and construction of LVDT with neat diagram.	4	L2	1.3.1
5	Explain operation of a Rotational Seismic Accelerometer with neat sketch.	4	L2	1.3.1
6	Explain working principlw of any two types of Electromagnetic transducers with neat sketches.	4	L2	1.3.1
7	Derive the equation to find the unknown resistance with a known resistance using Wheatstone bridge.	5	L3	2.1.3

Course Code and Title: **18EARC305 Measurement Systems**	
***Chapter Number and Title*: 3. Motion Measurement**	*Planned Hours:* ***5* hrs**

Learning Objectives

At the end of this chapter student should be able to:

Sr.No	TLO's	CO's	B L	CA Code
1	Discuss variable resistance displacement transducer, potentiometer, linear displacement transducers, velocity transducers and accelerometers.	3	L2	1.3
2	Compute the equation for the given circuits.	3	L3	2.1

Lesson Schedule

Class No. Portion covered per hour

11. Fundamental Standards, Relative Displacement: Translational and Rotationa

12. Relative Velocity: Translational and Rotational

13. Relative-Acceleration Measurements, Seismic Displacement Pickups

14. Seismic-Velocity Pickups, Seismic-Acceleration Pickups

15. Calibration and Vibration Pickups, Jerk Pickups.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Explain the working principle of variable resistance displacement transducer with the help of diagram	1	L2	1.3.1
2	Explain the working principle of moving coil type velocity transducer with the help of neat diagram.	1	L2	1.3.1
3	Explain the working principle of linear seismic displacement sensing accelerometer with the help of neat diagram.	1	L2	1.3.1
4	Derive an equation (e_0/e_{ex})) for the given circuit (refer the fig. 4.5, Page No. 164, Doebelin's Measurement System).	2	L3	2.1.3

UNIT II

Course Code and Title: **18EARC305 Measurement Systems**	
Chapter Number and Title: **4. Force, Torque and Shaft Power Measurement**	*Planned Hours:* **5 hrs**

Learning Objectives

At the end of this chapter student should be able to:

Sr.No	TLO's	CO's	B L	CA Code
1	Identify the standards of force, toque, and shaft power measurement.	3	L1	1.2
2	Discuss elastic force transducers, torque measurement on rotating shafts, shaft power measurements or dynamometers	3	L2	1.3
3	Compute the relative displacement, force transmitted, and torque for the given measuring device.	3	L3	2.1

Lesson Schedule

Class No. Portion covered per hour

16. Standards and Calibration, Basic Methods of Force Measurement
17. Characteristics of Elastic Force Transducers
18. Torque measurement on Rotating shaft
19. Shaft Power Measurement (Dynamometers)
20. Vibrating Wire Force Transducers.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What are the standards of force, toque, and shaft power measurement?	1	L1	1.2.1
2	Explain the working principle of pendulum scale (Multi-lever Type) with the help of neat diagram.	2	L2	1.3.1
3	Explain the working principle of elastic force meter (Proving Ring) with the help of neat diagram.	2	L2	1.3.1
4	Explain the working principle of mechanical dynamometer (Prony Brake) with the help of neat diagram.	2	L2	1.3.1
5	Explain the working principle of hydraulic dynamometer with the help of neat diagram.	2	L2	1.3.1
6	A mild steel shaft is used to connect a motor drive to a constant load torque. To measure this torque, a resistance strain gage with a resistance of 120 Ω and gage factor 2 is mounted at 45^0 to the shaft axis. shear modulus of steel is 80 GPa, shaft diameter is 50 mm and change in strain gage resistance due to load is 0.1 Ω. Find the load toque.	3	L3	2.1.3

Course Code and Title: **18EARC305 Measurement Systems**	
Chapter Number and Title: **5. Pressure & Sound Measurement**	*Planned Hours:* **5 hrs**

Learning Objectives

At the end of this chapter student should be able to:

Sr.No	TLO's	CO's	B L	CA Code
1	Identify the standards of force, toque, and shaft power measurement.	3	L1	1.2
2	Discuss deadweight gages and manometers, elastic transducers, vibrating-cylinder and resonant transducers and sound measurement transducers.	3	L2	1.3

Lesson Schedule

Class No. Portion covered per hour

21. Standards and Calibration, Basic Methods of Pressure Measurement
22. Deadweight Gages and Manometers, Elastic Transducers
23. Vibrating-Cylinder and Other Resonant Transducers
24. Dynamic Testing of Pressure-Measuring Systems
25. High-Pressure and Low-Pressure Measurement, Sound Measurement.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What are the standards of force, toque, and shaft power measurement?	1	L1	1.2.1
2	Explain the working principle, advantages, and disadvantages of the U-tube manometer with the help of neat diagram.	2	L2	1.3.1
3	Explain the working principle, advantages, and disadvantages of the Dead weight pressure gauge tester with the help of neat diagram.	2	L2	1.3.1
4	Explain the working principle, advantages, and disadvantages of the C type bourdon tube with the help of neat diagram.	2	L2	1.3.1
5	Explain the working principle, advantages, and disadvantages of the Diaphragm pressure gauge with the help of neat diagram.	2	L2	1.3.1

Course Code and Title: **18EARC305 Measurement Systems**	
***Chapter Number and Title*: 6. Flow and Temperature Measurement**	*Planned Hours:* **5 hrs**

Learning Objectives

At the end of this chapter student should be able to:

Sr.No	TLO's	CO's	B L	CA Code
1	Discuss flow measurement transducers.	3	L2	1.3
2	Discuss temperature measurement transducers.	3	L2	1.3
3	Compute the flow rate of the given flow and temperature measuring device.	3	L3	2.1

Lesson Schedule

Class No. Portion covered per hour

26. Local Flow Velocity, Magnitude and Direction
27. Gross Volume Flow Rate, Standards and Calibration of Temperature Measurement
28. Thermal-Expansion methods, Thermoelectric Sensors
29. Electrical-Resistance Sensors
30. Junction Semiconductor Sensors, Digital Thermometers, Radiation Methods, Problems

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Explain the working principle, advantages, and disadvantages of the Venturi tube flow meter with the help of neat diagram.	1	L2	1.3.1
2	Explain the working principle, advantages, and disadvantages of the Vortex flow meter with the help of neat diagram.	1	L3	1.3.1
3	Explain the working principle, advantages, and disadvantages of the Calorimetric flow meter with the help of neat diagram.	1	L2	1.3.1
4	Explain the working principle, advantages, and disadvantages of the Wire wound Resistance Temperature Detector with the help of neat diagram.	2	L2	1.3.1
5	Explain the working principle, advantages, and disadvantages of the following flow measurement devices with the help of neat diagram.	2	L3	1.3.1
6	Explain the working principle, advantages, and disadvantages of the Bead type and Probe type thermistor with the help of neat diagram.	2	L2	1.3.1
7	A pitot tube is used to measure the velocity of an air stream at 200C and 0.1MPa. If the velocity is 10m/s, what is the dynamic pressure in newton per square meter? What is the uncertainty of the velocity measurement and percentage uncertainty, if the dynamic pressure is measured with a manometer having an uncertainty of 1 Pa?	3	L2	2.1.3

UNIT III

Course Code and Title: **18EARC305 Measurement Systems**	
***Chapter Number and Title*: 7. Data Acquisition Systems**	*Planned Hours:* ***5* hrs**

Learning Objectives

At the end of this chapter student should be able to:

Sr.No	TLO's	CO's	B L	CA Code
1	Identify the essential features of data acquisition system.	4	L1	1.2
2	Discuss signal sampling and aliasing, Dual slope ADC and multiplexers.	4	L2	1.3

Lesson Schedule

Class No. Portion covered per hour

31. Data conversion devices, Signal sampling and aliasing
32. Sampling theorem, Quantization, Encoding
33. Digital to analog conversion methods, Analog to digital conversion methods
34. Sample & Hold circuit, Flash ADC, Successive approximation ADC
35. Dual slope ADC, Sigma Delta ADC, Multiplexers.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	What are the essential features of data acquisition system.	1	L1	1.2.1
2	Explain the signal sampling and aliasing with the help of example.	2	L2	1.3.1
3	Explain the principle, advantages and Disadvantages of the Sigma Delta ADC with neat block diagram.	2	L2	1.3.1
4	Explain any two types of ADC converters with the help of block diagram.	2	L2	1.3.1
5	Explain working principle of Dual slope ADC with a neat circuit diagram and also explain its properties and applications.	2	L2	1.3.1

Course Code and Title: **18EARC305 Measurement Systems**	
Chapter Number and Title: **8. Transmission and Recording of Data**	*Planned Hours:* ***5* hrs**

Learning Objectives

At the end of this chapter student should be able to:

Sr.No	TLO's	CO's	BL	CA Code
1	Discuss parallel and series types of data transmission.	4	L2	1.3
2	Discuss signal generators.	4	L2	1.3
3	Describe digital voltmeter	4	L2	1.3
4	Discuss about fiber optic sensor.	4	L2	1.3

Lesson Schedule

Class No. Portion covered per hour

36. Cable Transmission of Analog Voltage and Current Signals,
37. Cable Transmission of Digital Data, Fiber-Optic Data Transmission,
38. Analog Voltmeters and Potentiometers, Electrical Instruments,
39. Digital Voltmeters and Multimeters, Signal Generation,
40. Electromechanical XT and XY Recorders, Fiber Optic Sensors.

Review Questions

Sr.No	Questions	TLO	B L	PI Code
1	Explain the parallel and series types of data transmission with the help of diagram.	1	L2	1.3.1
2	Explain the four different types of signal generators.	2	L2	1.3.1
3	Explain the working principle digital voltmeter with the help of block diagram.	3	L2	1.3.1
4	Explain the working principle of X-Y recorder with the help of block diagram.	4	L2	1.3.1
6	Explain intrinsic and extrinsic fiber optic sensors with neat diagram.	4	L2	1.3.1

Question Paper Title: Model Question Paper for Minor Exam I		
Total Duration (H:M):1:15	Course: Measurement Systems (18EARC305)	Maximum Marks: 40
Note: Answer any two full questions		

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain the different types of Measurement Applications	10	1	L2	1	1.3.1
1b	Describe the functional elements of an instrument system with a block diagram	10	1	L2	1	1.3.1
2a	Explain different types of error occur in measurement	10	2	L2	2	.2.1.2
2b	A pressure transducer exhibits a temperature sensitivity of 0.1 units per degree Celsius and a pressure sensitivity of 2.5 units per MPa. If the temperature changes 20 degree Celsius during a measurement of a pressure of 120 MPa, determine the error due to the dual sensitivity of the transducer	10	2	L3	2	2.1.3
3a	A mild steel shaft is used to connect a motor drive to a constant load torque. To measure this torque, a resistance strain gage with a resistance of 120 ohms and gage factor 2 is mounted at 45 degree to the shaft axis. Shear modulus of steel is 80 GPa, shaft diameter is 50 mm and change in strain gage resistance due to load is 0.1 ohms. Find the load Torque	10	3	L3	2	2.2.1
3b	Define resolution and Sensitivity of Digital Voltmeter	10	3	L2	1	1.3.2

Question Paper Title: Model Question Paper for Minor Exam II		
Total Duration (H:M):1:15	**Course: Measurement Systems (18EARC305)**	**Maximum Marks: 40**
Note: Answer any two full questions		

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Explain the step test apparatus with a neat diagram.	10	4	L2	1	1.1.2
1b	A capacitance transducer uses a capacitance of 0.02 ±0.001 µF and the excitation voltage is 10 ±0.01 V. The capacitance plates have an area of 10 ±0.01 mm^2 and are separated by an air gap of 2 ±0.1 mm. If the plates move apart by 0.3 mm, determine the change in capacitance and the output voltage.	10	4	L3	2	2.1.2
2a	Describe the Gross volume flow rate.	10	5	L2	2	2.1.2
2b	A pulse-excited resistance thermometer has an excitation voltage in the form of a rectangular pulse of 100-V height and 0.1-s duration. The pulse is 'on' for 0.1 s and 'off' for 0.9 s in a repetitive cycle. Compute the ratio of peak/rms voltage for this pulse. What average beating power would this voltage pulse produce in a 500 ohm resistor?	10	5	L3	1	1.3.2
3a	Define Integration and Differentiation.	10	6	L3	1	1.2.1
3b	Design a lowpass filter with a cutoff frequency of 1000Hz with a load resistance of 500 Ω.	10	5	L3	2	2.1.3

Question Paper Title: Model Question Paper for End Semester Assessment		
Total Duration (H:M):3:00	Course: Measurement Systems (18EARC305)	Maximum Marks: 100
Note :Answer five questions; any two full questions from each unit-I and unit-II and one full question from unit-III		

UNIT I

Q.No.	Questions	Marks	CO	BL	PO	PI Code
1a	Discuss the input-output configuration of instruments and measurement systems.	10	1	sL2	1	1.3.1
1b	Explain with a schematic diagram for the determination of Hysteresis loop by method of reversals.	10	1	L2	2	2.1.3
2a	Describe the operating principle of basic accelerometer.	10	2	L2	1	1.3.1
2b	A velocity is to be designed with a natural frequency of 4 Hz, damping ratio of 0.2 and sensitivity of 5 mV/cm/s. The magnitude core weighs 0.2 kg and is mounted on springs. Determine the required spring constant for the springs. The velocity meter is mounted on a surface that is vibrating with a maximum velocity of 1.5 cm/s. Determine the voltage and phase angle if the frequency of vibration is (a) 10 Hz and (b) 20 Hz. Which measurement has the error and why?	10	2	L3	1	1.3.2
3a	A mild steel shaft is used to connect a motor drive to a constant load torque. To measure this torque, a resistance strain gage with a resistance of 120 ohms and gage factor 2 is mounted at 45 degree to the shaft axis. Shear modulus of steel is 80 GPa, shaft diameter is 50 mm and change in strain gage resistance due to load is 0.1 ohms. Find the load Torque.	10	3	L3	2	2.2.1
3b	How to determine the natural frequency of Vibration using Vibrating wire force transducer.	10	3	L3	2	2.1.2

UNIT II

Q.No.	Questions	Marks	CO	BL	PO	PI Code
4a	Explain the Vibrating-Cylinder and Resonant transducers.	10	4	L2	5	1.2.1
4b	A well type manometer uses a liquid having density 1200 kg/ m3. The well has a diameter of 100 mm and the tube has a diameter of 10mm. The manometer is used to measure a differential pressure in an air flow system. The scale placed alongside the tube has no correction factor for the area of the manometer. Calculate the value of a factor that may be multiplied by the manometer reading in mm to find the pressure differential in kPa.	10	4	L3	1	1.3.1
5a	Explain the Pulsed thermocouple technique.	10	5	L2	2	2.1.2

5b	A pilot tube is used to measure the velocity of an air stream of 20 degree Celsius and 0.1 MPa. If the velocity is 10m/s, what is the dynamic pressure in newton per square meter? What is the uncertainty of the velocity measurement and percentage uncertainty, if the dynamic pressure is measured with a manometer having an uncertainty of 1 Pa?	10	5	L3	1	1.2.1
6a	Explain Mechanical filters for accelerometers and filtering by statistical averaging.	10	6	L2	2	2.1.2
6b	Explain the Rate of Climb Sensor.	10	6	L2	1	1.2.1

UNIT III

Q.No.	Questions	Marks	CO	BL	PO	PI Code
7a	Write a short note on IEEE-488.2.	10	7	L2	1	1.3.1
7b	A synchro repeater system has one transmitter and five receivers. The torque gradient of a single pair of devices with very short cable connections is 0.0035 N-m/deg, and 10 percent of this is lost for each ohm of cable resistance. Each receiver drives a dial with 0.00035 N-m/deg of friction. If the allowable error is 0.5 degrees and cable resistance is 0.17 ohm/m, find the maximum allowable cable length.	10	7	L3	1	1.3.1
8a	Explain with a circuit diagram for Peak, Average and RMS meters and ohm meter using current measurement.	10	8	L2	1	1.3.1
8b	Differentiate between thermal array recorders and data acquisition systems.	10	8	L2	1	1.3.1

FMTH0301/Rev.5.3

Course Plan

Semester: VII Year: 2022

Course Title: **Design of Automatic Machinery**	*Course Code*: **17EARE402**
Total Contact Hours: **40**	*Duration of Exam*: **3 hours**
ISA Marks: **50**	*ESA Marks*: **50**
Lesson Plan Author: Mr. Vinod Kumar V. Meti	*Date*: 12/07/2022
Checked By: Mr. Amit Talli	*Date*: 13/07/2022

Course Outcomes-(CO)

At the end of the course student will be able to:

1. Demonstrate knowledge of basic concepts of automation of processes by explain the requirements for automation, the basic steps to achieve automation given the processes to be automated, justifying the type and cost of automation by being able to estimate and comparing the traditional project cost and automation project cost, trade-offs involved, estimating maximum profit, choosing between flexible or hard automation and generation of associated IP rights.
2. Demonstrate knowledge of the automation design process by identifying the market need and the product, generating system specifications, identifying the machines based on functions and transfer methods, machine configuration trade-offs, selection of mechanisms and discussing the process with case studies of the TBBL automation application.
3. Demonstrate knowledge of process of integrating the industrial robot in automation by identifying parts which can be handled by a robots, selecting the robot arm, designing the kinematic solution, analyzing the robot workspace, selecting or designing robot linear actuator modules and integrating the robot in typical industrial applications, explaining the basics of workstations, their requirements, and discussing the process of design and safety of work stations with case studies.
4. Demonstrate knowledge and skill in selection and design of feeders and conveyors by selecting and designing feeders and conveyors, discussing the process used with some case studies, selecting actuators and sensors which are used for the various elements of

the automation, discussing the process used with some case studies, develop the control system architecture including selection of the control elements and developing the control program and discuss the process using case studies.

5. Demonstrate knowledge and skill on bringing new automation to market by forming a team and developing a case study with a technical report depicting the details of entire process of designing the automatic machinery right from identifying the market need, developing the system specifications, selecting and designing the various components and modules and the final integration using case studies of applications such as precision automation, palletization, pouch singulation and packaging.

Course Title: **Design of Automatic Machinery** Course code: **17EARE402 Semester**: **7 Year**: **2022**

Course Outcomes-CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Demonstrate knowledge of basic concepts of automation of processes by explain the requirements for automation, the basic steps to achieve automation given the processes to be automated, justifying the type and cost of automation by being able to estimate and comparing the traditional project cost and automation project cost, trade-offs involved, estimating maximum profit, choosing between flexible or hard automation and generation of associated IP rights.	**M**		**M**											
2. Demonstrate knowledge of the automation design process by identifying the market need and the product, generating system specifications, identifying the machines based on functions and transfer methods, machine configuration trade-offs, selection of mechanisms and discussing the process with case studies of the TBBL automation application.	**M**		**M**											
3. Demonstrate knowledge of process of integrating the industrial robot in automation by identifying parts which can be handled by a robots, selecting the robot arm, designing the kinematic solution, analyzing the robot workspace, selecting or designing robot linear actuator modules and integrating the robot in typical industrial applications, explaining the basics of workstations, their requirements, and discussing the process of design and safety of work stations with case studies.	**H**		**M**											
4. Demonstrate knowledge and skill in selection and design of feeders and conveyors by selecting and designing feeders and conveyors, discussing the process used with some case studies, selecting actuators and sensors which are used for the various elements of the automation, discussing the process used with some case studies, develop the control system architecture including selection of the control elements	**M**		**H**											

and developing the control program and discuss the process using case studies.														
5. Demonstrate knowledge and skill on bringing new automation to market by forming a team and developing a case study with a technical report depicting the details of entire process of designing the automatic machinery right from identifying the market need, developing the system specifications, selecting and designing the various components and modules and the final integration using case studies of applications such as precision automation, palletization, pouch singulation and packaging.	**M**		**M**											

Degree of compliance L: Low M: Medium H: High

Competency addressed in the Course and corresponding Performance Indicators

Competency	Performance Indicators
1.1 - Demonstrate the competence in mathematical modeling	1.1.2 - Apply discipline specific advanced mathematical techniques to modeling and problem solving
1.2 - Demonstrate the competence in basic sciences.	1.2.1 – Apply mathematical technique to solve the problems
1.3 - Demonstrate the competence in engineering fundaments.	1.3.1 – Apply elements of mechanical engineering principles and laws to solve problems.
	1.3.2 - Apply basic electrical and electronics engineering principles and laws to solve problems.
2.1 - Demonstrate an ability to identify and characterize an engineering problem	2.1.2 – Identify the essential problems and objectives
	2.1.3 – Identifies all relevant constraints and requirements and formulate an accurate description of the problem
2.2 - Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 - Develops from the qualitative description of the problem mathematical, physical or computational models/solutions based on fundamental principles and justifiable assumptions
2.3 - Demonstrate an ability to formulate and interpret a model	2.3.1 - Evaluates the analysis for accuracy and validity of assumptions made
3.1 - Demonstrate an ability to define a complex open-ended problem in engineering terms	3.1.1 Recognizes that good problem definition assists in the design process
	3.1.2 Elicit and document, engineering requirements from stakeholders
	3.1.3 Synthesize engineering requirements from a review of the State of the Art
	3.1.4 Extract engineering requirements from relevant engineering Codes and Standards
	3.1.5 Explore and synthesize engineering requirements from larger social and professional concerns
	3.1.6 Determines design objectives, functional requirements and arrives at specifications

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: **17EARE402**	Course Title: **Design of Automatic Machinery**	
L-T-P-SS: 3-0-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 Hrs

UNIT – I		
No	**Content**	**Hrs**
1	**Chapter 1:** **Introduction and Steps to Automation** What is Automation, An Automation design process, examples of automation, problems and project assignments? **Justifying Automation** Traditional Project Cost Justification for a Purchase, Traditional Costing Estimating for Building and Selling Automation, Win–Win Purchasing Philosophy, Maximum Profit Cost Estimating for Building and Selling Automation, Justifying Flexible Automation over Hard Automation, Intellectual Property, Patents, Trade Marks, Copyrights, and Trade Secrets.	6
2	**Chapter 2:** **The Automation Design Process** System Specifications, Brainstorming, Machine Classification by Function, Machine Classification by Transfer Method, Machine Configuration Trade-offs Mechanisms Toolbox, TBBL Automation Project and Conclusions, Case Study Number 1: Case Opening, Case Study Number 2: Label Insertion and Printing, Case Study Number 3: Crossed Four-Bar BMC Unloader.	4
3	**Chapter 3:** **Workstations** Workstation Basics, Drive Mechanisms, Case Study Number 1: TBBL Workstation Design, Case Study Number 2: Automated Screwdriver Workstation Design, Machine Design and Safety. **Feeders** Feeders, Automatic Feeding and Orienting — Vibratory Feeders, Escapement Feeders, Vibratory Bowl Feeder, Centripetal Feeder, Flexible Feeders, Gravity Feed Tracks, Powered Feed Tracks, Escapements, Parts-Placing Mechanisms, Assembly Robots, Case Study Number 1: Dropping Cookies, Case Study Number 2: Feeding of TBBL Cases.	5
UNIT – II		

4	**Chapter 4: Conveyors** Flat Belt Conveyors, Tabletop Chain Conveyor, Belt Conveyors, Static (Gravity) Conveyors, Powered Conveyors, Heavy Unit Load Handling Conveyors, Case Study Number 3: Donut Loader Machine.	3
5	**Chapter 5:** **Single Station Manufacturing Cells** Single station manned cells, single station automated cells, applications of single station cells, analysis of single station systems. **Manual Assembly Lines** Fundamentals of manual assembly lines, Analysis of single model assembly lines, Line balancing algorithms, Mixed model assembly lines, Workstation considerations, Other considerations in assembly line design, Alternative assembly systems. **Automated Product Lines** Fundamentals of automated product lines, applications of automated product lines, Analysis of transfer lines.	6
6	**Chapter 6:** **Automated Assembly Systems** Fundamentals of automated assembly systems, Quantitative analysis of assembly systems. **Cellular Manufacturing** Part families, part classification and coding, product flow analysis, cellular manufacturing, applications of group technology, quantitative analysis in cellular manufacturing. **Flexible Manufacturing Systems** Introduction to flexible manufacturing system, flexible manufacturing systems components, flexible manufacturing systems applications and benefits, flexible manufacturing system planning and implementation issues, quantitative analysis of flexible manufacturing systems.	6
	UNIT - III	
7	**Chapter 7: System Specifications** Expectations, Other Problems Beyond Specifications, Example 1: Bulk Mail Carrier (BMC) Unloader, Specifications, Design Specifications, Comments, Request for Quote, Example 2: BMC Unloader Bid Award Package.	5
8	**Chapter 8: Packaging Machines** Liquid Filling Machines, Cartoning and Boxes, Labeling, Cases, Palletizing, Forming Pouche, Blister Packs and Bags.	5

TEXT BOOKS:

1. Stephen J. Derby., "Design of Automatic Machinery", Taylor & Francis, CRC Press, 2019
2. Patrick M. McGuire, P.E., "Conveyors", CRC Press, 2010.

REFERENCE:

3. Geoffrey Boothroyd, "Assembly Automation and Product Design", Taylor & Francis Group, CRC Press, 2005.

Evaluation Scheme

ISA Scheme

Assessment	**Weightage in Marks**
Minor Exam 1*	**25**
Minor Exam 2*	**25**
Activity**	
Any other**	
Total	**50**

Mandatory for every course ** any one or more of the indicated methods may be adopted for CIE after due approval from DUGC/DPGC.

Course Unitization for ISA and ESA

Unit	Chapter		Teaching Hours	Number of Questions in		Number of Questions in ESA
				Minor 1	Minor 2	
I	1	Introduction and Steps to Automation Justifying Automation	6	1		1
	2	The Automation Design Process	4	1		1
	3	Workstations Feeders	5	1		1
II	4	Conveyors	3		1	1
	5	Single Station Manufacturing Cells Manual Assembly Lines Automated Product Lines	6		1	1
	6	Automated Assembly Systems Cellular Manufacturing Flexible Manufacturing Systems	6		1	1
III	7	System Specifications	5			1
	8	Packaging Machines	5			1

Assessment Pattern

	Remember	Comprehend	Apply	Analyze	Evaluate	Create	Total
Minor 1	0	26	34	00	0	0	40
Minor 2	0	24	36	00	00	00	40
SEE	0	66	94	00	00	00	100

Note

- Each Question carries 20 marks and may consist of sub-questions.
- Mixing of sub-questions from different chapters within a chapter (***only for Chapter I and Chapter II***) is allowed in Minor I, II and SEE.
- Answer 5 full questions of 20 marks each (***two full questions from Chapter I, Chapter II, and 1 full question from Chapter III***) out of 8 in SEE.

Course Assessment Plan

Course Title: Design of Automatic Machinery		Code: 17EARE402			
Course outcomes (COs)	Weightage in assessment	Assessment Methods			
		ISA 1	ISA 2	Activity	ESA
1. Demonstrate knowledge of basic concepts of automation of processes by explain the requirements for automation, the basic steps to achieve automation given the processes to be automated, justifying the type and cost of automation by being able to estimate and comparing the traditional project cost and automation project cost, trade-offs involved, estimating maximum profit, choosing between flexible or hard automation and generation of associated IP rights.	10%	✓			✓
2. Demonstrate knowledge of the automation design process by identifying the market need and the product, generating system specifications, identifying the machines based on functions and transfer methods, machine configuration trade-offs, selection of mechanisms and discussing the process with case studies of the TBBL automation application.	30%	✓			✓
3. Demonstrate knowledge of process of integrating the industrial robot in automation by identifying parts which can be handled by a robots, selecting the robot arm, designing the kinematic solution, analyzing the robot workspace, selecting or designing	25%	✓	✓		✓

robot linear actuator modules and integrating the robot in typical industrial applications, explaining the basics of workstations, their requirements, and discussing the process of design and safety of work stations with case studies.					
4. Demonstrate knowledge and skill in selection and design of feeders and conveyors by selecting and designing feeders and conveyors, discussing the process used with some case studies, selecting actuators and sensors which are used for the various elements of the automation, discussing the process used with some case studies, develop the control system architecture including selection of the control elements and developing the control program and discuss the process using case studies.	25%		✓		✓
5. Demonstrate knowledge and skill on bringing new automation to market by forming a team and developing a case study with a technical report depicting the details of entire process of designing the automatic machinery right from identifying the market need, developing the system specifications, selecting and designing the various components and modules and the final integration using case studies of applications such as precision automation, palletization, pouch singulation and packaging.	10%			✓	✓
Weightage		20%	20%	10%	50%

Date: 13/07/2022 Head of Department

UNIT-I
Chapter wise Plan

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **1. Introduction and Steps to Automation, Justifying Automation**	*Planned Hours:* **06 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Define automation.	1	L1	1.3
2	What the reasons are for automate manufacturing processes.	1	L2	1.3
3	Discuss different steps to automation.	2	L2	1.3
4	Describe automation in black box approach.	1	L2	1.3
5	Discuss automation design processes.	2	L2	1.3
6	Discuss mechatronics strategy.	1	L2	1.3
7	Discuss peanut butter chocolate kiss cookies process.	2	L2	1.3
8	Solve the problems on the projects mentioned in the given problems.	2	L3	3.1
9	Describe traditional project cost justification for a purchase.	2	L2	1.3
10	Briefly describe the traditional costing estimating for building and selling automation.	2	L2	1.3
11	Discuss Cost Components With in an Automation Project.	2	L2	1.3
12	Describe groups involved in automation development and payments timing.	2	L2	1.3
13	Discuss win-win purchasing philosophy.	1	L2	1.3
14	How do you Justifying flexible automation over hard automation.	2	L2	1.3
15	Describe intellectual property, patents and trade secrets.	2	L2	1.3
16	Develop a cost and time estimate for the given problems.	2	L3	3.1

Lesson Schedule

Class No.   Portion covered per hour

1. What is Automation, An Automation design process, An Automation design process, Examples of automation,
2. Problems and project assignments, Problems and project assignments.
3. Traditional Project Cost Justification for a Purchase, Traditional Costing Estimating for Building and Selling Automation,
4. Win–Win Purchasing Philosophy, Maximum Profit Cost Estimating for Building and Selling Automation,
5. Justifying Flexible Automation over Hard Automation, Intellectual Property, Patents, and Trade Secrets.
6. Intellectual Property, Patents, and Trade Secrets.

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	What is automation?	1	L1	1.3.1
2	Explain the reasons to automate manufacturing processes.	2	L2	1.3.1
3	Explain different steps to automation.	3	L2	1.3.1
4	Explain automation in black box approach with neat diagram.	4	L2	1.3.1
5	Explain automation design process with block diagram.	5	L2	1.3.1
6	Explain mechatronics design strategy with diagram.	6	L2	1.3.1
7	Explain process example of peanut butter chocolate kiss cookies.	7	L2	1.3.1
8	Develop the possible processes to make chocolate chip cookies. How would one mix the dry ingredients? Crack the eggs? Mix the batter and know when it is well mixed? Dispense the batter with the embedded chocolate chips? It is recommended that one makes a batch of cookies and take notes of how humans perform these tasks, and then brainstorm on alternate processes.	8	L3	3.1.6
9	Briefly explain the traditional project cost justification for a purchase.	9	L2	1.3.1
10	Briefly explain the traditional costing estimating for building and selling automation.	10	L2	1.3.1
11	Explain Cost Components With in an Automation Project.	11	L2	1.3.1
12	Explain groups involved in automation development and payments timing.	12	L2	1.3.1
13	Explain win-win purchasing philosophy.	13	L2	1.3.1

14	How do you justify flexible automation over hard automation? Explain in brief.	14	L2	1.3.1
15	Briefly explain intellectual property, patents and trade secrets.	15	L2	1.3.1
16	Develop a cost and time estimate for: a) A five-course dinner. b) A party for 10–12 people. c) Refinishing a room. d) Some other event. Keep notes on costs, time, and unfulfilled expectations. Look at your estimating time as a function of the total time. How did you handle any cost overruns?	16	L3	3.1.6

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **2. The Automation Design Process**	*Planned Hours:* **04 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Describe machine classification by function.	3	L2	1.3
2	Explain assembly machine.	3	L2	1.3
3	Describe inspection machine.	3	L2	1.3
4	Explain test machine.	3	L2	1.3
5	Describe packaging machine.	3	L2	1.3
6	Describe the machine classification by transfer method.	3	L2	1.3
7	Describe the goals of modular automation.	3	L2	1.3
8	Why use modular automation concepts?	3	L2	1.3
9	Describe machine configuration trade-offs.	3	L2	1.3
10	Discuss the case study number 1: case opening.	3	L2	1.3
11	Discuss the case study number 2: label insertion and printing.	3	L2	1.3
12	Discuss the case study number 3: crossed four bar BMC unloader.	3	L2	1.3
13	Select one of the projects listed in the Appendix and: a) Brainstorm several methods to achieve the process; b) Develop several possible machine configurations; c) Construct a matrix to list the pros and cons of each configuration; d) Select the best configuration by making any assumptions you must make.	3	L3	3.1

Lesson Schedule

Class No. Portion covered per hour

7. System Specifications, Brainstorming, Machine Classification by Function,
8. Machine Classification by Transfer Method, Machine Classification by Transfer Method,
9. Machine Configuration Trade-offs Mechanisms Toolbox,
10. TBBL Automation Project and Conclusions.

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	Explain machine classification by function.	1	L2	1.3.1
2	Explain generic assembly machine with the help of diagram.	2	L2	1.3.1
3	Explain inspection machine with neat sketch.	3	L2	1.3.1
4	Explain test machine with neat sketch.	4	L2	1.3.1
5	Explain packaging machine with help of diagram.	5	L2	1.3.1
6	Briefly explain the machine classification by transfer method.	6	L2	1.3.1
7	Briefly explain the different goals of modular automation.	7	L2	1.3.1
8	Why use modular automation concepts? Explain in brief.	8	L2	1.3.1
9	Briefly explain machine configuration trade-offs.	9	L2	1.3.1
10	Briefly explain case study number 1: case opening.	10	L2	1.3.1
11	Briefly explain case study number 2: label insertion and printing.	11	L2	1.3.1
12	Briefly explain case study number 3: crossed four bar BMC unloader.	12	L2	1.3.1
13	Investigate and develop commercially available workstations. If you by chance happen to find a machine that does your entire list of processes, assume that your project constraints do not allow for that choice (for example, it costs too much, is too fast, is too big, etc.). There is almost always a better mousetrap to be built.	13	L3	3.1.6

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **3. Workstations, Feeders**	*Planned Hours:* **05 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Explain the building blocks of workstation	4	L2	1.3
2	Describe drive mechanisms.	4	L2	1.3
3	Discuss TBBL work station design case study.	4	L2	3.1
4	Discuss automated screwdriver workstation design case study.	4	L2	3.1
5	Construct a workstation to mix the chocolate chips into a cookie batter for your home use. Determine what would happen if one used their home lower powered hand mixer, and the batter was fairly thick.	4	L3	3.1
6	Investigate on the Web for available workstations to perform various tasks required by students or engineering employees.	4	L3	3.1
7	Design a workstation to automatically butter your toast as it leaves your toaster. Determine the relative needs for: • Structural members; • Bearing surfaces; • Drive mechanisms; • Types and ranges of motions; • General sensing needs; • Safety.	4	L3	3.1
8	What is feeder?	5	L1	1.3
9	Describe vibratory feeders.	5	L2	1.3
10	Describe escapement feeders.	5	L2	1.3
11	Describe vibratory bowl feeder.	5	L2	1.3
12	Explain centripetal feeder.	5	L2	1.3
13	Explain flexible feeders with sketch.	5	L2	1.3
14	Develop a pair of feeder systems to handle the standard No. 2 pencil before the eraser is crimped on, and the eraser itself. Determine what kind of feeder would seem to be best for unsharpened pencils due to their length, and how the high friction of multiple erasers would cause a challenge.	5	L3	3.1
15	You are an automation design engineer, and are tasked to	5	L3	3.1

	fill a standard desk stapler with a row of staples before the stapler is package in its box for retail sale. Identify how you would transport the empty stapler, the rows of staples, and how you would insert them without breaking them apart.			

Lesson Schedule

Class No. Portion covered per hour

11. Workstation Basics, Drive Mechanisms, Case Study Number 1: TBBL Workstation Design, Case Study Number 1: TBBL Workstation Design,
12. Case Study Number 2: Automated Screwdriver Workstation Design, Case Study Number 2: Automated Screwdriver Workstation Design,
13. Machine Design and Safety, Machine Design and Safety.
14. Feeders, Automatic Feeding and Orienting — Vibratory Feeders, Escapement Feeders, Vibratory Bowl Feeder, Centripetal Feeder, Flexible Feeders, Gravity Feed Tracks,
15. Powered Feed Tracks, Escapements, Parts-Placing Mechanisms, and Assembly Robots.

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	Explain the building blocks of workstation.	1	L2	1.3.1
2	Explain different types of drive mechanisms with neat sketches.	2	L2	1.3.1
3	Briefly explain TBBL work station design case study.	3	L2	1.3.1
4	Briefly explain automated screwdriver workstation design case study.	4	L2	1.3.1
5	Create some concept sketches for the needed workstations. List the requirements for the: • Structural members; • Bearing surfaces; • Types and ranges of motions; • General sensing needs.	5	L3	3.1.6
6	With the associated risks and benefits of the workstation concepts in the steps above, develop the most likely set of workstations and machine configuration. If this is solely an academic exercise, you may wish to go ahead with a choice that has more risk but will be a richer learning experience. In real life, you may want to limit your exposure to risk.	6	L3	3.1.6
7	Make an initial safety review of your leading design.	7	L3	3.1.6

	Develop where and how shielding should be implemented. Walk through the normal operation process, and any re-supply or error correcting actions and list possible concerns. Try to predict when, how and why someone might want to defeat your safety system, and see how you can anticipate and account for this.			
8	Explain about the feeders.	8	L1	1.3.1
9	Explain vibratory feeders with neat sketch.	9	L2	1.3.1
10	Briefly explain escapement feeders with neat sketch.	10	L2	1.3.1
11	Explain vibratory bowl feeder with the help of neat sketch.	11	L2	1.3.1
12	Briefly explain centripetal feeder with sketch.	12	L2	1.3.1
13	Explain flexible feeders with the help of neat sketch.	13	L2	1.3.1
14	Construct the viable options for feeders for your product's components. Find as many commercially available options, and conceptualize custom options. Determine what if any sensory feedback is needed to assure component placement accuracy when required.	14 & 15	L3	3.1.6

UNIT-II

Chapter wise Plan

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **4.Conveyors**	*Planned Hours:* **03 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Discuss about segmented conveyors with neat sketch.	5	L2	1.3
2	Describe Pick and place feeders.	5	L2	1.3
3	Discuss dropping cookies case study.	5	L2	1.3
4	Discuss case study of feeding of TBBL cases.	5	L2	1.3
5	Discuss donut loader machine case study.	5	L2	1.3
6	Go to your local supermarket or department store, and observe the checkout area. Note how the conveyor system and barcode scanner are functioning, and how the clerk bags the products. Develop conceptual design recommendations on how this system can be approved, and how much automation could be accomplished.	5	L3	3.1
7	Develop web competitive vendors of segmented conveyors that are "flexible". These conveyors can be routed via their modular framework to transport products both up and down, as well as turning to the right or left. Their paths can be snaked through existing walls, beams, and so on. Determine any concerns you might have if the product was either a can of soup, or a roll of paper towels.	5	L3	3.1

Lesson Schedule

Class No. Portion covered per hour

16. Flat Belt Conveyors, Tabletop Chain Conveyor,
17. Belt Conveyors, Static (Gravity) Conveyors,
18. Static (Gravity) Conveyors Powered Conveyors, Heavy Unit Load Handling Conveyors.

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	Explain segmented conveyors with neat sketch.	1	L2	1.3.1
2	Briefly explain Pick and place feeders with the help of neat sketch.	2	L2	1.3.1
3	Briefly explain dropping cookies case study.	3	L2	1.3.1
4	Briefly explain case study of feeding of TBBL cases.	4	L2	1.3.1
5	Briefly explain donut loader machine case study.	5	L2	1.3.1
6	Develop the viable options for conveyors for your product's components or final assembly. Find the type of conveying surface (smooth, slippery, high friction) to gain the proper advantage. Compare with the need for product accumulators vs. the relative costs of each type of conveyor.	6 & 7	L3	3.1.6

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **5. Single Station Manufacturing Cells, Manual Assembly Lines, Automated Product Lines**	*Planned Hours:* **06 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Discuss about single station automated cell	6	L2	1.3
2	Explain about semi-automated station means.	6	L2	1.3
3	Explain about manual assembly line.	6	L2	1.3
4	Explain automated production line.	6	L2	1.3
5	Explain dial indexing machine.	6	L2	1.3

Lesson Schedule

Class No. Portion covered per hour

19. Single station manned cells, single station automated cells,
20. Applications of single station cells,
21. Analysis of single station systems
22. Fundamentals of manual assembly lines
23. Fundamentals of automated product lines,
24. Applications of automated product lines

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	Name three reasons why single station manned cells are so widely used in industry.	1	L2	1.3.1
2	What does the term semi-automated station means?	2	L2	1.3.1
3	What is a single station automated cell?	1	L2	1.3.1
4	Name three of the four factors that favor the use of manual assembly lines.	3	L2	1.3.1
5	What is a manual assembly line?	3	L2	1.3.1
6	Name three of the four conditions under which automated production lines are appropriate.	4	L2	1.3.1
7	What is an automated production line?	4	L2	1.3.1
8	What is a pallet fixture, as the term is used in the context of an automated production line?	4	L2	1.3.1
9	What is a dial indexing machine?	5	L2	1.3.1

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **6. Automated Assembly Systems, Cellular Manufacturing, Flexible Manufacturing Systems**	*Planned Hours:* **06 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Explain about automated assembly technology	7	L2	1.3
2	Discuss programmable part feeder	7	L2	1.3
3	Explain group technology	7	L2	1.3
4	Explain cellular manufacturing	7	L2	1.3
5	Explain part family	7	L2	1.3
6	Explain production flow analysis	7	L2	1.3
7	Explain about flexible manufacturing system	7	L2	1.3

Lesson Schedule

Class No. Portion covered per hour

25. Fundamentals of automated assembly systems
26. Part families, part classification and coding,
27. Product flow analysis, cellular manufacturing, applications of group technology
28. What is a flexible manufacturing system?, flexible manufacturing systems components,
29. Flexible manufacturing systems applications and benefits, FMS planning and implementation issues,
30. Quantitative analysis of flexible manufacturing systems

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	Name three of the four conditions under which automated assembly technology should be considered.	1	L2	1.3.1
2	What are the four automated assembly system configurations listed in the text?	1	L2	1.3.1
3	What is a programmable part feeder?	2	L2	1.3.1
4	What is group technology?	3	L2	1.3.1
5	What is cellular manufacturing?	4	L2	1.3.1
6	What is part family?	5	L2	1.3.1

7	What is production flow analysis?	6	L2	1.3.1
8	What are the typical objectives when implementing cellular manufacturing?	4	L2	1.3.1
9	Name three production situations in which FMS technology can be applied.	7	L2	1.3.1
10	What is flexible manufacturing system?	7	L2	1.3.1
11	What is the difference between a dedicated FMS and a random-order FMS?	7	L2	1.3.1
12	What are the four basic components of a flexible manufacturing system?	7	L2	1.3.1

UNIT-III
Chapter wise Plan

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **7. System Specifications**	*Planned Hours:* **05 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Discuss the operation of Bulk Mail Carrier (BMC) Unloader and its specification.	2	L2	1.3
2	Discuss the design specification.	2	L2	1.3
3	Discuss the operation of BMC Unloader Bid Award Package	2	L2	1.3
4	Develop the model of the project.	2	L3	3.1

Lesson Schedule

Class No. Portion covered per hour

31. Expectations, Other Problems Beyond Specifications,
32. Example 1: Bulk Mail Carrier (BMC) Unloader, Specifications,
33. Design Specifications, Comments,
34. Request for Quote,
35. Example 2: BMC Unloader Bid Award Package.

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	Explain the design specification of BMC Unloader.	1 & 2	L2	1.3.1
2	Explain BMC Unloader Bid Award Package.	3	L2	1.3.1
3	Project Name: Pizza Stacking System Task - Stack six frozen pizzas, each in vacuum-type plastic wrap, into a box. Stacking process can be done pizza right side up or upside down, but if upside down then the box needs to be filled from the bottom. Pizzas need to be transported right side up. Box flaps need to be closed and taped.	4	L3	3.1.6

	Recommended Production Rate - One box of six pizzas per ten seconds. Recommended Items to Purchase - Several frozen pizzas that are vacuum plastic wrapped. Possible Mockup - Material handing method to move pizzas with their irregular surface shape. Steps to be performed: following: a. Draw the approximate model for the project. b. Construct a cost and time estimate. c. Brainstorm several methods to achieve the process; d. Create a matrix to list the pros and cons of each configuration; e. Select the best configuration by making any assumptions you must make. f. Develop the complete model of the project.			

Course Code and Title: **17EARE402 Design of Automatic Machinery**	
Chapter Number and Title: **8. Packaging Machines**	*Planned Hours:* **05 hrs**

Learning Outcomes:

At the end of the topic student should be able to:

Sr. No	TLO's	CO's	B L	CA Code
1	Discuss the operation of Liquid Filling Machines.	2	L2	1.3
2	Discuss about Cartoning and Boxes.	2	L2	1.3
3	Discuss Labeling and Cases.	2	L2	1.3
4	Discuss Palletizing.	2	L2	1.3
5	Discuss Forming Pouches.	2	L2	1.3
6	Discuss Blister Packs & Bags.	2	L2	1.3

Learning objectives (LO):

At the end of the chapter the student should be able to

Lesson Schedule

Class No. Portion covered per hour

36. Liquid Filling Machines,
37. Cartoning and Boxes,
38. Labeling, Cases, Palletizing,
39. Forming Pouche,
40. Blister Packs and Bags.

Review Questions

Sr. No	Questions	TLO	B L	PI Code
1	Explain the operation of Liquid Filling Machines with the help of neat sketch.	1	L2	1.3.1
2	Explain the process of Cartoning and Boxes with the help of neat sketch.	2	L2	1.3.1
3	What is the procedure for labeling cases?	3	L2	1.3.1
4	Explain different types of Palletizing.	4	L2	1.3.1
5	Explain Forming Pouches.	5	L2	1.3.1
6	Explain different types of packs and bags.	6	L2	1.3.1

Model Question Paper for ISA-I					
Course Code: 17EARE402	**Course Title: Design of Automatic Machinery**				
Duration: 75 minutes	**Max. Marks: 40**				
Note: Answer any two full questions.					
Q. No	**Questions**	**Marks**	**CO**	**PI Code**	**BL**
Q1 a)	What is automation? Explain in brief.	4	3	1.3.1	L2
b)	How do you justify the modular automation goals? Explain in brief.	6	3	1.3.1	L2
c)	Develop the possible processes to make chocolate chip cookies. How would one mix the dry ingredients? Crack the eggs? Mix the batter and know when it is well mixed? Dispense the batter with the embedded chocolate chips? It is recommended that one makes a batch of cookies and take notes of how humans perform these tasks, and then brainstorm on alternate processes.	10	3	3.1.6	L3
Q2 a)	Explain win-win purchasing philosophy.	4	1	1.3.1	L2
b)	You are an automation design engineer, and are tasked to fill a standard desk stapler with a row of staples before the stapler is package in its box for retail sale. Determine how you would transport the empty stapler, the rows of staples, and how you would insert them without breaking them apart.	6	2	3.1.6	L3
c)	Create a list of probable reasons why one should automate this process. Concerns should include the relative likelihood that manually there would be: i. Improvement of quality; ii. Reduction of repetitive motion injuries; iii. Improved productivity; iv. Ability to meet expanding market.	10	2	3.1.6	L3
Q3 a)	Create some concept sketches for the needed workstations. List the requirements for the: i. structural members;	8	3	3.1.6	L2

	ii. bearing surfaces; iii. types and ranges of motions; iv. general sensing needs.				
b)	Pizza Stacking System Task — Stack six frozen pizzas, each in vacuum-type plastic wrap, into a box. Stacking process can be done pizza right side up or upside down, but if upside down then the box needs to be filled from the bottom. Pizzas need to be transported right side up. Box flaps need to be closed and taped. Recommended Production Rate — One box of six pizzas per ten seconds. Recommended Items to Purchase — Several frozen pizzas that are vacuum plastic wrapped. Possible Mockup — Material handing method to move pizzas with their irregular surface shape. i. Brainstorm several methods to achieve the process; ii. Develop possible machine configuration; iii. Create a matrix to list the pros and cons of each configuration; iv. Select the best configuration by making any assumptions you must make.	12	2	3.1.6	L3

Model Question Paper for ISA-II					
Course Code: 17EARE402	**Course Title: Design of Automatic Machinery**				
Duration: 75 minutes	**Max. Marks: 40**				
Note: Answer any two full questions.					
Q. No	**Questions**	**Marks**	**CO**	**PI Code**	**BL**
Q1 a)	Explain an automatic pallet changer and machining center.	08	5	131	L2
b)	Create a workstation to mix the chocolate chips into a cookie batter for your home use. Determine what would happen if one used their home lower powered hand mixer, and the batter was fairly thick. Determine the impact temperature has on the batter's viscosity. Would the need for this workstation be the same in both the Arctic and at the equator?	12	6	3.1.6	L3
Q2 a)	Determine the viable options for feeders for your product's components. Find as many commercially available options, and conceptualize custom options. Determine what if any sensory feedback is needed to assure component placement accuracy when required.	12	7	3.1.6	L3
b)	Explain i. Group technology ii. Cellular manufacturing iii. Part family	08	7	1.3.1	L2
Q3 a)	Briefly explain i. Roller conveyors ii. Chain conveyors iii. Portable conveyors iv. Vibrating conveyors v. Screw/Spiral conveyors	10	5	1.3.1	L2
b)	Develop the viable options for conveyors for your product's components or final assembly. Find the type of conveying surface (smooth, slippery, high friction) to gain the proper advantage. Compare with the need for product accumulators vs. the relative costs of each type of conveyor.	10	5	3.1.6	L3

Model Question Paper for ESA	
Course Code: 17EARE402	**Course Title: Design of Automatic Machinery**
Duration: 180 minutes	**Max. Marks: 100**

Note: Answer **five** questions;any **two full questions** from each **chapter-I and chapter-II** and **onefull question** from **chapter-III.**

Missing data to be assumed with justification

Q. No	Questions	Marks	CO	PI Code	BL
	UNIT I				
Q1 a)	What is automation? Explain in brief.	4	3	1.3.1	L2
b)	How do you justify the modular automation goals? Explain in brief.	6	3	1.3.1	L2
c)	Develop possible processes to make chocolate chip cookies. How would one mix the dry ingredients? Crack the eggs? Mix the batter and know when it is well mixed? Dispense the batter with the embedded chocolate chips? It is recommended that one makes a batch of cookies and take notes of how humans perform these tasks, and then brainstorm on alternate processes.	10	3	3.1.6	L3
Q2 a)	Explain win-win purchasing philosophy.	4	1	1.3.1	L1
b)	You are an automation design engineer, and are tasked to fill a standard desk stapler with a row of staples before the stapler is package in its box for retail sale. Determine how you would transport the empty stapler, the rows of staples, and how you would insert them without breaking them apart.	6	2	3.1.6	L2
c)	Construct a list of probable reasons why one should automate this process. Concerns should include the relative likelihood that manually there would be: i. Improvement of quality; ii. Reduction of repetitive motion injuries;	10	2	3.1.6	L3

	iii. Improved productivity; iv. Ability to meet expanding market.				
Q3 a)	Construct some concept sketches for the needed workstations. List the requirements for the: i. structural members; ii. bearing surfaces; iii. types and ranges of motions; iv. general sensing needs.	8	3	3.1.6	L3
b)	Pizza Stacking System Task — Stack six frozen pizzas, each in vacuum-type plastic wrap, into a box. Stacking process can be done pizza right side up or upside down, but if upside down then the box needs to be filled from the bottom. Pizzas need to be transported right side up. Box flaps need to be closed and taped. Recommended Production Rate — One box of six pizzas per ten seconds. Recommended Items to Purchase — Several frozen pizzas that are vacuum plastic wrapped. Possible Mockup — Material handing method to move pizzas with their irregular surface shape. i. Brainstorm several methods to achieve the process; ii. Develop possible machine configuration; iii. Construct a matrix to list the pros and cons of each configuration; iv. Select the best configuration by making any assumptions you must make.	12	2	3.1.6	L3
UNIT II					
Q4 a)	Explain what is an automatic pallet changer and machining center?	08	5	1.3.1	L2
b)	Create a workstation to mix the chocolate chips into a cookie batter for your home use. Determine what would happen if	12	6	3.1.6	L3

	one used their home lower powered hand mixer, and the batter was fairly thick. Determine the impact temperature has on the batter's viscosity. Would the need for this workstation be the same in both the Arctic and at the equator?				
Q5 a)	Determine the viable options for feeders for your product's components. Find as many commercially available options, and conceptualize custom options. Determine what if any sensory feedback is needed to assure component placement accuracy when required.	12	7	3.1.6	L3
b)	Explain i. Group technology ii. Cellular manufacturing iii. Part family	08	7	1.3.1	L2
Q6 a)	Briefly explain i. Roller conveyors ii. Chain conveyors iii. Portable conveyors iv. Vibrating conveyors v. Screw/Spiral conveyors	10	5	1.3.1	L2
b)	Develop the viable options for conveyors for your product's components or final assembly. Find the type of conveying surface (smooth, slippery, high friction) to gain the proper advantage. Compare with the need for product accumulators vs. the relative costs of each type of conveyor.	10	5	3.1.6	L3
	UNIT III				
Q7:a)	Project Name: Scoop Ice Cream Cone From Freezer • Task - To make ice cream cones at dairy store without human intervention. Should work with larger freezer with sliding doors to openthe top. Ice cream is in square three gallon cardboard containers, stored in three rows of eight flavors each. Cones are square bottom type. Single scoop sized cones only. Gripper needs to be rinsed after each made cone. • Recommended Production Rate - One cone every 20 seconds.	20	2	3.1.6	L3

	• Recommended Items to Purchase - Several different types of ice cream scoops and a few half gallons of ice cream. • Possible Mockup - Hand-powered but designed for automation scoop. Steps to be performed: i. Draw the approximate model for the project. ii. Construct a cost and time estimate. iii. Brainstorm several methods to achieve the process; iv. Develop a matrix to list the pros and cons of each configuration; v. Select the best configuration by making any assumptions you must make. vi. Design the complete model of the project.				
Q8:a)	Explain the operation of Liquid Filling Machines with the help of neat sketch.	10	1	1.3.1	L2
b)	Explain the process of Cartoning and Boxes with the help of neat sketch.	10	2	1.3.1	L2

Course Project

Team Size: Max 5 members

Assessment Marks: 10

Instructions:

1. Students need make a team on their own with a team size of Max 5.
2. All students need to work as a team and submit sub-assignments as a team.
3. All sub-assignment tasks needs to be prepared in power point format and emailed before the deadline.
4. The final outcome of the assignment should contain the complete design model of the problem.
5. Assignment marks will be based on the below mentioned traits:
    a. Draw the approximate model for the project.
    b. Create a cost and time estimate.
    c. Brainstorm several methods to achieve the process;
    d. Create a matrix to list the pros and cons of each configuration;
    e. Select the best configuration by making any assumptions you must make.
    f. Design the complete model of the project.

1) Project Name: Scoop Ice Cream Cone From Freezer

- **Task -**To make ice cream cones at dairy store without human intervention. Should work with larger freezer with sliding doors to openthe top. Ice cream is in square three gallon cardboard containers, stored in three rows of eight flavors each. Cones are square bottom type. Single scoop sized cones only. Gripper needs to be rinsed after each made cone.
- **Recommended Production Rate -**One cone every 20 seconds.
- **Recommended Items to Purchase -** Several different types of ice cream scoops and a few half gallons of ice cream.
- **Possible Mockup -**Hand-powered but designed for automation scoop.

Steps to be performed:

i. Draw the approximate model for the project.
j. Create a cost and time estimate.
k. Brainstorm several methods to achieve the process;
l. Create a matrix to list the pros and cons of each configuration;
m. Select the best configuration by making any assumptions you must make.
n. Design the complete model of the project.

2) Project Name: Book Picking

- **Task -** E commerce companies like Amazon.com have thousands of pallets filled with books. Automation needs to be able to find the top book on a pallet and grab it without damaging the loose book jacket. The book needs to keep some identity while it gets transported to order processing location. Book location on the pallet is in interlocking rows.

- **Recommended Production Rate -** Grab one book from pallet and place onto transport system in five seconds.
- **Recommended Items to Purchase -** Several cheap hardcover books with jacket.
- **Possible Mockup -** Book grabbing device.

Steps to be performed:

a. Draw the approximate model for the project.
b. Create a cost and time estimate.
c. Brainstorm several methods to achieve the process;
d. Create a matrix to list the pros and cons of each configuration;
e. Select the best configuration by making any assumptions you must make.
f. Design the complete model of the project.

Course Outcomes	Project Task	Outcome of the Project Task	Assessment (Marks)
Present a survey on the current automation design processes, specifications and their applications in packaging machines & manufacturing industries.	Carry out Market Survey, identification of the need for automatic machinery.		**10**
Demonstrate the knowledge of automation design processes.	Apply engineering design process, develop specifications and functions.	Brainstorming	**10**
Demonstrate the knowledge of workstation design using structural members and bearing devices.	Design components, sub-assemblies and assemblies.	Design Model of the complete process (Animation).	**10**
Work in team to complete a design project utilizing the automation design process.	All tasks		**10**

Unit	Chapter		Teaching Hours	Tutorial (Hours)	HW/ Assignments (Hours)
I	1	Introduction and Steps to Automation	6	3	
	2	Justifying Automation	8	3	
	3	The Automation Design Process	6	3	
II	4	Workstations	7	3	
	5	Feeders	6	3	
	6	Conveyors	7	3	
III	7	System Specifications	5	1	
	8	Packaging Machines	5	1	
		Total	50	20	

CORRECTIONS/NOTES

FMTH0301/Rev.5.3

Course Plan

Semester: VI	Year: 2021-22
Course Title: Robot Dynamics & Control	Course Code: 17EARE302
Total Contact hrs: 40	Duration of ESA: 3 Hours
ISA Marks: 50	ESA Marks: 50
Lesson Plan Author: Prof. Amit T	Date: 15 – 01- 2022
Checked By: Dr. Vinod V Meti	Date: 17 – 01 - 2022

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Derive the Lagrangian – Euler equations of motion for simple robot systems.
2. Determine the motor torque and the effect of gear reductions ratio
3. Explain the control strategies that achieve the desired path ideally.
4. Express a trajectory, which is a configuration as a function of time, as the composition of a geometric path (a configuration as a function of a path parameter) and a time-scaling (a path position as a function of time) and apply the motion planning schemes to industrial robot arm
5. Understand different types of motion planning problems and properties of motion planners and design the manipulator based on the task requirements.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Title: Robot Dynamics & Control	Semester: VI
Course Code: 17EARE302	Year: 2021- 2022

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Derive the Lagrangian – Euler equations of motion for simple robot systems.	M													
2. Determine the motor torque and the effect of gear reductions ratio	M													
3. Explain the control strategies that achieve the desired path ideally.	M													
4. Express a trajectory, which is a configuration as a function of time, as the composition of a geometric path (a configuration as a function of a path parameter) and a time-scaling (a path position as a function of time) and apply the motion planning schemes to industrial robot arm	M													
5. Understand different types of motion planning problems and properties of motion planners and design the manipulator based on the task requirements.	M													

Degree of compliance **L**: Low **M**: Medium **H**: High

Competency addressed in the Course and corresponding Performance Indicators

Competency: 1.3	Demonstrate competence in engineering fundamentals
PI Code: 1.3.1	Apply elements of mechanical engineering principles and laws to solve problems

Eg: 1.2.3: Represents program outcome ‘1’, competency ‘2’ and performance indicator ‘3’.

Course Content

Course Code: 17EARE302	Course Title: Robot Dynamics & Control	
L-T-P : 3-0-0	Credits: 3	Contact Hrs: 40
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hrs: 40		Exam Duration: 3 Hours

Content	Hrs
Unit - 1	
Chapter 1: Dynamics of Open Chains Introduction to robot dynamics, Lagrangian Formulation, Basic Concepts and examples, General Formulation, Mass Matrix, Gravity terms, Inertia Matrix, Coriolis Matrix, Friction, Effect of Payload	9
Chapter 2: Actuation, Gearing, & Friction Introduction, Characteristics of actuating systems robot, Comparison of actuating systems dynamics, Motors and Gearing, Apparent Inertia, Independent joint control, Motor Inertias, Friction, Joint and Link Flexibility, Robot Dynamics in the URDF format	7
Unit - 2	
Chapter 3: Motion Control Introduction to robot motion control, trends in robotic research, motion control, types of manipulator control, robust & adaptive control, motion and model-based control, kinematic and dynamic control schemes, Feedforward and feedback control	8
Chapter 4: Trajectory Planning Introduction to trajectory generation, Cubic polynomial schemes, Higher-order polynomial function, cycloidal function, parabolic blends, joint-space, and task-space schemes	7
Unit - 3	
Chapter 5: Motion Planning Overview of Motion Planning, Types of Motion Planning Problems, Motion planning- arms vs. mobile robots, Motion Planning Schemes – Graph-based methods, Motion Planning Schemes – Analytical approaches	5
Chapter 6: Manipulator-mechanism design Introduction, Basing the design on task requirements, Kinematic configuration, Quantitative measures of workspace Attributes, Stiffness and deflections, Position sensing, Force sensing	5

Text Books (List of books as mentioned in the approved syllabus)

1. Modern Robotics: Mechanics, Planning, and Control, K. M. Lynch and F. C. Park, Cambridge University Press, 2017
2. Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson; 3rd edition (27 July 2004)
3. Robotics, Vision and Control Fundamental Algorithms in MATLAB, Peter Corke, Springer Berlin Heidelberg, Springer, Cham, 978-3-319-54413-7

References

1. Robot Modeling and Control, M. W. Spong, S. Hutchinson, and M. Vidyasagar, Wiley, 2020

Evaluation Scheme

ISA Scheme

Assessment	Weightage in Marks
ISA-1	20
ISA-2	20
Activity/Assignment	10
Total	50

Course Unitization for ISA and End Semester Assessment

Topics / Chapters	Teaching Credits	No. of Questions in ISA-1	No. of Questions in ISA-2	No. of Questions in Activity	No. of Questions in ESA
Unit I					
Dynamics of Open Chains	9	1.5	--	--	1.5
Actuation, Gearing, & Friction	7	1.5	--	--	1.5
Unit II					
Motion Control	8	--	1.5	--	1.5
Trajectory Planning	7	--	1.5	--	1.5
Unit III					
Motion Planning	5	--	--	--	1
Manipulator-mechanism design	5	--	--	--	1

Note

1. Each Question carries 20 marks and may consists of sub-questions.
2. Mixing of sub-questions from different chapters within a unit (only for Unit I and Unit II) is allowed in ISA I, II and ESA
3. Answer 5 full questions of 20 marks each (two full questions from Unit I, II and one full questions from Unit III) out of 8 questions in ESA.

Date:19-01-2022 Head of Department

Course Assessment Plan

Course Title: Robot Dynamics & Control					Code: 17EARE302	
Course outcomes (COs)	Weightage in assessment	Assessment Methods				
		ISA-1	ISA-2	Assignment	ESA	
1. Derive the Lagrangian – Euler equations of motion for simple robot systems.	20	✓			✓	
2. Determine the motor torque and the effect of gear reductions ratio	20	✓			✓	
3. Explain the control strategies that achieve the desired path ideally.	20		✓		✓	
4. Express a trajectory, which is a configuration as a function of time, as the composition of a geometric path (a configuration as a function of a path parameter) and a time-scaling (a path position as a function of time) and apply the motion planning schemes to industrial robot arm	20		✓		✓	
5. Understand different types of motion planning problems and properties of motion planners and design the manipulator based on the task requirements.	20				✓	
Weightage		20%	20%	10%	50%	

Chapter wise Plan

Course Code and Title: 17EARE302 Robot Dynamics & Control	
Chapter Number and Title: 1. Dynamics of Open Chains	Planned Hours: 9 **hrs**

Learning Outcomes:-

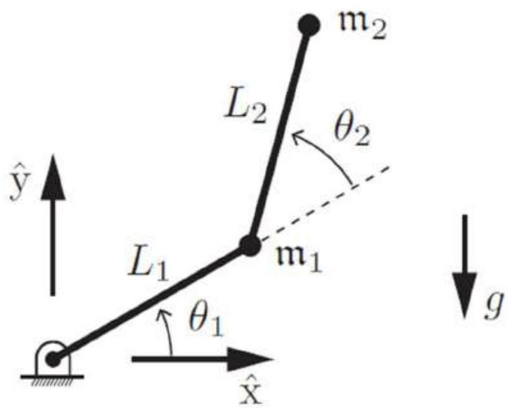
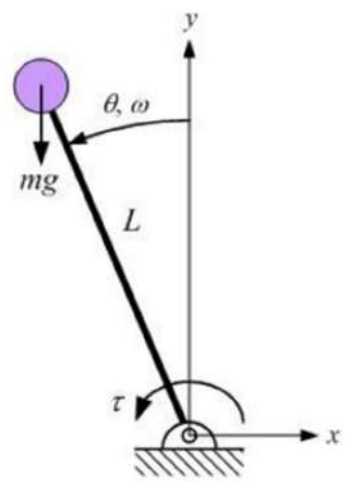
At the end of the topic the student should be able to:

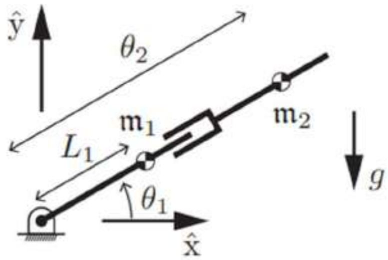
Topic Learning Outcomes	COs	BL	CA Code
1. Derive the Lagrangian equations of motion for a simple robot system	1	L3	1.3
2. Understand the components of dynamic equations	1	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to robot dynamics
2. Lagrangian Formulation
3. Basic Concepts and examples
4. General Formulation
5. Mass Matrix
6. Gravity Terms
7. Inertia Matrix
8. Coriolis Matrix
9. Friction, Effect of Payload

Review Questions

SI.No. - Questions	TLOs	BL	PI Code
1. Derive the equations of motion for the 2-DOF planar robot as shown in Figure 1.	1	L3	1.3.1

			
2. For a given single rotary link manipulator refer figure, what will be the potential energy and kinetic energy? 	2	L3	1.3.1
3. Figure 3 illustrates an RP robot moving in a vertical plane. The mass of link 1 is m1 and the center of mass is a distance L1 from joint 1. The scalar inertia of link 1 about an axis through the center of mass and out of the plane is I1. The mass of link 2 is m2, the center of mass is a distance ✓2 from joint 1, and the scalar inertia of link 2 about its center of mass is I2. Gravity g acts downward on the page. (a) Let the location of the center of mass of link i be (xi, yi). Find (xi, yi) for i = 1, 2, and their time derivatives, in terms of and ˙ ✓. (b) Write the potential energy of each of the two links, P1 and P2, using the joint variables.	2	L3	1.3.1

Chapter wise Plan

Course Code and Title: 17EARE302 Robot Dynamics & Control	
Chapter Number and Title: 2. ACTUATION, GEARING, & FRICTION	Planned Hours: 7 **hrs**

Learning Outcomes:-

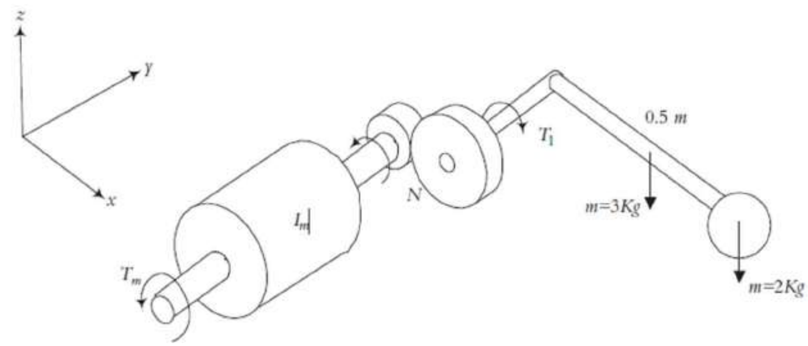
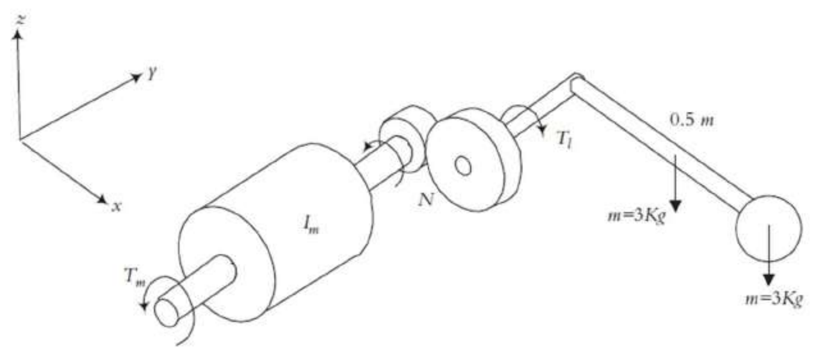
At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
3. Understand how actuator gearing impacts the apparent inertia of a motor's rotor	2	L2	1.3
4. Calculate the inertia felt by the motor in a robot system	2	L3	1.3

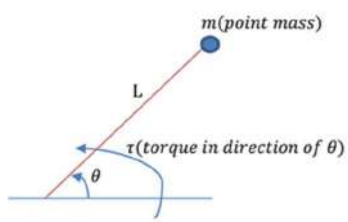
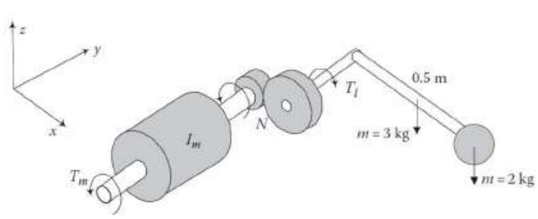
Lesson Schedule Class No. - Portion covered per hour
1. Introduction, Characteristics of actuating systems robot
2. Comparison of actuating systems dynamics
3. Motors and gearing
4. Apparent Inertia
5. Independent joint control
6. Motor Inertias
7. Friction, Joint and Link Flexibility, Robot Dynamics in the URDF format

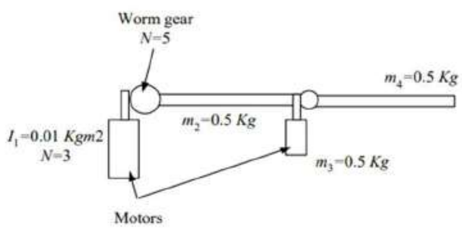
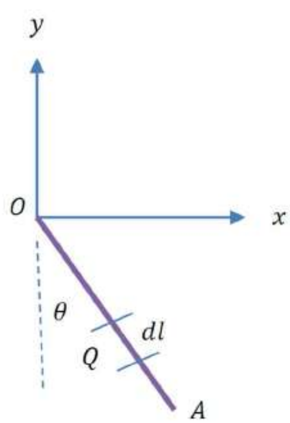
Review Questions

Sl.No. - Questions	TLOs	BL	PI Code

1. A motor with rotor inertia of 0.015 Kgm^2 and maximum torque of 8 Nm is connected to a uniformly distributed arm with a concentrated mass at its end, as shown in Figure 1. Ignoring the inertia of a pair of reduction gears and viscous friction in the system, calculate the total inertia felt by the motor and the maximum angular acceleration it can develop if the gear ratio is (a) 3 or (b) 30. 	2	L3	1.3.1
2. A motor with rotor inertia of 0.030 Kgm2 and maximum torque of 12 Nm is connected to a uniformly distributed arm with a concentrated mass at its end, as shown in Figure 2. Ignoring the inertia of a pair of reduction gears and viscous friction in the system, calculate the total inertia felt by the motor and the maximum angular acceleration it can develop if the gear ratio is a) 5, b) 50, c) 100. Compare the results. 	2	L3	1.3.1
3. A motor with rotor inertia of 0.030 Kgm2 and maximum torque of 12 Nm is connected to a uniformly distributed arm with a concentrated mass at its end, as shown in Figure 2. Ignoring the inertia of a pair of reduction gears and viscous friction in the system, calculate the total inertia felt by the motor and the maximum angular acceleration it can develop if the gear ratio is a) 5, b) 50, c) 100. Compare the results. Repeat Problem 2, but assume that the two gears have 0.002 Kgm2 and 0.005 Kgm2 inertias respectively.	2	L3	1.3.1

4. Compare the characteristics of electrical, hydraulic, and pneumatic actuators.	1	L2	1.3.1

	Model Question Paper for Minor Examination (ISA) - I					
Course Code: 17EARE302		Course Title: Robot Dynamics & Control				
Duration: 75 Minutes						
Max. Marks: 40						
	Note: Answer any two full questions					
Q.No	**Questions**	**Marks**	**CO**	**BL**	**PO**	**PI Code**
1a	Figure 1a illustrates one DoF planar robot moving in a 2D plane. The mass of the link is negligible. Derive the Lagrangian - Euler equations of motion for the 1-DOF system shown. Assume point mass attached at the end of the link. 	10	1	L3	1	1.3.1
1b	A motor with rotor inertia of 0.020 kgm^2 and maximum torque of 10 Nm is connected to a uniformly distributed arm with a concentrated mass at its end, as shown in Figure 1b. Ignoring the inertia of a pair of reduction gears and viscous friction in the system, calculate the total inertia felt by the moto and the maximum angular acceleration it can develop if the gear ratio is (a) 6 or (b) 60 	10	2	L3	1	1.3.1
2a	The three-axis robot shown in Figure 2a is powered by geared servo motor attached to the joints by worm gears. Each link is 22 cm long made of hollow	10	2	L3	1	1.3.1

	2baluminum bars, each weighing 0.5 Kg. the center 1of mass of the second motor is 20 cm from the center of rotation, the gear ratio is 30 worm gear sets. The worst-case scenario for the elbow joint is when the arm is fully extended, as shown. Calculate the torque needed to accelerate both arms together, fully extended, at a rate of 100 rad/s^2. Assume the inertia of the worm gears is negligible. 					
2b	Classify and explain robot dynamics. Also, briefly explain the two popular approaches to obtain equations of motion of a robot.	10	1	L2	1	1.3.1
3a	Figure 3a illustrates one DoF planar robot moving in a 2D plane. The mass of the link is Uniformly distributed. Derive the Lagrangian - Euler equations of motion for the 1-DOF system shown. 	10	1	L3	1	1.3.1
3b	Summarize the characteristics of Hydraulic, Electric, and Pneumatic actuator.	10	2	L2	1	1.3.1

Chapter wise Plan

Course Code and Title: 17EARE302 Robot Dynamics & Control	
Chapter Number and Title: 3. Motion Control	Planned Hours: 8 **hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Discuss the types of manipulator control schemes	3	L2	1.3
2. Discuss robust and adaptive control schemes	3	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to robot motion control,
2. trends in robotic research
3. Motion control
4. Types of manipulator control
5. Robust & adaptive control
6. Motion and model-based control
7. Kinematic and dynamic control schemes
8. Feedforward and feedback control

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Explain the inverse differential kinematic model (open – loop/Feed – forward control) with the help of a block diagram.	1	L2	1.3.1
2. Explain the robot kinematic (Motion) control in task space with the help of a block diagram.	1	L2	1.3.1
3. Briefly explain the classification of robot motion control.	1	L2	1.3.1
4. Explain briefly about the robust adaptive control.	2	L2	1.3.1

Chapter wise Plan

Course Code and Title: 17EARE302 and Robot Dynamics & Control	
Chapter Number and Title: 4. TRAJECTORY PLANNING	Planned Hours: 7 **hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	PI Code
1. Apply popular time scaling, such as third-order polynomial, fifth-order polynomial	4	L3	1.3
2. Generate paths in joint-space and task-space schemes	4	L3	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Introduction to trajectory generation
2. Cubic polynomial schemes
3. Higher-order polynomial function
4. Cycloidal function
5. Parabolic blends
6. Joint-space
7. Task-space schemes

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. It is desired to have the first joint of a 6-axis robot go from an initial angle of 50 deg to a final angle of 80 deg in 3 seconds. Calculate the coefficients for a third-order polynomial joint-space trajectory. Determine the joint angles, velocities, and accelerations at 1, 2, and 3 seconds. It is assumed that the robot starts from rest and stops at its destination.	1	L3	1.3.1
2. A fifth-order polynomial is to be used to control the motions of the joints of a robot in joint space. Find the coefficients of a fifth-order polynomial that will allow a joint to go from an initial angle of 0 deg to a final joint angle of 75 deg in 3	1	L3	1.3.1

seconds, while the initial and final velocities are zero and initial acceleration and final decelerations are 10 deg/sec2.			
3. Joint 1 of a 6-axis robot is to go from an initial angle of 30 to the final angle of 120 in 4 seconds with a cruising velocity of 30 /sec. Find the necessary blending time for a trajectory with linear segments and parabolic blends and plot the joint positions, velocities, and accelerations.	2	L3	1.3.1

Model Question Paper for Minor Examination (ISA) - II		
Course Code: 17EARE302		Course Title: Robot Dynamics & Control
Duration: 75 Minutes		
Max. Marks: 40		
Note: Answer any two full questions		

Q.No	Questions	Marks	CO	BL	PO	PI Code
1a	Joint 1 of a 6-axis robot is to go from an initial angle of 30 to the final angle of 120 in 4 seconds with a cruising velocity of 30 /sec. Find the necessary blending time for a trajectory with linear segments and parabolic blends and plot the joint positions, velocities, and accelerations	10	4	L3	1	1.3.1
1b	Explain the inverse differential kinematic model (open – loop/Feed – forward control) with the help of a block diagram.	10	3	L2	1	1.3.1
2a	A fifth-order polynomial is to be used to control the motions of the joints of a robot in joint space. Find the coefficients of a fifth-order polynomial that will allow a joint to go from an initial angle of 0 deg to a final joint angle of 75 deg in 3 seconds, while the initial and final velocities are zero and initial acceleration and final decelerations are 10 deg/sec2.	10	4	L3	1	1.3.1
2b	Explain briefly about the robust adaptive control.	10	3	L2	1	1.3.1
3a	It is desired to have the first joint of a 6-axis robot go from an initial angle of 50 deg to a final angle of 80 deg in 3 seconds. Calculate the coefficients for a third-order polynomial joint-space trajectory. Determine the joint angles, velocities, and accelerations at 1, 2, and 3 seconds. It is assumed that the robot starts from rest and stops at its destination	10	4	L3	1	1.3.1

3b	Explain the robot kinematic (Motion) control in task space with the help of a block diagram.	10	3	L2	1	1.3.1

Chapter wise Plan

Course Code and Title: 17EARE302 Robot Dynamics & Control	
Chapter Number and Title: 5. Motion Planning	Planned Hours: 5 **hrs**

Learning Outcomes:-

At the end of the topic the student should be able to:

Topic Learning Outcomes	COs	BL	CA Code
1. Understand different types of motion planning problems and the properties of motion planners.	5	L2	1.3
2. Explain types of motion planning schemes and their advantages and disadvantages	5	L2	1.3

Lesson Schedule Class No. - Portion covered per hour
1. Overview of Motion Planning
2. Types of Motion Planning Problems
3. Motion planning- arms vs. mobile robots
4. Motion Planning Schemes – Graph-based methods
5. Motion Planning Schemes – Analytical approaches

Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. Classify different motion planning schemes.	1	L2	1.3.1
2. Explain the difference between the motion planning of the robot arm and the mobile robot.	1	L2	1.3.1
3. List graph-based methods of motion planning schemes.	1	L2	1.3.1
4. Explain the potential field approach for motion planning.	2	L2	1.3.1
5. Explain the probabilistic approach for motion planning schemes and list their disadvantages.	2	L2	1.3.1

Chapter wise Plan

Course Code and Title: 17EARE302 Robot Dynamics & Control	
Chapter Number and Title: 6. Manipulator-mechanism design	Planned Hours: 5 **hrs**

Learning Outcomes:-

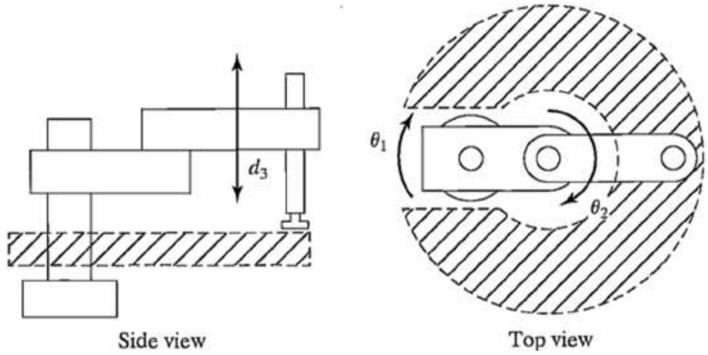
At the end of the topic the student should be able to:

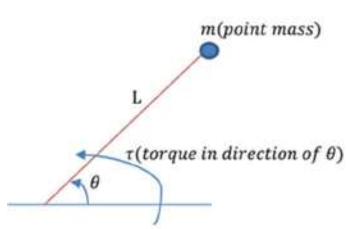
Topic Learning Outcomes	COs	BL	CA Code
1. Determine the structural length index of a robot arm	5	L3	1.3
2. Determine the stiffness and deflection of various components of the robot system	5	L3	1.3
3. Explain various position and force sensors	5	L2	1.3

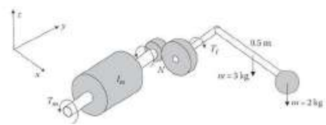
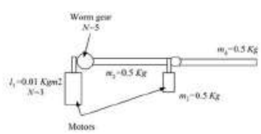
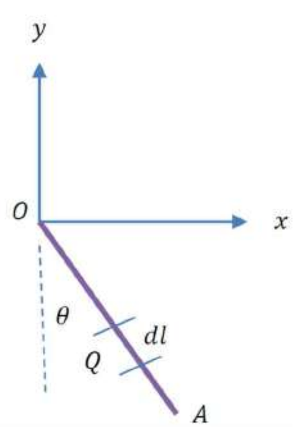
Lesson Schedule Class No. - Portion covered per hour
1. Introduction
2. Basing the design on task requirements
3. Kinematic configuration
4. Quantitative measures of workspace attributes
5. Stiffness and deflections, Position sensing ,Force sensing

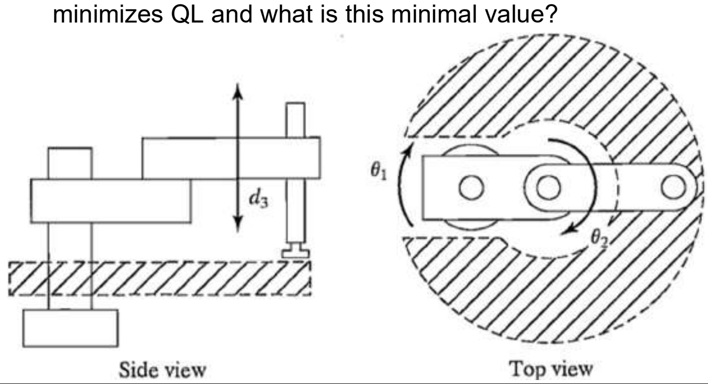
Review Questions

Sl.No. - Questions	TLOs	BL	PI Code
1. A SCARA manipulator like that of Fig. 1 has links 1 and 2 of equal length 1/2, and the range of motion of the prismatic joint 3 is given by d3. Assume for a simplicity that the joint limits are absent, and find QL. What value of d3 minimizes QL and what is this minimal value?	1	L3	1.3.1

			
2. A shaft with torsional stiffness equal to 500.0 N-m/radian is connected to the input side of a gear set with i, = 10, whose output gear (when the input gear is fixed) exhibits a stiffness of 5000.0 N m/radian. What is the output stiffness of the combined drive system?	2	L3	1.3.1
3. A shaft with torsional stiffness equal to 500.0 N--m/radian is connected to the input side of a gear set with i, = 10, whose output gear (when the input gear is fixed) exhibits a stiffness of 5000.0 N- m/radian. What is the output stiffness of the combined drive system?	2	L3	1.3.1
4. List the issues the designer must address while designing force – sensor system.	2	L2	1.3.1

Model Question Paper for End Semester Assessment (ESA)						
Course Code: 17EARE302	Course Title: Robot Dynamics & Control					
Duration: 75 Minutes						
Max. Marks: 40						
Note:						
Q.No	Questions	Marks	CO	BL	PO	PI Code
1a	Figure 1a illustrates one DoF planar robot moving in a 2D plane. The mass of the link is negligible. Derive the Lagrangian - Euler equations of motion for the 1-DOF system shown. Assume point mass attached at the end of the link. 	10	1	L3	1	1.3.1

1b	A motor with rotor inertia of 0.020 kgm^2 and maximum torque of 10 Nm is connected to a uniformly distributed arm with a concentrated mass at its end, as shown in Figure 1b. Ignoring the inertia of a pair of reduction gears and viscous friction in the system, calculate the total inertia felt by the moto and the maximum angular acceleration it can develop if the gear ratio is (a) 6 or (b) 60 	10	2	L3	1	1.3.1
2a	The three-axis robot shown in Figure 2a is powered by geared servo motor attached to the joints by worm gears. Each link is 22 cm long made of hollow 2baluminum bars, each weighing 0.5 Kg. the center 1of mass of the second motor is 20 cm from the center of rotation, the gear ratio is 30 worm gear sets. The worst-case scenario for the elbow joint is when the arm is fully extended, as shown. Calculate the torque needed to accelerate both arms together, fully extended, at a rate of 100 rad/s^2. Assume the inertia of the worm gears is negligible. 	10	2	L3	1	1.3.1
2b	Classify and explain robot dynamics. Also, briefly explain the two popular approaches to obtain equations of motion of a robot.	10	1	L2	1	1.3.1
3a	Figure 3a illustrates one DoF planar robot moving in a 2D plane. The mass of the link is Uniformly distributed. Derive the Lagrangian - Euler equations of motion for the 1-DOF system shown. 	10	1	L3	1	1.3.1
3b	Summarize the characteristics of Hydraulic, Electric, and Pneumatic actuator.	10	2	L2	1	1.3.1

4a	Joint 1 of a 6-axis robot is to go from an initial angle of 30 to the final angle of 120 in 4 seconds with a cruising velocity of 30 /sec. Find the necessary blending time for a trajectory with linear segments and parabolic blends and plot the joint positions, velocities, and accelerations	10	4	L3	1	1.3.1
4b	Explain the inverse differential kinematic model (open – loop/Feed – forward control) with the help of a block diagram.	10	3	L2	1	1.3.1
5a	A fifth-order polynomial is to be used to control the motions of the joints of a robot in joint space. Find the coefficients of a fifth-order polynomial that will allow a joint to go from an initial angle of 0 deg to a final joint angle of 75 deg in 3 seconds, while the initial and final velocities are zero and initial acceleration and final decelerations are 10 deg/sec2.	10	4	L3	1	1.3.1
5b	Explain briefly about the robust adaptive control.	10	3	L2	1	1.3.1
6a	It is desired to have the first joint of a 6-axis robot go from an initial angle of 50 deg to a final angle of 80 deg in 3 seconds. Calculate the coefficients for a third-order polynomial joint-space trajectory. Determine the joint angles, velocities, and accelerations at 1, 2, and 3 seconds. It is assumed that the robot starts from rest and stops at its destination	10	4	L3	1	1.3.1
6b	Explain the robot kinematic (Motion) control in task space with the help of a block diagram.	10	3	L2	1	1.3.1
7a	List graph-based methods of motion planning schemes.	10	5	L2	1	1.3.1
7b	Explain the potential field approach for motion planning.	10	5	L2	1	1.3.1
8a	A shaft with torsional stiffness equal to 500.0 N-m/radian is connected to the input side of a gear set with i, = 10, whose output gear (when the input gear is fixed) exhibits a stiffness of 5000.0 N m/radian. What is the output stiffness of the combined drive system?	10	5	L3	1	1.3.1
8b	A SCARA manipulator like that of Fig. 1 has links 1 and 2 of equal length 1/2, and the range of motion of the prismatic joint 3 is given by d3. Assume for a simplicity that the joint limits are absent, and find QL. What value of d3 minimizes QL and what is this minimal value? 	10	5	L3	1	1.3.1