1.1.2: Syllabus Revised Courses

Course Code: 16EMEP203 **Course Title: Engineering Design**

L-T-P: 0-0-3 Credits: 3 Contact Hrs: 6 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 72 Exam Duration: 2 hrs

Engineering Design [Part A]

1	Planning: Analyse Need, Formulate a Product Proposal, Clarify the Task, Requirements Modeling (SRS), Elaborate Requirements List, Design Specifications	6
2	Concept Development: Function to Architecture, Establish Functions Structure, Search for Working Principles & Working Structures, Combine & Firm-up into Concept Variants, Evaluate against Technical & Economic criteria, Best Feasible Design	9
3	System-level Design: Product Architecture -State Diagrams, Data-flow Diagrams, Configuration Design, Parametric Design, Construction Structure, Preliminary BOM, Co-simulation across domains	9
4	Detail Design: Geometry, Dimensions, Material, PCB Design, Component Selection, Class Diagrams, Code Generation, Design Verification, Detailed & Assembly Drawings Production & Assembly Instructions, Final BOM, Product Specifications	12

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

1. Clive L Dym and Patrick Little, "Engineering Design: A Project Based Introduction", John Wiley & Sons
2. Yousef Haik, "Engineering Design Process", Cengage Learning India Private Limited, New Delhi

References

1. Pahl, G., Beitz, W., Feldhusen, J. and Grote ; "Engineering Design-A Systematic Approach" by, K.-H- Springer; 3rd ed. 2007

Laboratory Plan

Laboratory Title: **Engineering Design[Part B]**	Lab. Code: **15EMEP203[Part B]**
Total Hours: **40**	Duration of ESA Hours: -
ISA Marks: **40**	ESA Marks: **0**

Part – B

COURSE CONTENT

Course Code: **15EMEP203 [Part B]** Course Title: **Engineering Design Practice [Part B]**
L-T-P-S**: 0-0-0-1.5** Credits:**1.5**
Contact Hrs: **3hrs/week** ISA Marks: **40** ESA Marks: **00**
Teaching Hours**: 13 Sessions of 3 hours each (40hrs)**

Part – B1 [3D Modeling]	***7 sessions***
1. Introduction to 3D Modeling and different work benches: Sketcher Workbench: Demonstration of sketch tools, modifying tools, geometrical constraints and dimensional constraints.	***3 Hours / 1 sessions***
2. Part Modeling: Shape toolbar for adding materials, shape toolbar for removing materials, modifying tools, types of views etc.,	***6 Hours / 2 sessions***
3. Assembly and Co-simulation: Component placement, Placement types (Surface, Axis, and Planes), Feature settings etc. Integration of two different domain tools.	***9 Hours / 3 sessions***
4. Drawing: Drawing properties, Adding drawing models, View types, Scale factors, Section apply, View display	***3 Hours / 1 sessions***
Part – B2 [2D Drafting]	***6 sessions***
1. Orthographic Projections – Sectional [MANUAL drawings] Conversion of pictorial views into orthographic projections, Sectional views such as half section, full section, local section, removed section and offset section.[1st and 3rd angle projection]	***12 Hours / 4 sessions***
2. Thread forms and Threaded Fasteners: [MANUAL drawings] **Thread forms:** Thread terminology, thread profiles, [ISO Metric, BSW, Square and Acme, Sellers thread].**Fasteners:** Hexagonal headed bolt and nut with washer, square headed bolt and nut with washer (assembly).	***3 Hours / 1 sessions***
3. 2D Assembly Drawings: Part and Assembly Drawings, Generating bill of materials for assembly. [Creating sectional views of parts and assembly of protected type flanged coupling]	***3 Hours / 1 sessions***

Books/References:

Text books:

1. Machine Drawing by K.R. Gopalakrishna, Subhas Publications, 22nd Edition - 2013.
2. Machine Drawing byN.D.Bhat&V.M.Panchal, Charotar Publishing House.

Reference books:

1. A Text Book of Computer Aided Machine Drawing, S. Trymbaka Murthy, CBS Publishers, New Delhi, 2007 Edition.

Course Code: 16EMEC201 **Course Title: Instrumentation & Control Engineering**

L-T-P: 3-1-0 Credits: 4 Contact Hrs: 5 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 + 25 Exam Duration: 3 hrs

Unit – 1

1. Introduction to Instrumentation & Control Engineering — 04 hrs

Generalized configurations and functional description of measuring instruments, Static Performance characteristics of instruments, Generalized configurations and functional description of control systems. Control system design, Design examples - Open loop and Close loop automatic control

2. Measurement of Physical Parameter — 07 hrs

Motion measurement - Displacement: Translation and Rotational, Velocity: Translation and Rotational, Acceleration measurements, Force, Torque and Power measurement, Pressure and Temperature measurement, Flowrate measurement

3. Concepts of Control Engineering — 04 hrs

Introduction**,** Differential equations of physical systems, The Laplace Transform, Order of system, Block representation of system elements, Reduction of block diagrams to get transfer function

Unit – 2

4. Mathematical Models of Physical Systems: — 08 hrs

The transfer function of linear and rotational Mechanical systems, Thermal systems, Liquid system, Electrical systems, Transfer function of DC motor, Instrument modeling and static performance study

5. System Response — 07 hrs

Introduction, Poles, Zeros, and System Response, 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, Response specifications, Design of 1st and 2nd order system . Introduction to stability and the stability analysis by Routh-Hurwitz Criterion**.** Instrument Dynamic Performance Characteristics

Unit – 3

6. System Stability — 05 hrs

Introduction to Stability, 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. Frequency Response Techniques: Bode Plots. Stability analysis using bode plots

7. Control Action — 05 hrs

Types of Controllers, Mathematical modeling of PID, ON-OFF controller, Effect of Proportional, Derivative and Integral elements on system behavior, Design of Controller for given simple applications

Text Book

1. Katsuhiko Ogata, Modern Control Engineering, 5th edition
2. Ernest Doebelin and Dhanesh Manik, Measurement Systems, 6th edition, Tata McGraw-Hill Education Pvt. Ltd., 2011

References

1. Richard C Dorf and Robert H. Bishop, 'Modern Control Systems', Addison Wesley.
2. Norman S. Nise, 'Control. Systems', John Wiley & Sons
3. T.G Beckwith, R.D Marangoni and J.H Lienhard, "Mechanical Measurements", 5th edition, Addison Wesley, 1993
4. R.S Figiola and D.E Beasley, "Theory and Design for Mechanical Measurement", 2nd edition, John Wiley 1995

Tutorial

Use of more examples and discussed at all places regularly. Assignment on a instrument's cost and specification. Solving more problems on various topics as per syllabus. Exploring experiments mentioned in Transducer and Instrumentation Virtual Lab at IIT Kanpur.

Course Code: 16EMEP204 **Course Title: Mechatronics Lab**

L-T-P: 0-0-3 Credits: 3 Contact Hrs: 6 Hrs/Week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 72 Exam Duration: 2 hrs

Introduction to Mechatronics: Definition & overview of Mechatronics, Key elements. Mechatronics Design approach, Mechatronics and sustainability, examples of mechatronic systems

Sensor, Actuators:
Review of Sensors and Actuators. Classification and application.

Signal conditioning:
ADC, DAC, MUX, Demux, encoder, Decoder; Data Acquisition System(DAQ)

Drive Circuits
power drives based on MOSFET- H bridge, SCR, TRIAC, IGBT, IPM; VFD; Servo drives-AC, DC;

Microcontrollers: Introduction to FF, Registers as memory element, Memory Hierarchy in Computer; Address/Data lines; Micro-controller Vs Microprocessor; RISC vs CISC, Harward Vs. Von neoman , Introduction to 8051 Architecture; Introduction to communication protocols-RS232, I2C, Ethernet Etc. Introduction to Programmable logic controller(PLC) and it's Architecture; examples of applications; Ladder diagrams, logic functions, latching, interlocking, Timer/counter, web controlled application, Programming on industrial applications;

Robotics: Types of robot, Robotic arm terminology, Robotic arm configuration, Robot applications, Evolution of Robots, Co-ordinates of Robots;

Automation & 3D printing: Introduction to Automation and Applications of Automation; Introduction to 3D printing Hardware and Software.

Machine Vision System & IOT: Introduction to Machine Vision; Image Acquisition; Image Processing; Visual Navigation; Introduction to IOT; Applications of IOT

Quad Copter & Simulators:: Introduction, Construction, Components Specification, tuning and working demonstration.

Text Books:

1. Devdas Shetty, Rechard A. Kolk, Mechatronics System Design, Cengage Learning – 2nd edition 2011 .
2. W. Bolton, 'Programmable Logic Controllers', Elsevier – 4th edition 2006.

Reference for Mechatronics:

1. David Bradley · David W. Russell, Mechatronics in Action: Case Studies in Mechatronics – Applications and Education, Springer 2010
2. Robert H Bishop, Mechatronics -an Introduction, Taylor & Francis Group 2006
3. W. Bolton, Mechatronics, Pearson Education Asia – 2nd edition 2001
4. Jacob Fraden, Handbook of Modern Sensor, Springer Science Business Media -Fourth Edition 2010
5. http://www.arduino.cc
6. Garry Dunning, 'Introduction to Programmable Logic Controllers' Thomson

List of planned Experiments:

Sl. No.	Particulars
1.	PLC1- software Familiarization and Basic Programming.
2.	PLC2- Timer, Counter programming.
3.	PLC3- Building applications
4.	PLC4- SAP applications: Water level controller, Sequencing of 3 motors, Washing machine sequencing, Welding process/ conveyor controller, Dc motor controller
5.	PLC5- Industrial Based Application, Demonstration
6.	PLC6- Web based control
7.	ADC, DAC Circuit realization.
8.	MUX, Demux realization using Trainer Kit
9.	encoder, Decoder realization using Trainer Kit
10.	Flip Flop as memory and counter
11.	Image Processing basics using Matlab/Simulink/LabVIEW
12.	Image Processing using Raspberry PI/myRIO as Target Hardware
13.	Ball tracking application based on image processing
14.	Quad Copter flight Control
15.	3DP working demonstration showing all components and its working.
16.	Building few IOT applications using Raspberry PI/myRIO
17.	DC Servo motor using Arduino/myRIO
18.	AC servo motor control demonstration
19.	Course Project

VII Semester Syllabus
Curriculum Content

Course Code: 18EMEW301 | **Course Title: Minor Project**

L-T-P: 0-0-3 | Credits: 6 | Contact Hrs: 3 hrs/week

ISA Marks: 50 | ESA Marks: 50 | Total Marks: 100

Exam Duration: 3 hrs

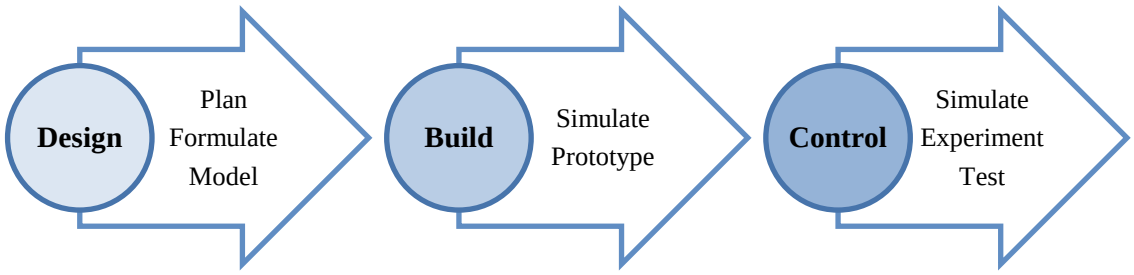
Themes for Minor Projects

Precision Agriculture	Factory Automation	Hospital Automation	Social Issues
▪ Observe, Measure, Act, ▪ Replacing human labor with automation ▪ Eg: Moisture control in soil	▪ Includes industry, workplace, assembly, machining operations, etc ▪ Eg: Automation of manual paper punching/ cutting machine	▪ Assistance for patients ▪ Hospital Logistics ▪ Medical instruments re/design ▪ Eg: Equipment to lift/ transfer patient from one place to another	▪ Issues concerned with water conversation, air pollution and public sanitation. ▪ Eg: An instrument to monitor, measure and control water pollution within a factory. (as per defined industry standards)

Any other Machatronics products

5

Methodology to be followed for carrying out the projects:



Role of Guide:

- The guide has to provide technical know-how from inception of project to execution
- Help students in identifying proper sources for raw materials, tools and other requirements
- Form a team and encourage students to take roles and responsibilities so that each one of them can enhance their knowledge and skills
- The Guide has to assess the student competencies with regard to his project work. More specifically to assess the student's individual contribution to the project
- Develop the clarity of assessment among the team in every phase of the project and advised to check for the formatting of the presentation and project report
- Continuous monitoring of project at different phases with the help of PLM e-NOVIA to work on paper-less office theme.

Evaluation of Minor-Project

The evaluation of project work shall be done in two stages as Continuous Internal Evaluation (CIE) and Semester End Examination (SEE) having equal weightages in marks.

CIE Evaluation:

- The CIE evaluation of project work shall be done in stages by the expert review panel including guide. In addition the guide shall separately evaluate the progress of project till its completion.
- There shall be three reviews by the panel experts and marks shall be allotted as per the weightages given for each review. The student shall showcase the progress of work through the presentation, videos, models, prototypes, etc to the panel members during the reviews.
- Each of the micro activities involved in accomplishing a project have been identified and included in the evaluation criteria as performance indicators. These performance indicators are being made known to students from day one of the project which helps them to plan and be guided to reach the intended goal. The assessment of each of the performance indicators is carried out as per rubrics which are also shared with the students.
- The review panel will be given a detailed assessment rubrics for each review based on which the panel experts will award the marks.
- Project guide shall be having individual responsibility to assess the entire project work and award the marks as per the assessment rubrics.
- During each review the panel experts shall advice the students with various aspects of the work for continuous development and Implementation.

SEE Evaluation:

- Student shall prepare a detailed project report according to approved guidelines and duly signed by the guide(s) and the Head of the Department and submit it to the examiners.
- The SEE evaluation of the project work shall be based on the demonstration of the model/prototype, presentation, project report submitted and a Viva-Voce by a team consisting of the Guide, an Internal examiner (other than the guide) and an External Examiner appointed by the department.
- Student shall submit a copy of the approved project report after the successful completion of viva examinations to the department.

Course Code: 19EMEC301 **Course Title: Finite Element Methods**

L-T-P : 3-0-0 Credits: 03 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 03

Unit - 1

1. Introduction to FEM: 7 hrs

FEM paradigm : History, present/future, Research, Application, stress at a point, stress components on arbitrary plane, Equilibrium equations, compatibility equations, Generalized Hook's law, Plane stress and plain strain, principle of minimum potential energy and virtual work, RR method and Galerkin's methods, FEM steps, Advantages, disadvantages and limitations.

2 Interpolation Functions For General Element Formulation : 8hrs

Discretization process, types of elements, size of elements, location of node, node numbering scheme and mesh requirements in finite element method, polynomial form of interpolation functions, convergence requirements, Pascal triangle, shape functions (1D, 2D, LST, CST, Quad, Higher order elements).

Unit - 2

3. Basic FEA analysis: 8hrs

Elimination approach, Penalty approach and Thermal effect based practical engineering problems. Multi-point constraint, Iso-parametric and Axi-symmetric elements.

4. Advanced FEA analysis: 7hrs

Practical aspects of industrial machine components, Field issues related to structural applications using higher order polynomials.

Unit - 3

4. Post processing techniques: 5hrs

Validate and interpret the results, Average and Un-average stresses, Special tricks for post processing, Design modification, CAE Reports

5. Experimental Validation and Data Acquisition: 5hrs

Strain gauge, Photo elasticity, Load cells, Torque Sensors/Transducers, Dynamic tests, Acceleration test, Fatigue life measurement, Natural Frequency measurements.

Text Book

1. K. H. Huebner, D. L. Dewhirst, D. E. Smith and T. G. Byrom, The Finite Element Method for Engineers, 4th edition, Wiley, New York, 2001.
2. T. R. Chandraputala and A. D. Belegundu, Introduction to Finite Elements in Engineering, Third Edition, Prentice Hall of India, 2004.
3. Nitin Ghokale, Practical finite element analysis, Finite to infinite, 2008.

References

1. N. S. Ottosen and H. Petersson. Introduction to the Finite Element Method, Prentice-Hall, Englewood Cliffs, 1992.
2. S. S. Rao, Finite Element Method in Engineering , Fourth Edition, Elsevier Publishing, 2007.

Course Code: 19EMEP301 **Course Title: CAD modelling and PLM Lab**

L-T-P: 2-0-2 Credits: 4 Contact Hrs:6hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 80 Exam Duration: 3 hrs

Sl. No.	Work Benches of 3D PLM	No of weeks
1	**Sketcher**- Brief introduction on Sketcher work bench environment Structure of users and saving of files. **Exercises on Sketch** Tools, Profile Tool bar and Constraint Tool bar: Generate the following 2D sketches and make them Iso-constrained.	1
2	**Part Design**-Exercise on 3d models using pad, slot, shaft, groove, hole ,rib and stiffener commands, cut revolve, Dress up commands like chamfer, fillets etc. *(*Multi-Sections Solid and Removed Multi-Sections Solid Commands	2
3	**Generative shape design (GSD)**- Exercises using GSD to generate complicate surfaces using sub tool bars: Extrude-Revolution, Offset Var and Sweeps Extrude, Revolve, Trim, Transformation and Fillet tools Exercises on Wireframe, Surfaces and Operations Tool bar: (Conversion of Surface model into Solid model	3
4.	**Assembly Design**- Introduction to Assembly Design Work bench Bottom-Up and Top-Down assembly approaches Invoking existing components into assembly work Exercise to demonstrate Top-Down assembly approach.	2
5	**Drafting**- Converting existing 3D models into 2d drawings with all relevant details, sectional views, sheet selection, indicating GD&T symbols and dimensioning**.**	3
6	**Enovia**- Introduction to CATIA 3D experience PLM Import the existing CATIA 3D experience data and store in Search and identify the data located in 3D experience database Modify the data in any PLM process Sharing information with users Analyze and Identify impacts of modifications Save the modifications into database	1

Reference Book:

Training material given by EDS on 3D experience

Course Code:19EMEP302 **Course Title: FEM Lab**

L-T-P: 0-0-1 Credits: 1 Contact Hrs: 2 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 24 No of Sessions: 12 Exam Duration: 2 hrs

Category: Demonstration		**No. of Lab. Sessions per batch (estimate)**
1	Scientific Research Exposure (Research Education): Methods to search/extract Journal papers (Reputed journal paper), Referring papers, Drafting a paper. Introduction to ANSYS Workbench and familiarity. Real time Current/future field issues : Problem Identification	**03**
Category: Exercises		
Expt./Job No.	**Experiment/job Details**	**No. of Lab. Sessions per batch (estimate)**
1.	Static Structural analysis a) Uniform bar, b) Bracket, c) Machine Components	01
2.	Linear Buckling a) Columns & Struts (Different Boundary Conditions) b) Machine component	01
3.	Non-Linear Structural Analysis a) Geometric Nonlinearity b) Material Nonlinearity c) Contact Nonlinearity	02
4.	Dynamic Analysis (Modal/Harmonic/Transient Analysis) a) Beam (Different Boundary Conditions) b) Machine components	01
5.	Thermal Analysis a) Fins b) Heat Exchangers c) Machine component	01
6.	Drop Test & Impact Analysis a) Mobile drop test b) TV, Refrigerator etc.	01
7.	Optimization	01
8.	Model Test	01
Category: Structured Enquiry		

Execute all the FEM Analysis modules which are dealt under the lab exercise.

Identify the component (Sub-assembly need have Minimum 3 to 4 components)
Start from scratch

- Measure the dimensions of component
- Generate the Solid Modeling of components with overall assembly (In any of the CAD Software)
- Import the model in neutral form to ANSYS Workbench
- Collection of data relevant to Material Properties
- Understand the physics of the problem (Working Principle with load's and boundary conditions)
- Interpretation of Results with conclusion.

Category: Open ended
1. Identify field issue pertaining to any component/product in today's industry. 2. Collect the information/literature on earlier worked project through external/internal search (Journal Paper/Patent/reports) 3. Comprehend the physics of the problem with working principle. 4. Prepare the abstract and apply to a national/international conference 5. Identify material properties, boundary conditions and load steps. 6. Carryout the analysis as per the FEA steps. 7. Provide engineering solutions to the identified sub assembly (deformation and stresses, material change, weight reduction, increasing load bearing capacity, fatigue life calculation, prediction of endurance limit of component and damage factor). 8. Prepare the draft on the worked out problem and apply to a national/international conference

Materials and Resources Required:

1. Books/References: Nitin Ghokale, Practical finite element analysis
2. Manuals: Sham Tickoo, ANSYS for Engineers and Designers

Course Code: 19EMEC201 **Course Title: Control Systems**

L-T-P: 2-1-0 Credits: 3 Contact Hrs: 4 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – 1

1. Introduction to Control System 3 hrs

Generalized configurations and functional description of control systems. Control system design. Examples of Control System. Introduction to Linear, Nonlinear, Time Variant and Time Invariant systems.

2. Modeling of Physical Systems: 8 hrs

Introduction, Differential equations of physical systems, The Laplace Transform, Order of system; The transfer function of linear and rotational Mechanical systems, Gear Train, Electrical systems, Electro-mechanical System, Thermal systems, Hydraulic System; Block representation of system elements, Reduction of block diagrams to get transfer function.

Unit – 2

3. System Response 6 hrs

Introduction, Poles, Zeros, and System Response, 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. Design of 1st and 2nd order system.

4.Control Action 5 hrs

Introduction to PID controller design. Types of Controllers, Mathematical modeling of PID, ON-OFF controller, Effect of Proportional, Derivative and Integral elements on system behavior, Design of Controller for given simple applications. Design For Deadbeat Response.

Unit – 3

5. System Stability 4 hrs

Introduction to stability. Stability analysis by time response, S-plane and Routh-Hurwitz Criterion. Effect of gain adjustment, addition of pole and addition of zero on system response and system stability. Defining the Root locus, General rules for constructing root loci, Sketching the Root locus, Controller Design using root locus.

6. **Frequency Domain Analysis** 4 hrs

Nyquist stability criteria, Bode Plots. Stability analysis using bode plots.

Text Book

1. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 12th edition, Addison Wesley
2. A. Anandkumar, Control Systems, 2nd edition, PHI Learning Private Limited, 2014.

References

1. Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson Publications.
2. Norman S. Nise, Control. Systems, 6th edition, John Wiley & Sons.

Course Code: 19EMEP201 **Course Title: Control Systems Lab**

L-T-P: 0-0-2 Credits: 2 Contact Hrs: 4 hrs/week

ISA Marks: 80 ESA Marks: 20 Total Marks: 100

Teaching Hrs: 48 Exam Duration: 2 hrs

Experiment Number		Experiments	No of sessions
01	a)	Reduce a given block diagram using a tool and verify with analytical solution.	1
	b)	To solve differential equations using graphical programming.	1
	c)	To build Graphical User Interface for a given application with at least 5 functions.	1
02	a)	For a potential divider circuit (Zero order) find response by experimentally and analytical. Simulate both using a tool.	2
	b)	Evaluate the effects of varying system parameters on zero, first and second order systems for various standard test signals.	2
	c)	Determine the step response for a given mechanical system and validate the results through electrical analogous system.	2
	d)	Study the step response for Electro - Mechanical system, Gear Train, Hydraulic, Hydraulic lift, thermal physical modeled systems	4
03	a)	Design a positional control system for a DC servo motor and carryout investigations.	8
04	a)	Comparative study of Time response, root locus and Bode plot with respect to stability.	1

Course Code: 19EMAB301 **Course Title: Numerical methods and Statistics**

L-T-P: 3-0-1 Credits: 04 Contact Hours: 6 hrs/week

CIE Marks: 50 SEE Marks: 50 Total Marks: 100

Teaching Hours: 40 Examination Duration: 3hrs

Unit I

1. Numerical Methods 8 hrs

Introduction to numerical methods. Roots of equations using Bisection Method, Newton- Raphson Method, Finite differences, Forward, Backward Operators. Newton Gregory forward and backward interpolation formulae. Newton's divided difference formula for un equal intervals. Numerical solution of first order ODE, Euler's and Modified Euler's method, Runge Kutta 4^{th} order method. Implementation using python-programming

2. Matrices and System of linear equations 8 hrs

Introduction to system of linear equations, Rank of a matrix by elementary row transformations. Consistency of system of linear equation solution of system by (i) Direct methods-Gauss elimination, Gauss Jordon method (ii) Iterative methods- Guass-Seidal method. Eigenvalues and Eigenvectors of a matrix. Largest Eigenvalue and the corresponding Eigenvector by power method. Implementation using python-programming.

Unit II

3. Curve fitting and regression 5 hrs

Introduction to method of least squares, fitting of curves $y = a + bx$, $y = ab^x$, $y=a + bx +cx^2$, correlation and regression.

4. Probability 9 hrs

Definition of probability, addition rule, conditional probability, multiplication rule, Baye's rule. (no proof) Discrete and continuous random variables- PDF-CDF- Binomial, Poisson and Normal distributions (Problems only).

Unit III

5. Sampling distributions 10 hrs

(a) Sampling, Sampling distribution, Standard error, Null and alternate hypothesis, Type-I and Type- II errors, Level of significance. Confidence limits for means (large sample).

(b) Testing of hypothesis for means. large and small samples and student's t- distribution and Confidence limits for means (small sample).

Text Books

1. Bali and Iyengar, A text book of Engineering Mathematics, 6ed, Laxmi Publications(p) Ltd, New Delhi,2003
2. Chapra S C and Canale R P, Numerical methods for Engineers, 5ed, TATA McGraw-Hill, 2007
3. Gupta S C and Kapoor V K, Fundamentals of Mathematical Statistics, 9ed, Sultan Chand & Sons, New Delhi, 2002

Reference Books:

1. Sastry S S, Introductory method for numerical analysis, 3ed, PHI, 2003.
2. J. Susan Milton, Jesse C. Arnold, Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 4^{th} Ed, TATA McGraw-Hill Edition 2007.

Course Code: 15EMEC402 **Course Title: Design of Thermal Systems**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit I

1. Heat exchangers Classification and Selection: 5 Hrs

Introduction, Recuperation and Regeneration, Transfer process, Geometry and Construction, - Tubular Heat Exchanger, Plate Heat Exchanger, Extended Surface heat exchanger, Heat Transfer Mechanisms, Flow arrangements, Applications and Selection of Heat Exchangers.

2. Design of Shell and Tube heat exchanger 10 Hrs

Construction of shell and tube exchanger, specifications and classification of S&T Heat Exchanger, some Typical operating limits for heat exchangers of S&T Type, Design of Shell and Tube Heat Exchangers.

Unit II

3. Condensers : Classification of condensers, various types of condensers and their applications, Shell and tube condensers : Analysis and design, special consideration in Reflux Condensers: Flooding , Condensers for mixtures , Design of shell and tube Exchangers, compact condensers, air cooled condensers , direct contact condensers , numerical problems 5 Hrs

4. Modeling of Thermal Equipment: 6 Hrs

Counter flow heat exchanger, Evaporators and Condensers, Heat exchanger effectiveness, Effectiveness of a counter flow heat exchanger, NTU, Pressure drop and pumping power, Numerical Problems.

5. Optimization: 4 Hrs

Mathematical representation of optimization problems, A water chilling system, Optimization procedure, Setting up the mathematical statement of the optimization problem.

Unit III

6. **Lagrange Multipliers:** 5 Hrs

The Lagrange multiplier equations, unconstrained optimization, Constrained optimization.

7. Dynamic Programming: 5 Hrs

Characteristic of the Dynamic programming solution, Apparently constrained problem, Application of Dynamic programming to energy system problems.

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

1. W.F.Stoecker, Design of Thermal Systems, 3 ed., MGH, 1989.
2. Sarit K. Das., Process heat transfer, Narosa Publishing House 1st Edition, 2005
3. Sadik Kakac, Hongtan Liu, Heat Exchanger Selection, Rating and Thermal Design, 2 ed., CRC Press, 2002.

References.

1. Yogesh Jaluria, Design and Optimisation of Thermal Systems, 2nd ed., CRC Press,2008
2. Hodge B.K., Analysis and Design of Thermal Systems, 1 ed., PHI, 1990.

Course Code: 19EMEC401 **Course Title: I C Engines**

L-T-P: 2-0-0 Credits: 2 Contact Hrs: 2 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 26 Exam Duration: 3 hrs

Unit I

1. Introduction to I C Engines 5 Hrs

Internal Combustion Engine Classification, Operating Cycles, Spark Ignition and Compression-Ignition Engines.

Combustion in Spark Ignition Engines

Ignition limits, Normal combustion, Thermodynamic Analysis of SI Engine Combustion - stages, ignition lag, and effect of engine variables on ignition lag Causes of Cycle-by-Cycle and Cylinder-to-Cylinder Variations and flame propagation phase, detonation, Abnormal Combustion: Knock Fundamentals and fuel factors, Factors affecting knock.SI engine combustion chambers.

2. Combustion in Compression Ignition Engines 5 Hrs

Types of Diesel Combustion Systems, Direct and Indirect-Injection Systems, Comparison, Combustion Efficiency, Normal combustion – stages, delay period, variables affecting delay period. Diesel knock, comparison between diesel and petrol engine knocks. CI engine combustion chambers, Fuel spray behavior. HRR analysis.

Unit II

3. Engine Exhaust Emission Control 5 Hrs

Formation of NOX, HC/CO mechanism , Smoke and Particulate emissions, Green House Effect, Methods of controlling emissions , Three way catalytic converter and Particulate Trap, Emission (HC, CO, NO and NOX) measuring equipments, Smoke and Particulate measurement, Indian Driving Cycles and emission norms.

4. Overall Engine Performance 6 Hrs

Alternate fuels, Operating Variables that Affect SI Engine Performance, Efficiency, and Emissions: Spark Timing, Mixture Composition, Load and Speed, Compression Ratio. Variables that Affect CI Engine Performance, Efficiency, and Emissions: Load and Speed, Fuel-Injection Parameters.

Unit III

5. Recent Trends in IC Engines 5 Hrs

Dual fuel Engine, Common Rail Direct Injection Diesel Engine (CRDI), Homogeneous Charge Compression Ignition Engine (HCCI), Reactivity controlled compression ignition engine (RCCI) Lean Burn Engine, Surface Ignition alcohol CI Engine, VVT engines, Gasoline Direct Injection Engine.

Text Books:

1. John B Heywood, “Internal Combustion Engine Fundamentals”, Tata McGraw-Hill, 1988
2. Heinz Heisler, “Advanced Engine Technology”, SAE International Publications, USA, 1998
3. Patterson D.J. and Henein N.A, “Emissions from combustion engines and their control”, Ann ArborScience, publishers Inc, USA, 1978

Reference Books:

1. Ganesan V. “Internal Combustion Engines”, Third Edition, Tata Mcgraw-Hill, 2007.
2. Gupta H.N, “Fundamentals of Internal Combustion Engines”, Prentice Hall of India, 2006.
3. Ultrich Adler, “Automotive Electric / Electronic Systems”, Published by Robert Bosh GmbH, 1995.

Course Code: 15EMEE308 **Course Title: HVAC Systems**

L-T-P: 3-0-0 Credits: 3 Contact Hrs: 3 hrs/week

ISA Marks: 50 ESA Marks: 50 Total Marks: 100

Teaching Hrs: 40 Exam Duration: 3 hrs

Unit – I

1: Introduction to HVAC Systems and Psychrometry 5 hrs

Purpose, applications, definition and components of air conditioning - Need and methods of ventilation. Evolution of air properties and psychrometric chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing, etc. - Bypass factor and Sensible heat ratio, Numerical problems.

2: Human Comfort, Summer and winter AC 5 hrs

Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort - Thermal response - comfort factors - Environmental indices - Indoor air quality. - Simple summer AC process, Room sensible heat factor, Coil sensible heat factor, ADP - Precision AC - Winter AC.

3: AC Systems and Equipment 6 hrs

Classification of air conditioning systems, Filters, types, efficiency – Fan laws, cooling coils and heating coils, sizing and off design performance - Cooling and dehumidifying coil, dry and wet, sizing, performance.

Unit – II

4: Heat Transfer 3 hrs

Heat transfer in wall and roof, sol-air temperature, insulation, cooling load temperature difference - Fenestration, types of glass, sun shade, shading coefficient, maximum radiation, cooling load factor

5: Cooling load and heating load estimation 7 hrs

Thermodynamics of human body and mathematical model, Human comfort chart, Design conditions, outdoor, indoor - External load, wall, roof, glass - Internal load, occupancy, lighting, equipments - Ventilation, air quantity, loads - Load estimation methods. Vapour transfer in wall, vapour barrier, load estimation basics.

Introduction to AutoCAD REVIT software

6: Air distribution, diffusion and Ventilation 6 hrs

Ducts, types, energy equation for pipe flow, friction chart, methods of sizing, air distribution systems, ADPI, outlet/inlet selection.

Need, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings, Natural, wind effect, stack effect, combined effect - Mechanical, forced, exhaust, combined - Displacement ventilation

Unit – III

7: Ventilation system design 4 hrs

Exhaust ducts, filters, blowers, hoods, chimney, etc.

8: Industrial ventilation 4 hrs

Steel plants, car parks, plant rooms, mines, etc.

Text Book:

1. Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler, Heating, Ventilating and Air Conditioning: Analysis and Design, 6th Edition, July 2004,
2. W P Jones, Air Conditioning Engineering ELBS 3rd edn Edward Arnold (Publishers) ltd. Londan.

Reference Book:

1. Harris, Modern Air Conditioning Practice 3nd Edn McGraw Hill Book Company
2. S. N. Sapali, Refrigeration and air conditioning 2nd Edn, PHI learning pvt ltd, Delhi 2016
3. C P Arora, Refrigeration and air conditioning 3rd edn