## Program Outcomes (PO) and Program Specific Outcomes

**PO 1: Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.

**PO 2: Problem analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO 3: Design/Development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

**PO 4: Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**PO 5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

**PO 6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**PO 7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO 8: Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**PO 9: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO 10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

**PO 11: Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO 12:Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**PSO 13: Engineering Drawing & Modelling:** Use modern CAD tools and appropriate design standards to develop component and system drawings.

**PSO 14: Manufacturing:** Apply the knowledge of manufacturing processes to develop a component with appropriate consideration for productivity, quality and cost.

**PSO 15: Preventive Maintenance of Mechanical Systems:** Demonstrate knowledge and understanding of the principles of preventive maintenance and apply those to develop schedule for machine tools.

**Program Outcomes-Competencies-Performance Indicators**

**PO 1: Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.

| Competency | Indicators |
|---|---|
| 1.1 Demonstrate competence in mathematical modelling | 1.1.1 Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems<br>1.1.2 Apply advanced mathematical techniques to model and solve mechanical engg. problems |
| 1.2 Demonstrate competence in basic sciences | 1.2.1 Apply laws of natural science to an engineering problem |
| 1.3 Demonstrate competence in engineering fundamentals | 1.3.1 Apply fundamental engineering concepts to solve engineering problems |
| 1.4 Demonstrate competence in specialized engineering knowledge to the program | 1.4.1 Apply Mechanical engineering concepts to solve engineering problems. |

**PO 2: Problem analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

| Competency | Indicators |
|---|---|
| 2.1 Demonstrate an ability to identify and characterize an engineering problem | 2.1.1 Articulate problem statements and identify objectives<br>2.1.2 Identify engineering systems, variables, and parameters to solve the problems<br>2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem |
| 2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem | 2.2.1 Reframe complex problems into interconnected sub-problems<br>2.2.2 Identify, assemble and evaluate information and resources.<br>2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions<br>2.2.4 Compare and contrast alternative solution processes to select the best process. |
| 2.3 Demonstrate an ability to formulate and interpret a model | 2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.<br>2.3.2 Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required. |
| 2.4 Demonstrate an ability to execute a solution process and analyze results | 2.4.1 Apply engineering mathematics and computations to solve mathematical models<br>2.4.2 Produce and validate results through skilful use of contemporary engg. tools and models<br>2.4.3 Identify sources of error in the solution process, and limitations of the solution.<br>2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis |

**PO 3: Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

| Competency | Indicators |
|---|---|
| 3.1 Demonstrate an ability to define a complex / open-ended problem in engineering terms | 3.1.1 Recognize that need analysis is key to good problem definition<br>3.1.2 Elicit and document, engineering requirements from stakeholders<br>3.1.3 Synthesize engineering requirements from a review of the state-of-the-art<br>3.1.4 Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHRAE.<br>3.1.5 Explore and synthesize engg. requirements from larger social and professional concerns<br>3.1.6 Determine design objectives, functional requirements and arrive 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<br>3.2.2 Build models/prototypes to develop diverse set of design solutions<br>3.2.3 Identify suitable criteria for evaluation of alternate design solutions |

| Competency | Indicators |
|---|---|
| 3.3 Demonstrate an ability to select optimal design scheme for further development | 3.3.1 Apply formal decision making tools to select optimal engineering design solutions for further development<br>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)<br>3.4.2 Generate information through appropriate tests to improve or revise design |

**PO 4: Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

| Competency | Indicators |
|---|---|
| 4.1 Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding | 4.1.1 Define a problem, its scope and importance for purposes of investigation<br>4.1.2 Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation<br>4.1.3 Apply appropriate instrumentation and/or software tools to make measurements of physical quantities<br>4.1.4 Establish a relationship between measured data and underlying physical principles. |
| 4.2 Demonstrate an ability to design experiments to solve open ended problems | 4.2.1 Design and develop experimental approach, specify appropriate equipment and procedures<br>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 analyze data and reach a valid conclusion | 4.3.1 Use appropriate procedures, tools and techniques to conduct experiments and collect data<br>4.3.2 Analyze data for trends and correlations, stating possible errors and limitations<br>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<br>4.3.4 Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions |

**PO 5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

| Competency | Indicators |
|---|---|
| 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<br>5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering 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.<br>5.2.2 Demonstrate proficiency in using discipline specific tools |
| 5.3 Demonstrate an ability to evaluate the suitability and limitations of tools used to solve an engineering problem | 5.3.1 Discuss limitations and validate tools, techniques and resources<br>5.3.2 Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use. |

**PO 6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

| Competency | Indicators |
|---|---|
| 6.1 Demonstrate an ability to describe engineering roles in a broader context, e.g. pertaining to the environment, health, safety, and public welfare | 6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest |

| | |
|---|---|
| 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 |

**PO 7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

| Competency | Indicators |
|---|---|
| 7.1 Demonstrate an understanding of the impact of engineering and industrial practices on social, environmental and in economic contexts | 7.1.1 Identify risks/impacts in the life-cycle of an engineering product or activity<br>7.1.2 Understand the relationship between the technical, socio economic and environmental dimensions of sustainability |
| 7.2 Demonstrate an ability to apply principles of sustainable design and development | 7.2.1 Describe management techniques for sustainable development |

**PO 8: Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

| Competency | Indicators |
|---|---|
| 8.1 Demonstrate an ability to recognize ethical dilemmas | 8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives |
| 8.2 Demonstrate an ability to apply the Code of Ethics | 8.2.1 Identify tenets of the ASME professional code of ethics<br>8.2.2 Examine and apply moral & ethical principles to historically famous case studies |

**PO 9: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

| Competency | Indicators |
|---|---|
| 9.1 Demonstrate an ability to form a team and define a role for each member | 9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team<br>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 |

**PO 10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

| Competency | Indicators |
|---|---|
| 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<br>10.1.2 Produce clear, well-constructed, and well-supported written engineering documents<br>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<br>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<br>10.3.2 Use a variety of media effectively to convey a message in a document or a presentation |

**PO 11: Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

| Competency | Indicators |
|---|---|
| 11.1 Demonstrate an ability to evaluate the economic and financial performance of an | 11.1.1 Describe various economic and financial costs/benefits of an engineering activity |

| | |
|---|---|
| engineering activity | 11.1.2 Analyze different forms of financial statements to evaluate the financial status of an engineering project |
| 11.2 Demonstrate an ability to Compare and contrast the costs/benefits of alternate proposals for an engg. activity | 11.2.1 Analyze and select the most appropriate proposal based on economic and financial considerations. |
| 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.<br>11.3.2 Use project management tools to schedule an engineering project so it is completed on time and on budget. |

**PO 12: Life-long learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

| Competency | Indicators |
|---|---|
| 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<br>12.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap |
| 12.2 Demonstrate an ability to identify changing trends in engineering knowledge and practice | 12.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current<br>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 |
| 12.3 Demonstrate an ability to identify and access sources for new information | 12.3.1 Source and comprehend technical literature and other credible sources of information |

**Program Specific Program Outcomes**

**PO 13: Engineering Drawing & Modelling:** Use modern CAD tools and appropriate design standards to develop component and system drawings.

| Competency | Indicators |
|---|---|
| 13.1 Demonstrate competence in computer drafting, GD&T applications, and selection of fits & tolerances | 13.1.1 Develop 2D drawings of components / systems using modern CAD tools.<br>13.1.2 Develop 3D models of components / systems using modern CAD tools<br>13.1.3 Apply GD&T principles as per ASME standards to manufacturing drawings, with all relevant data like material, hardness, surface finish, and tolerances. |
| 13.2 Demonstrate proficiency in blue print reading / manufacturing drawings | 13.2.1 Apply principles of engineering drawing<br>13.2.2 Apply knowledge of GD&T principles, material properties, surface finish, and tolerances. |

**PO 14: Manufacturing:** Apply the knowledge of manufacturing processes to develop a component with appropriate consideration for productivity, quality and cost.

| Competency | Indicators |
|---|---|
| 14.1 Demonstrate an ability to carry out feasibility study | 14.1.1 Ability to prepare a brief outline of the possible steps of manufacturing |
| 14.2 Demonstrate an ability to prepare process flow chart | 14.2.1 Identify appropriate metal cutting/ metal forming/ any other manufacturing processes for a given component.<br>14.2.2 Apply manufacturing knowledge to develop process sheets to manufacture a component in a most economical way within the available resources. |

**PO 15: Preventive Maintenance of Mechanical Systems:** Demonstrate knowledge and understanding of the principles of preventive maintenance and apply those to develop schedule for machine tools.

| Competency | Indicators |
|---|---|
| 15.1 Demonstrate an ability to explain basic steps involved in preventive maintenance of machine tools | 15.1.1 Apply knowledge of principles of preventive maintenance<br>15.1.2 Ability to prepare preventive maintenance chart for a given machine tool referring to OEM's manual. |

Course Title: **Mechanics of Materials**

## Course Outcomes (COs):

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

1. Analyze the component subjected to various kinds of loads using the fundamental concepts of stress and strain.
2. Compare the shaft designed based on strength and stiffness criteria subjected to pure torsion.
3. Compute the load carrying capacity of columns for different conditions of support and materials.
4. Interpret the shear force and bending moment diagrams for a structural member subjected to various types of loads and couple.
5. Design a structural member for a given cross-section, shear/bending stress and support conditions.
6. Formulate and solve the problems on deflection and slope for a structural member subjected to various load and support condition.
7. Evaluate the stresses and strains at a point in a component subjected to different state of stress.
8. Write a computer program and/or macros using spreadsheets to solve given problems, verify using ForceEffect app, analyse the same by varying input parameters and submit a report as part of assignment.

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

| Course Title: Mechanics of Materials | Semester: 3 - Semester |
|---|---|
| Course Code: 15EMEF201 | Year: 2016-17 |

| Course Outcomes (COs) / Program Outcomes (POs) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Analyze the component subjected to various kinds of loads using the fundamental concepts of stress and strain. | 3 | 1 | | | | | | | | | | | | | |
| 2. Compare the shaft designed based on strength and stiffness criteria subjected to pure torsion. | 2 | 2 | | | | | | | | | | | | | |
| 3. Compute the load carrying capacity of columns for different conditions of support and materials. | 2 | 1 | | | | | | | | | | | | | |
| 4. Interpret the shear force and bending moment diagrams for a structural member subjected to various types of loads and couple. | | 2 | | | | | | | | | | | | | |
| 5. Design a structural member for a given cross-section, shear/bending stress and support conditions. | 3 | 2 | | | | | | | | | | | | | |
| 6. Formulate and solve the problems on deflection and slope for a structural member subjected to various load and support condition. | 3 | 2 | | | | | | | | | | | | | |
| 7. Evaluate the stresses and strains at a point in a component subjected to different state of stress. | 3 | 2 | | | | | | | | | | | | | |
| 8. Write a computer program and/or macros using spreadsheets to solve given problems, verify using ForceEffect app, analyse the same by varying input parameters and submit a report as part of assignment. | 3 | 2 | | | 1 | | | | | 1 | | | | | |

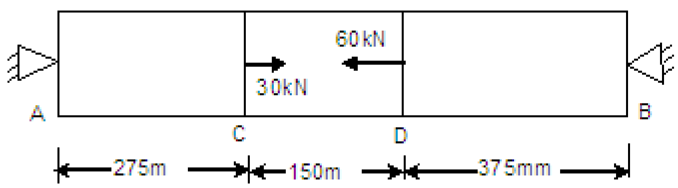
Degree of compliance **1**: Low **2**: Medium **3**: High

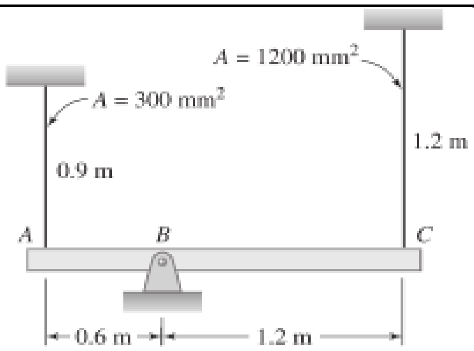
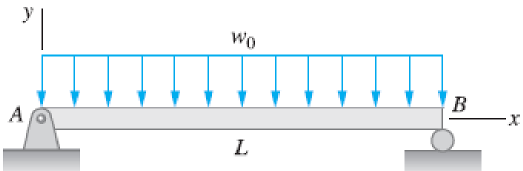
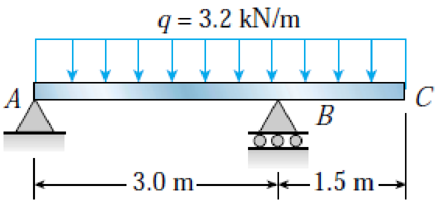
## Course Attainment

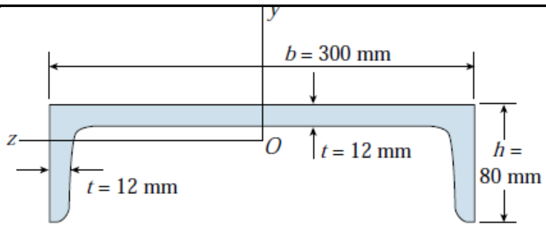
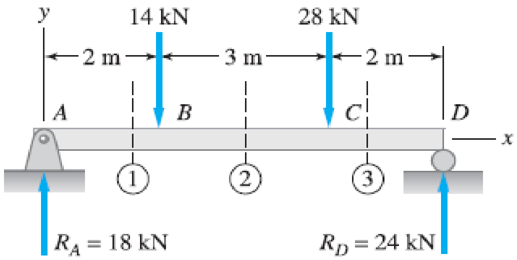
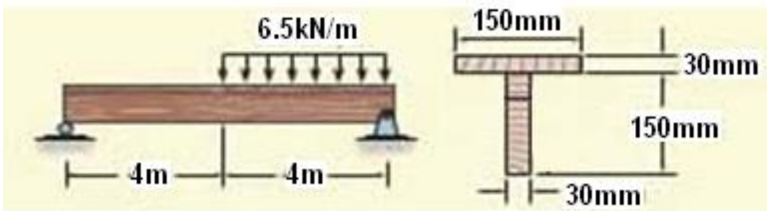
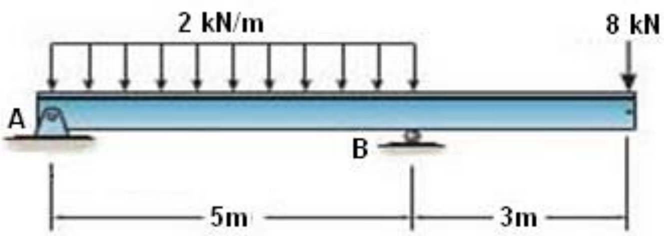
**Course: Mechanics of Materials (15EMEF201)**

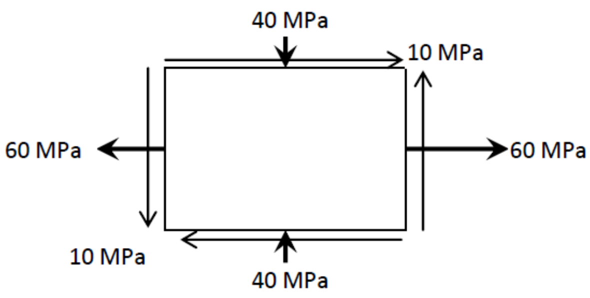
| COs | PO1 | | PO2 | | PO5 | | PO10 | | PSO13 | | PSO14 | | PSO15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA |
| 15EMEF201.1 | 2 | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEF201.2 | 1 | 2 | 1 | 2 | - | - | - | - | - | - | - | - | - | - |
| 15EMEF201.3 | 0 | 1 | 0 | 1 | - | - | - | - | - | - | - | - | - | - |
| 15EMEF201.4 | - | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - |
| 15EMEF201.5 | 2 | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEF201.6 | 2 | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEF201.7 | 0 | 3 | 0 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEF201.8 | 3 | 0 | 3 | 0 | 3 | 0 | 3 | 0 | - | - | - | - | - | - |
| 15EMEF201 | 1.89 | 2.85 | 1.91 | 2.73 | 3 | 0 | 3 | 0 | - | - | - | - | - | - |

| Question Paper Title: Model Question Paper for Semester End Examination | | |
|---|---|---|
| Total Duration (H:M): 180 Min | Course: Mechanics of Materials (15EMEC201) | Maximum Marks :100 |
| Note :Answer two full questions from Unit I, II and one full question from Unit III<br>Missing data may be suitably assumed wherever necessary with justification. | | |

| | Unit 1 | | | | | |
|---|---|---|---|---|---|---|
| Q.No | Questions | Marks | CO | B L | PO | PI Code |
| 1(a) | A steel specimen of 12.5 mm diameter and 150 mm gauge length is subjected to tensile test. It is observed that load at yield point is 43 kN and maximum load is 60kN. A load of 16.4 kN is required to cause an elastic extension of 0.1 mm. Final length of specimen is 190 mm and the diameter of the neck after the fracture is 8 mm. Determine Yield point stress, Ultimate stress, Percentage increase in length, Percentage reduction in area and Young's modulus. | 10 | 1 | L2 | 1 | 1.3.1 |
| 1(b) | A bar of 800mm length is attached rigidly at A and B as shown in Fig 1b.Forces of 30kN and 60kN act as shown on the bar. If E=200GPa, determine the reactions at the two ends. If the bar diameter is 25mm, find the stresses and change in length of each portion.<br><br><br>Fig.1b | 10 | 1 | L3 | 1 | 1.3.1 |
| 2(a) | A solid steel shaft transmits 100 KW at 150 rpm. Evaluate the suitable diameter of the shaft if the maximum torque transmitted exceeds the mean torque by 20% in each revolution. Take shear stress permissible as 60 MPa, G= 80 MPa, and twist permissible as $4^o$. | 10 | 2 | L3 | 2 | 2.1.2 |
| 2(b) | A metallic bar 250mm x 80mm x 30mm is subjected to a force of 20kN (Tensile), 30kN (Tensile) and 15kN (Tensile) along x, y and z direction respectively. Determine the change in volume of the block. Take $E=2(10)^5$ $N/mm^2$ and Poisson's ratio=0.25. | 10 | 1 | L3 | 2 | 2.1.2 |
| 3(a) | The rigid bar ABC is supported by a pin at B and two vertical steel rods as shown in Fig.3a. Initially the bar is horizontal and the rods are stress-free. Determine the stress in each rod if the temperature of the rod at A is decreased by $40^0$C. Neglect the weight of bar ABC. Use α = 11.7 x $10^6$ $/^0$C and E = 200 GPa for steel. | 10 | 1 | L3 | 1 | 1.3.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| |   **Fig**.3a | | | | | |
| 3(b) | A tubular column pin-jointed at both ends has outer and inner diameters as 40 mm and 36 mm respectively and is 2.4 m long. Compare the crippling loads given by Euler's and Rankine's formulae. Take E = 204 GPa, Yield stress =310 MPa, a = 1/7500. If the elastic limit is taken as 220 MPa, find the length below which the Euler's formula ceases to apply. | 10 | 2 | L3 | 2 | 2.1.2 |
| | **Unit 2** | | | | | |
| 4(a) | For the beam shown in Fig. 4a, derive the expressions for V and M, and draw the shear force and bending moment diagrams. Neglect the weight of the beam.   **Fig**.4a | 08 | 4 | L3 | 2 | 2.1.2 |
| 4(b) | The beam ABC as shown in Fig. Q4(b) has simple supports at A and B. A uniform load of intensity q = 3.2 kN/m acts throughout the entire length of the beam. The beam has a cross section of channel shape with width b = 300 mm and height h = 80 mm Fig. (b). The web thickness is t = 12 mm, and the average thickness of the sloping flanges is the same. For the purpose of calculating the properties of the cross section, assume that the cross section consists of three rectangles. Determine the maximum tensile and compressive stresses in the beam due to the uniform load. It is required to reduce the tensile stress to its 75% value. Identify the parameters for the same.   | 12 | 5 | L3 | 2 | 2.1.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | <br>Fig. Q4(b) | | | | | |
| 5(a) | A cantilever is loaded with point load at the end. Derive an expression for the maximum deflection. | 08 | 6 | L2 | 1 | 1.3.1 |
| 5(b) | The simply supported beam in Fig. 5(b) carries two concentrated loads. Draw the shear force and bending moment diagrams. Neglect the weight of the beam. Note that the support reactions at A and D have been computed and are shown. If both the reactions to be equal to 21 kN, find the distance from A that the force 14kN to be shifted.<br><br>**Fig**. 5(b) | 12 | 4 | L3 | 2 | 2.1.2 |
| 6(a) | The wooden beam shown in Fig. 6(a) is made from two boards. Determine the maximum shear stress in the glue necessary to hold the boards together along the seam where they are joined. It is required to reduce the maximum shear stress to its 80% value. Identify the parameters for the same. Use any one parameter to prove it.<br><br>Fig. Q6(a) | 08 | 5 | L3 | 2 | 2.1.2 |
| 6(b) | The beam is subjected to the load as shown in Fig. Q6(b) Determine the equations of the slope and maximum deflection. EI is the constant. It is required to reduce the maximum deflection to its 60%. Identify the parameters for the same.<br> | 12 | 6 | L3 | 2 | 2.1.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Fig. Q6(b) | | | | | |
| | **Unit 3** | | | | | |
| 7(a) | A state of stress at a point in a strained material is as shown in Fig.7a. Compute i) Direction of principal planes; ii) Magnitudes of principal stresses; iii) Magnitude of maximum shear stress and its direction.<br><br><br>Fig.7a | 10 | 7 | L2 | 1 | 1.3.1 |
| 7(b) | A hollow shaft of 40mm outer diameter and 25 mm inner diameter is subjected to a twisting moment of 120 kN-m, simultaneously, is subjected to an axial thrust of 10kN and a bending moment of 80 N-m. Find the principal planes and stresses. Also find the planes of maximum shear stress and the stresses on these planes. | 10 | 7 | L3 | 2 | 2.1.2 |
| 8(a) | A thin cylindrical shell with 400 mm inner diameter, 1 m length and 14 mm wall thickness is subjected to an internal pressure 2 MPa. Determine i) Circumferential stress and longitudinal stress and ii) Change in dimensions. Take E = 200 GPa and μ=0.30. | 10 | 7 | L2 | 1 | 1.3.1 |
| 8(b) | A cylinder of a hydraulic ram of 60 mm diameter is to withstand an internal pressure of 35 MPa. Determine the thickness of the metal if the maximum tensile stress and shear stress in the material are limited to 55 MPa and 50 MPa. Also draw the both stress distribution diagrams. | 10 | 7 | L3 | 2 | 2.1.2 |

Course Title: **Fluid Mechanics and Hydraulic Machines**

## Course Outcomes (COs):

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

1. Estimate forces acting on submerged and floating bodies using laws of fluid statics.
2. Evaluate the velocity and acceleration components for 3D fluid flow field.
3. Apply the conservation of mass, momentum and energy to fluid flow applications.
4. Identify various fluid flow measurement techniques, losses associated with pipe flow to determine the pumping power requirements.
5. Apply the fundamental principle of dimensional homogeneity to identify non dimensional parameters for experimental modeling.
6. Apply the basic principles of fluid mechanics to preliminary design of the turbo machines (Pumps and Turbines).

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

| | |
|---|---|
| Course Title: **Fluid Mechanics and Hydraulic Machines** | Semester: V |
| Course Code: 15EMEC301 | Year: 2017-18 |

| **Course Outcomes (COs) / Program Outcomes (POs)** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Estimate forces acting on submerged and floating bodies using laws of fluid statics. | **2** | | | | | | | | | | | | | | |
| 2. Evaluate the velocity and acceleration components for 3D fluid flow field. | **2** | **2** | | | | | | | | | | | | | |
| 3. Apply the conservation of mass, momentum and energy to fluid flow applications. | **2** | **2** | | | | | | | | | | | | | |
| 4. Identify various fluid flow measurement techniques, losses associated with pipe flow to determine the pumping power requirements. | | **3** | | | | | | | | | | | | | |
| 5. Apply the fundamental principle of dimensional homogeneity to identify non dimensional parameters for experimental modeling. | **3** | | | | | | | | | | | | | | |
| 6. Apply the basic principles of fluid mechanics to preliminary design of the turbo machines (Pumps and Turbines). | | **3** | | | | | | | | | | | | | |

Degree of compliance 1: Low, 2: Medium, 3: High

## Course Attainment

**Course:Fluid Mechanics and Hydraulic Machines (15EMEC301)**

| COs | PO1 | | PO2 | | PO4 | | PO9 | | PO10 | | PSO13 | | PSO15 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA | ISA | ESA |
| 15EMEC301.1 | 3 | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| 15EMEC301.2 | 2 | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEC301.3 | 2 | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEC301.4 | - | - | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEC301.5 | 1 | 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| 15EMEC301.6 | - | - | 0 | 3 | - | - | - | - | - | - | - | - | - | - |
| 15EMEC301 | 2.6 | 2.55 | 2.54 | 3 | - | - | - | - | - | - | - | - | - | - |

| Question Paper Title: Model Question Paper for End Semester Assessment | |
|---|---|
| Course : Fluid Mechanics and Hydraulic Machines | Course Code : 15EMEC301 |
| Total Duration (H:M): 3 hrs | 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 | A cylindrical body is 2m in diameter, 2.5m long and weighs 2.2 metric tons. The density of seawater is 1025 kg/$m^3$. Show that the body cannot float with its axis vertical. | 10 | 5 | L2 | 1 | 1.3.1 |
| 1b | 0.25 $m^3$/s of water is flowing in a pipe having a diameter of 300mm. If the pipe is bent by $135^0$, find the magnitude and direction of the resultant force on the bend. The pressure of water flowing is 39.24 N/$cm^2$. If the bend angle is reduced to $120^0$ and if the pipe diameter at the exit is reduce to 200mm. Calculate resultant force on the bend. Comment on the results of both the cases. | 10 | 1 | L3 | 1 | 1.1.1 |
| 2a | A U – tube manometer is used to measure the pressure of water in a pipe line, which is in excess of atmospheric pressure. The right limb of the manometer contains mercury and is open to atmosphere. The contact between water and mercury is in the left limb. Determine the pressure of water in the main line, if the difference in the level of mercury in the limbs of U tube is 10 cm and the free surface of mercury is in level with the center of the pipe.<br>If the pressure of water in pipe line is reduced to 9810 N/$m^2$. Calculate the new difference in the level of mercury.<br>Sketch the arrangements in the both cases. | 10 | 4 | L3 | 2 | 2.1.3 |
| 2b | In a two – dimensional incompressible flow the fluid velocity components are given by u=x-4y and v =-y-4x. Show that velocity potential exists and determine its form. Find also the stream function. | 10 | 1 | L2 | 1 | 1.1.1 |
| 3a | Two large plane surfaces are 2.4 cm apart. The space between the surfaces is filled with glycerin. What force is required to drag a very thin plate of surface area 0.5 square meters between the two large plane surfaces at a speed of 0.6 m/s, if :<br>(i) The thin plate is in the middle of the two plane surfaces and | 10 | 4 | L3 | 2 | 2.1.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (ii) the thin plate is at a distance of 0.8 cm from one of the plane surfaces<br>(iii) plot the distribution of shear force required to drag the thin film, when the thin film is moved from one of the plane surfaces in steps of 0.1 cm.<br>(iv) analyze the results of the plot. Take μ = 8.1 x $10^{-1}$ Ns/$m^2$ | | | | | |
| 3b | Water is flowing through a pipe having diameters 30 cm and 20 cm at the bottom and upper end respectively. The intensity of pressure at the bottom end is 25 N/$cm^2$ and the pressure at the upper end is 10 N/$cm^2$. Determine the difference in datum head if the rate of flow through the pipe is 0.04 $m^3$/sec. | 10 | 5 | L3 | 1 | 1.4.1 |

| **UNIT - II** | | | | | | |
|---|---|---|---|---|---|---|
| **Q.No.** | **Questions** | **Marks** | **CO** | **BL** | **PO** | **PI Code** |
| 4a | Define the following dimensionless numbers and state their significance for fluid flow problems. (i) Reynold's number (ii) Froude number and (iii) Mach number. | 10 | 5 | L2 | 1 | 1.3.1 |
| 4b | There is horizontal crack 4 cm wide and 2.5 mm deep in a wall of thickness 10 cm. Water leaks through the crack. Find the rate of leakage of water through the crack if the difference of pressure between the two ends of the crack is 0.03 N/$cm^2$. Take the viscosity of water as 0.01 poise. | 10 | 1 | L3 | 1 | 1.1.1 |
| 5a | Two reservoirs having difference of water level as 15 m are connected by a pipeline 4000m long and of 400 mm diameter. If the last 2000m of the pipe is replaced by two pipes of 2000m long and 400 mm diameter each, find the discharge through the pipe and also determine the increase in discharge. Take f=0.01. | 10 | 4 | L3 | 2 | 2.1.3 |
| 5b | A crude oil of viscosity 0.97 poise and relative density 0.9 is flowing through a horizontal circular pipe of diameter 10 cm and length 10m. Calculate the difference of pressure at the two ends of the pipe, if 100 kg of oil is collected in a tank in 30 seconds. | 10 | 1 | L2 | 1 | 1.1.1 |
| 6a | A horizontal pipeline 40m long is connected to a water tank at one end and discharges freely into atmosphere at the other end. For the first 25m of its length from the tank. The pipe is 15 cm diameter and its diameter is suddenly enlarged to 30 cm. The height of water in the tank is 8.0m above the centre of the pipe. Considering all losses of head, which occur, determine the rate of flow. Take f = 0.01 for both sections of the pipe. | 10 | 4 | L3 | 2 | 2.1.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6b | Consider a liquid in a cylindrical container in which both the container and the liquid are rotating as a rigid body (solid-body rotation). The elevation difference h between the center of the liquid surface and the rim of the liquid surface is a function of angular velocity v, fluid density ρ, gravitational acceleration g, and radius R Use the method of repeating variables to find a dimensionless relationship between the parameters. | 10 | 5 | L3 | 1 | 1.4.1 |

| UNIT - III | | | | | | |
|---|---|---|---|---|---|---|
| **Q.No.** | **Questions** | **Marks** | **CO** | **BL** | **PO** | **PI Code** |
| 7a | A centrifugal pump is being designed to pump liquid refrigerant R-134a at room temperature and atmospheric pressure. The impeller inlet and outlet radii are $r_1$=100 and $r_2$=180mm, respectively. The impeller inlet and outlet widths are $b_1$= 50 and $b_2$= 30 mm. The pump is to deliver 0.25 $m^3/s$ of the liquid at a net head of 14.5m when the impeller rotates at 1720 rpm. Design the blade shape for the case in which these operating conditions are the design conditions of the pump (V1, t= 0); specifically, calculate angles $\beta_1$ and $\beta_2$, and discuss the shape of the blade. Also predict the horsepower required by the pump. | 10 | 6 | L3 | 2 | 2.1.2 |
| 7b | For each statement about centrifugal pumps, choose whether the statement is true or false, and discuss your answer briefly. (a) A centrifugal pump with radial blades has higher efficiency than the same pump with backward-inclined blades. (b) A centrifugal pump with radial blades produces a larger pressure rise than the same pump with backward- or forward inclined blades over a wide range of V. | 10 | 6 | L2 | 2 | 2.1.2 |
| 8a | What is the more common term for an energy producing turbomachine? How about an energy-absorbing turbomachine? Explain this terminology. | 10 | 6 | L2 | 2 | 1.3.1 |
| 8b | A Francis turbine with an overall efficiency of 75% is required to produce 148.25 kW power. It is working under a head of 7.62m. The peripheral velocity=0.26√2gH and the radial velocity of flow at inlet is 0.96√2gH. The wheel runs at 150rpm and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge, determine; (i) Guide blade angle (ii) The wheel vane angle at inlet (iii) Diameter of wheel at inlet (iv) Width of the wheel at inlet. | 10 | 6 | L3 | 2 | 2.1.2 |

Once the question paper is set, the following visual representation is generated to understand the overall cognitive level of the question paper.

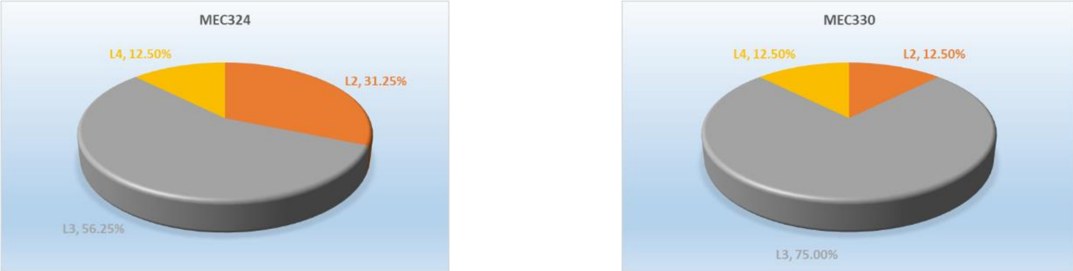



Figure Question paper pattern showing the learning levels addressed

Question papers with emphasis on assessing only lower cognitive level may be modified by the review committee to improve the quality of question paper.

**PO Attainment - Direct**

The direct attainment status for the students of 2017-18 academic year has been calculated by considering the average of attainment in all the core courses of the program and the associated graphs in Fig.

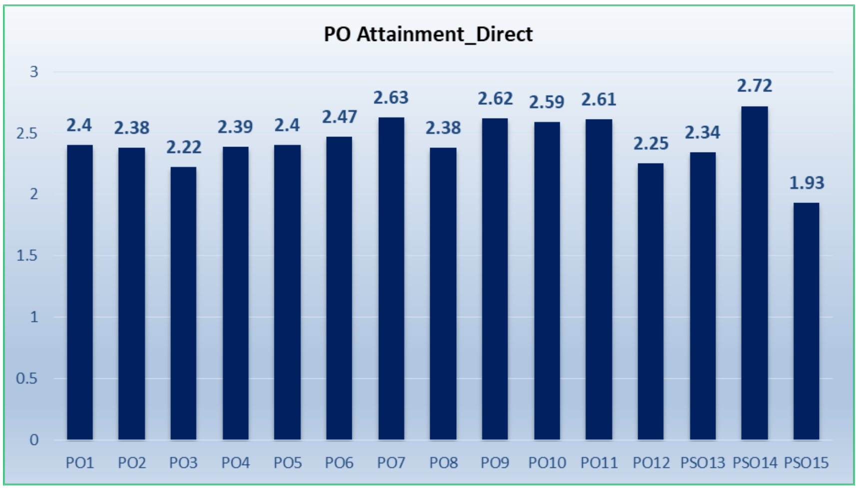



Figure Direct Attainment Status of Program Outcomes

The attainment for design and development of solutions is 2.22 (around 75%) of the maximum possible attainment of 3. The attainment exceeds 80% in case of professional outcomes except PO8 and PO12 and the attainment of program specific outcome PO15 is the least among all. The School has taken measures in the School faculty meeting to enhance the attainment. At the same time measures have also been identified to improve the attainment in case of technical outcomes. The details are provided in the Criterion 7.

**PO Attainment – Indirect**

The school has captured through survey the perceptions of alumni, employers and graduated students about the program outcomes' attainment. The survey details are as follows:

***a. Alumni Survey for Program Outcomes***

The alumni survey questions are consciously mapped to the POs. The no. of responses received (71nos.) from alumni for every question in terms of completely satisfied, satisfied, dissatisfied, and completely dissatisfied has been computed.

The 4 options are assigned with weights as completely dissatisfied – 0.0, dissatisfied – 1.0, satisfied – 2.0, completely satisfied – 3.0. Number of responses per question per option is multiplied with the corresponding weight factor to get weighted response.

The sum of the weighted responses (*for 4 options*) for each question is divided by the total no. of responses for that particular question to get average response. The combined weighted average for each question and hence for each PO is calculated.

***b. Employer Survey for Program Outcomes***

The employer survey questions are consciously mapped to the POs. The no. of responses received (27nos.) from employer as regards to ranking the working professional (*graduate of the program*) for every question as excellent, high, good average and low has been computed.

The 5 options are assigned with weights as low – 0.0, average – 0.75, good – 0.50, high – 2.25, excellent – 3.0. Number of responses per question per option is multiplied with the corresponding weight factor to get weighted response. The sum of the weighted responses (*for 5 options*) is divided by the total no. of responses for that particular question to get average response. The combined weighted average for each question and hence for each PO is calculated.

***c. Exit Survey for Program Outcomes***

The exit survey questions are consciously mapped to the POs. The no. of responses received from outgoing graduates (165nos.) for every question in terms of completely satisfied, satisfied, dissatisfied, and completely dissatisfied has been computed.

The 4 options are assigned with weights as completely dissatisfied – 0.0, dissatisfied – 1.0, satisfied – 2.0, completely satisfied – 3.0. Number of responses per question per option is multiplied with the corresponding weight factor to get weighted response. The sum of the weighted responses (*for 4 options*) for each question is divided by the total no. of responses for that particular question to get average response. The combined weighted average for each question and hence for each PO is calculated.

The average attainment of Program Outcomes from these surveys is as in Table.

Table Attainment of POs - Indirect Method

| Survey | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO13 | PSO14 | PSO15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alumni | 2.38 | 2.23 | 2.04 | 1.86 | 2.01 | 2.04 | 2.29 | 2.44 | 2.65 | 2.42 | 2.31 | 2.28 | 2.03 | 2.05 | 1.94 |
| Employer | 2.29 | 2.34 | 2.07 | 2.16 | 2.32 | 2.15 | 2.35 | 2.26 | 2.45 | 2.37 | 2.35 | 2.26 | 2.21 | 2.07 | 1.75 |
| Exit | 2.10 | 2.13 | 2.16 | 1.98 | 2.11 | 1.99 | 2.05 | 1.99 | 2.10 | 2.06 | 2.05 | 2.15 | - | - | - |
| **Indirect Attainment** | **2.26** | **2.23** | **2.09** | **2.00** | **2.15** | **2.06** | **2.23** | **2.23** | **2.40** | **2.28** | **2.24** | **2.23** | **2.12** | **2.06** | **1.85** |

The following graph in Fig. gives the overall attainment status of Program Outcomes through indirect method.

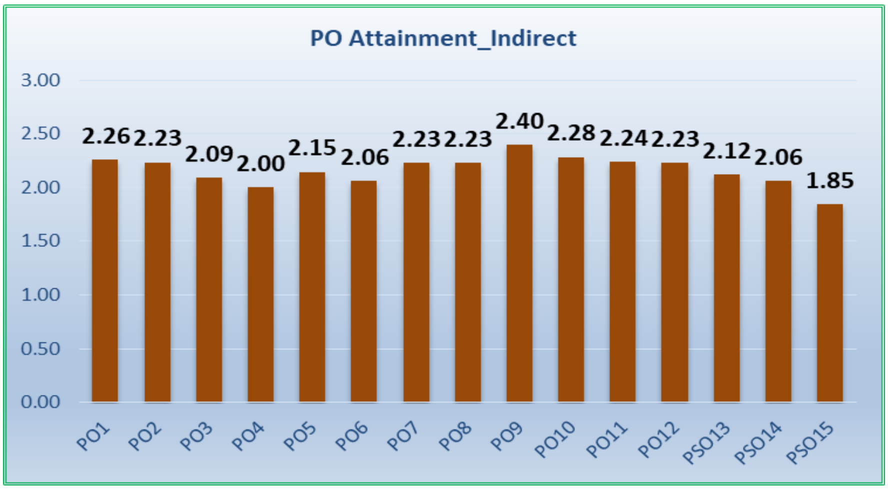
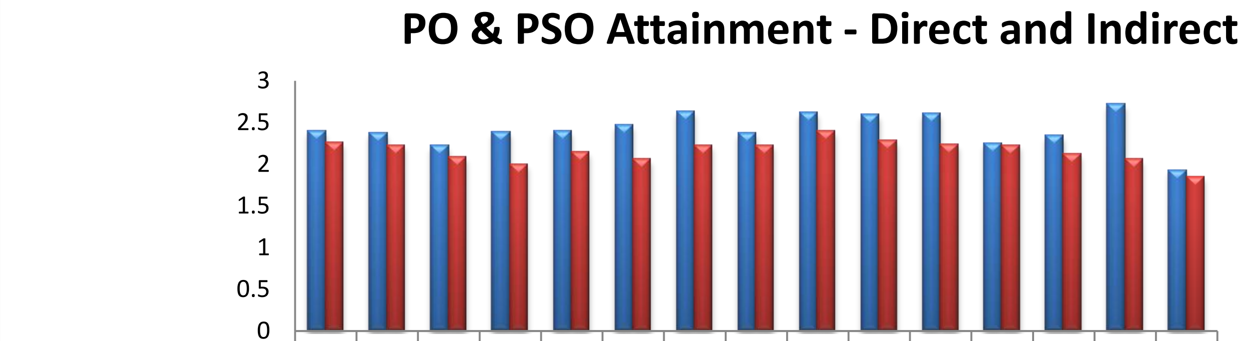



Figure Indirect Attainment Status of Program Outcomes

The attainment for both technical and professional outcomes is 70% and above except PO4 and PO6. The attainment in program specific outcomes is in the range of 60% to 70%. The school committee took a decision to devise a comprehensive improvement plan, which is discussed in section 7.1 of Criterion 7. As per the plan, identify three POs, one from each group (Technical 1 to 5, Professional 6 to 12 and Program Specific Outcomes 13, 14, 15) where the attainment status is low(less than 70% in the present case) compared to other POs in the same group and channelize efforts at program level in improving the attainment while the course coordinators/course instructors exercise care on the outcomes relevant to their courses to strengthen student learning in the respective outcomes.

The following graph in Fig. gives the comparison between direct and indirect attainment of Program Outcomes.




| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO13 | PSO14 | PS015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Direct Attainment | 2.4 | 2.38 | 2.22 | 2.39 | 2.4 | 2.47 | 2.63 | 2.38 | 2.62 | 2.59 | 2.61 | 2.25 | 2.34 | 2.72 | 1.93 |
| Indirect Attainment | 2.26 | 2.23 | 2.09 | 2 | 2.15 | 2.06 | 2.23 | 2.23 | 2.4 | 2.28 | 2.24 | 2.23 | 2.12 | 2.06 | 1.85 |

The following graph in Fig. gives the total attainment of Program Outcomes.