# PDM UNIVERSITY
# DEPARTMENTOF MECHANICAL ENGINEERING
# Master of Technology (Thermal Engineering)

**PROGRAM SCHEME**

**SEMESTER - I**

| MODULE CODE | CATEGORY | MODULE | L | T | P | C | INTERNAL MARKS | EXTERNAL MARKS | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| MECH5151 | PC | HEAT TRANSFER-I | 4 | 0 | 0 | 4 | 50 | 100 | 150 |
| MECH5152 | PC | ADVANCE FLUID DYNAMICS | 3 | 1 | 0 | 3.5 | 50 | 100 | 150 |
| MECH5153 | PC | ADVANCED THERMODYNAMICS | 3 | 1 | 0 | 3.5 | 50 | 100 | 150 |
| MECH5154 | PC | ADVANCED THERMODYNAMICS LAB | 0 | 0 | 2 | 1 | 25 | 25 | 50 |
| MECH5155 | PC | INSTRUMENTATION & MEASUREMENTS | 3 | 0 | 0 | 3 | 25 | 75 | 100 |
| MECH5156 | PC | INSTRUMENTATION & MEASUREMENTS LAB | 0 | 0 | 2 | 1 | 25 | 25 | 50 |
| MECH5157 | SP | SPECIAL PROBLEM | 0 | 0 | 2 | 1 | 25 | 25 | 50 |
| | GE | ELECTIVE-A | 4 | 0 | 0 | 4 | 50 | 100 | 150 |
| **TOTAL** | | | **17** | **2** | **6** | **21** | **300** | **550** | **850** |

**L = Lecture**

**T = Tutorial**

**P = Practical**

**C = Credit Point**

| MODULE CODE | GENERIC ELECTIVE - A |
|---|---|
| SAPA0320 | SAP (ABAP)ψ |
| SAPM0321 | SAP (MM)ψ |
| SAPS0322 | SAP (SD)ψ |
| SAPH0323 | SAP (HCM)ψ |
| SAPF0324 | SAP (FI)ψ |
| CCNA0325 | CCNAψ |
| MATH0302 | NUMERICAL ANALYSIS & OPTIMISATION |

**ψAdditional fee, if any, shall be borne by the student.**

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## SEMESTER - I

**HEAT TRANSFER-I**

| L | T | P |
|---|---|---|
| 4 | 0 | 0 |

| | |
|---|---|
| MODULE CODE | MECH5151 |
| CREDIT POINTS | 4 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To achieve knowledge of advanced techniques for analysis of heat transfer processes in thermal systems.
2. To introduce history, importance and components of chemical engineering, concepts of unit operations and unit processes, and current scenario of chemical & allied process industries.

**LEARNING OUTCOMES:**

1. Able to understand the basic laws of heat transfer.
2. Account for the consequence of heat transfer in thermal analyses of engineering systems.
3. Ability to analyze problems involving steady state heat conduction in simple geometries.
4. Able to develop solutions for transient heat conduction in simple geometries.
5. Enhance the knowledge to obtain numerical solutions for conduction and radiation heat transfer problems.
6. Understand the fundamentals of convective heat transfer process.

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**Module Content:**

| |
|---|
| *Unit I: Introduction and Basic Concepts*<br>Thermodynamics and Heat Transfer, Heat and other form of energy, Energy balance for steady- flow systems, Surface energy balance, Heat Transfer Mechanisms, Simultaneous heat transfer mechanism, Problem-solving Technique. |
| *Unit II: Heat Conduction Equation*<br>Statement of Problem, Steady versus Transient Heat transfer, Multidimensional Heat Transfer, One- Dimensional Heat Conduction Equation in large plane wall, in long cylinder and in a sphere; Combined one dimensional Heat conduction Equation. General Heat conduction Equation in Rectangular, Cylindrical and Spherical coordinates. Boundary and initial condition – Specified Temperature Boundary condition, Specified heat flux Boundary condition, Convection Boundary condition, Radiation Boundary condition, Interface Boundary condition and Generalized Boundary condition. Solution of steady One-Dimensional Heat conduction Problems. Variable Thermal conductivity. |
| *Unit III:* Steady Heat conduction<br>Steady Heat conduction in plane walls – Thermal Resistance concept, Thermal Resistance Network and Multilayer plane wall; Thermal contact resistance, Generalized Thermal Resistance Networks; Heat conduction in cylinders and spheres, critical radius of insulations; Heat transfer from finned surface – Fin Equation, Fin Efficiency, Fin Effectiveness, Proper Length of a fin. Heat Transfer of common configuration. |
| *Unit IV: Transient Heat Conduction*<br>Lumped System Analysis, Transient Heat conduction in large plane walls, Long cylinders, and sphere with spatial Effects, Transient Heat conduction in semi-infinite solids, Transient Heat conduction in Multidimensional systems |
| *Unit V: Numerical Methods in Heat Conduction*<br>Reasons for Numerical methods, Finite Difference Formulation of Differential Equations, One- Dimensional steady Heat conduction, Two- Dimensional steady Heat conduction, Transient Heat Conduction. |
| *Unit VI: Fundamental of Thermal Radiation and Radiation Heat Transfer*<br>Introduction, Thermal Radiation, Blackbody Radiation, Radiation Intensity, Radiative Properties, Atmospheric and solar Radiation. The View factor, View factor relation, Radiation Heat transfer: Black surfaces, Radiation Heat transfer: Diffuse, gray surfaces; Radiation shield and Radiation effects, Radiation Exchange with emitting and absorbing gases. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Y A Cengel – Heat & Mass Transfer, 4th Edition, McGraw-Hill Publishers, 2010<br>2. Mills, A. F., Heat and Mass Transfer, Irwin, Chicago, Ill., 1995.<br>3. Incropera, F. P., and DeWitt, D. P., Fundamentals of Heat and Mass transfer, Wiley, New York, 1996.<br>4. White, F. M., Viscous fluid flow, McGraw-Hill, New York, 1991. |
| **REFERENCE BOOKS** | 1. Vincenti, W. G., and Kruger, C. H., Introduction to physical gas dynamics, Wiley, New York, 1965.<br>2. Kays, W. M., and Crawford, M. E., Convective heat and mass transfer, McGraw-Hill, New York, 1993.<br>3. Bejan, A., Convection heat transfer, J. Wiley, New York, 1995.<br>4. Siegel, R., and Howell, J. R., Thermal radiation heat transfer, Hemisphere Pub. Corp. Washington, D.C., 1992. |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

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## MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES

**Theory:**

| Assessments | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Class Test | X | | | x | | x |
| Quiz | | x | x | | | |
| Assignment | X | | x | x | x | |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | a | b | c | d | e | f | g | h | i | j | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 5 | 3 | 2 | 2,6 | | 4 | 4 | 5,6 | | 2 | 3 |

## EVALUATION

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

- Problems encountered in the content delivery;
- Suggested remedies / corrective measures;
- Approved refinement decisions due for implementation;
- Actions taken based on previous course review; and
- Report discussed and analysed; actions taken as a result of this process and are communicated to the main stakeholders.

# PDM UNIVERSITY
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**ADVANCED FLUID DYNAMICS** **L T P**

3 1 0

| | |
|---|---|
| MODULE CODE | MECH5152 |
| CREDIT POINTS | 3.5 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To study fundamental, physical and mathematical concepts and the basic equations and situations.
2. To analysis flow characteristics like potential flow, sonic flow etc.
3. To understand the present solution and application to the navier-stokes equation.
4. To understand concept of boundary layer, laminar and turbulent flow clearly.

**LEARNING OUTCOMES:**

1. Ability to understanding the concept of fluid and the models of fluids.
2. Ability to understanding the basic physical meaning of general equations.
3. Able to Understanding the concept of stream function and potential function.
4. Able to derive the equation for viscous flow, including laminar flow and turbulent flow.
5. Ability to address such problems in engineering, and to solve the problems.
6. Ability to cooperate with the team members.

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**Module Content:**

| |
|---|
| *Unit I: Basics of thermodynamics*<br>Recapitulation of basic laws of fluid flow in integral and differential form; Ideal and non-ideal flows; continuum view point and general equations of fluid motion; Newtonian fluids; Fluid statics; Fluid Kinematics; Reynolds transport theorem; Integral and differential forms of governing equations; mass; momentum and energy conservation equations. |
| *Unit II: Two dimensional flow*<br>Subsonic flow, physical significance of irrotational motion; Kelvin's theorem; Differential equation in terms of velocity Potential and stream function; Flow with small perturbation; flow past a wave shaped wall; Gothert's rule; Prandtl-Glanertrul; Hodograph method. |
| *Unit III: Differential analysis*<br>Navier-Stokes Equations and their exact solutions; Couette flows; Poiseuille flows; Fully developed flows in non-circular cross-sections; Unsteady flows- Creeping flows, Turbulence, models, flow equations, steady and unsteady turbulent boundary layers; Introduction to computational fluid dynamics (CFD); Boundary conditions; Basic discretization – Finite difference method, Finite volume method and Finite element method. |
| *Unit IV: Laminar boundary layer analysis*<br>Laminar boundary layers; Boundary layer analysis-equations, boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations; Approximate Methods; Flow separation; Entry flow into a duct. |
| *Unit V: Turbulent Boundary layer flow*<br>Introduction; Fluctuations and time-averaging; General equations of turbulent flow; Turbulent boundary layer equation; Flat plate turbulent boundary layer; Turbulent pipe flow; Prandtl mixing hypothesis; Turbulence modeling; Free turbulent flows. |
| Unit VI: Potential flow analysis<br>Recapitulation of fluid kinematics; Stream and velocity potential function; Circulation; Irrotational vortex; Basic plane potential flows; Uniform stream; Source and sink; Vortex flow; Doublet; Superposition of basic plane potential flows; Flow past a circular cylinder; Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Compressible Fluid Flow: S M Yahiya Tata McGraw Hill, New Delhi.<br>2. Introduction to Fluid Mechanics: Fox W Robert, TMcDonald John Wiley & Sons, New Delhi.<br>3. Fluid Mechanics: Frank M White Tata McGraw-Hill, New Delhi. |
| **REFERENCE BOOKS** | 1. Fundamentals of Aerodynamics: John D. Anderson Jr McGraw-Hill, New york<br>2. Computational Fluid Dynamics: The Basics with Applications, John D. Anderson Jr,McGraw-Hill, New York.<br>3. Advanced Engineering Fluid Mechanics: K Muralidhar and G Biswas Narosa Publication, New Delhi.<br>4. Incompressible Flow: R L Panton John Wiley and Sons, New Delhi. |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

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## MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES

**Theory:**

| Assessments | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Class Test | | x | x | | | x |
| Quiz | | | x | | X | |
| Assignment | X | x | | x | | |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | a | b | c | d | e | f | g | H | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 1 | 3 | 2,6 | 2 | 6 | 3 | 4 | | 5 | 2 | 3 |

## EVALUATION

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

- Problems encountered in the content delivery;
- Suggested remedies / corrective measures;
- Approved refinement decisions due for implementation;
- Actions taken based on previous course review; and
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**ADVANCED THERMODYNAMICS**

| L | T | P |
|---|---|---|
| 3 | 1 | 0 |

| | |
|---|---|
| MODULE CODE | MECH5153 |
| CREDIT POINTS | 3.5 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To learn fundamental, physical and mathematical concepts and the basic equations.
2. To understand the study real gas behavior and joule Thompson coefficient.
3. To understand the concept of psychrometry and air conditioning.
4. To learn basic concepts of boundary layer, laminar and turbulent flow clearly.
5. To understand the equilibrium conditions, irreversibility phenomenon and power generation cycles.

**LEARNING OUTCOMES:**

1. Able to analyse the equilibrium and kinetics of combustion of different fuels.
2. Ability to use computer software to solve combustion kinetics and flame structures with detailed reaction mechanisms.
3. Able to understand the fundamental principles of thermodynamics to numerous engineering devices.
4. Enhance the knowledge of systems approach to simplify a complex problem.

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**MODULE CONTENT:**

| |
|---|
| *Unit I*: *Basics of thermodynamics*<br>Review of thermo dynamic laws and corollaries: recapitulation of zeroth, first, second laws of thermodynamics; First and second law analysis of simple closed and open systems; concepts of entropy; irreversibility; availability; Energy; evaluation of thermodynamic properties of working substance; General conditions for thermodynamic equilibrium; Introduction to instability of thermodynamic equilibrium. |
| *Unit II: Pure substances*<br>Single-component pure substances; Equations of state; real gas behaviour; Vander waal's equation generalised compressibility factor; Energy properties of real gases; Vapour pressure; Clausiusclapeyron equation; Throttling; Joule thompson coefficient. |
| *Unit III: Multi component system and psychometry*<br>Multi-component Systems - Non-reactive mixture of perfect gases; Governing laws; Evaluation of properties; Mixture of real gases; Psychrometry- Psychrometric chart; Applications to air conditioning processes and cooling towers. |
| *Unit IV: Combustion*<br>Thermodynamics of Reactive Mixtures: Combustion; combustion reactions; enthalpy of formation; Entropy of formation; reference levels for tables; Energy of formation; Heat of reaction; Adiabatic flame temperature general product; Enthalpies; Equilibrium- Chemical equilibrium of ideal gases, effects of non-reacting gases equilibrium in multiple reactions; Vanthoff's equation, chemical potential and phase equilibrium, gibbs phase rule. |
| *Unit V: Applications of thermodynamics*<br>Mechanical Engineering applications of thermodynamics: Power generation; Maximum power subject to size constraint; Maximum power from hot stream; External irreversibilities, internal irreversibilities, Advanced steam-turbine power plants; advanced gas-turbine power plants; combined steam-turbine and gas-turbine power plants; Supercritical power cycle. |
| *Unit VI: Power and refrigeration*<br>Power-Thermodynamic properties of thermal radiation; Reversible processes; irreversible processes; Ideal conversion of enclosed blackbody radiation; Maximization of power output per unit collector area; Convectively cooled collectors, Extraterrestrial solar power plant; Non isothermal collectors; Time-varying conditions; Solar-driven refrigerators. Refrigeration: Optimal intermediate cooling; Liquefaction; Refrigerator models with heat transfer irreversibilities: Magnetic refrigeration. entropy generation minimization; trade-off between competing irreversibilities; Balanced counter flow heat exchangers; Heat exchangers with negligible pressure-drop irreversibility; storage systems. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Advanced Engineering Thermodynamics: A Bejan John Wiley and sons, New Delhi.<br>2. Kinetic Theory and Statistical Thermodynamics: F W Sears, G L Salinger Narosa Publishing House, New Delhi.<br>3. Fundamentals of Engineering Thermodynamics: M J Moran, H N Shapiro John Wiley and Sons, New Delhi. |
| **REFERENCE BOOKS** | 1. Heat and Thermodynamics: M W Zemansky, R H Dittman McGraw Hill, New York. |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

**MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES**

**Theory:**

| Assessments | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Class Test | x | | X | |
| Quiz | | x | | |
| Assignment | x | x | | x |

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## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | a | b | c | D | e | f | g | H | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 4 | 3 | 3 | 2 | 4 | 3 | 2 | 1 | | 4 | |

## EVALUATION

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

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**ADVANCED THERMODYNAMICS LAB**

| L | T | P |
|---|---|---|
| 0 | 0 | 2 |

| | |
|---|---|
| MODULE CODE | MECH5154 |
| CREDIT POINTS | 1 |
| FORMATIVE ASSESSMENT MARKS | 25 |
| SUMMATIVE ASSESSMENT MARKS | 25 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**OBJECTIVES:**

1. To provide a good platform to mechanical engineering students to understand, model and appreciate concept of dynamics involved in thermal energy transformation.
2. To prepare them to carry out experimental investigation and analysis at later stages of graduation.

**LEARNING OUTCOMES:**

1. Enhance the knowledge of mathematics, science and engineeringfundamentals to model the energy conversion phenomenon.
2. Able to identify and formulate power production based on the fundamentals laws of thermal engineering.
3. Able to investigate the effectiveness of energy conversion process in mechanical power generation for the benefit of mankind.
4. Exposure to acquire knowledge of basic concepts learnt in fundamentals laws of thermodynamics from which learning ideas how to sustain in energy crisis and think beyond curriculum in the field of alternative and renewable sources of energy.
5. Able to communicate effectively the concepts of internal combustion engines and try to think beyond curriculum in alternative sources of energy.

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**LIST OF EXPERIMENTS**

| | |
|---|---|
| 1. | To plot the temp. v/s time response of the three pipes of different materials (test pipe, copper pipes , stainless pipes). |
| 2. | To evaluate natural convective heat transfer coefficient and to calculate and to plot variation of natural convective heat transfer coefficient along the vertical tube. |
| 3. | Study of single cylinder four stroke petrol engine. |
| 4. | Comparative study of fuel oils. |
| 5. | Study Linear Variable Differential Transformer (LVDT) and use it in experimental set up to measure a small displacement. |
| 6. | To measure the stress & strain using strain gauges mounted on simply supported beam/cantilever beam. |
| 7. | To determine COP of cascade refrigeration system. |
| 8. | To determine gas pollutants and smoke density of exhaust gases. |
| 9. | Study of performance testing refrigeration system. |
| 10. | Testing of box type solar cooker in outdoor conditions. |
| 11. | Study of parallel flow and counter flow heat exchanger. |
| 12. | Perform study of cooling tower. |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 50 marks for practical.

**Practical:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1 | Internal Assessment | 2 | 25 |
| 2 | External Assessment | 1 | 25 |

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## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | a | b | c | D | E | f | g | h | I | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 3,5 | 2,6 | 2,3 | 4 | 1,2 | | 4 | | 3 | | 5 |

## EVALUATION

At the end of semester, Subject teacher will submit an evaluation report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the subject with respect to its strengths as well as those areas which could be improved. The review report contains the following:

- Approved refinement decisions due for implementation,
- Actions taken based on previous subject review,
- Problems encountered in the subject delivery,
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**INSTRUMENTATION& MEASUREMENTS**

| L | T | P |
|---|---|---|
| 3 | 0 | 0 |

| | |
|---|---|
| MODULE CODE | MECH5155 |
| CREDIT POINTS | 3 |
| FORMATIVE ASSESMENT MARKS | 25 |
| SUMMATIVE ASSESMENT MARKS | 75 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To learn basic concepts of instrumentation and measurement techniques.
2. To get familiar with Study signal processing and control.
3. Analyze displacement and motion measurement techniques.
4. To acquire knowledge of study angular velocity and torque measurement.
5. Analyze temperature and pressure measurement.
6. Study obstruction meter and applications of instrumentation.

**LEARNING OUTCOMES:**

1. Able to analyse the response of any electrical machine.
2. Exposure to troubleshoot the operation of an electrical machine.
3. Ability to select a suitable measuring instrument for a given application.
4. Ability to estimate and correct deviations in measurements due to the influence.

of the instrumentand due to the accuracy of the instrument.

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**MODULE CONTENT:**

| |
|---|
| *Unit I: Basics of Instrumentation*<br>*I*ntroduction to instrumentation; Major elements of a measurement system order; Type of signals; Response of instruments; Importance of sensors in measuring system; Errors and response characteristics of sensors; Measurement error, measurement techniques. |
| *Unit II: Signal conditioning*<br>Amplification and noise filtering; impedance matching; Wheatstone bridge technique; Digital signal processing- Sampling rate, aliasing, discretization, A/D and D/A converters, frequency content of a signal, concept of FFT; Common measuring instrument-Multimeters, oscilloscope, spectrum analyzer, display and recorder, plotter; Statistical analysis of data- Concept of normal distribution, mean and variance (standard deviation). |
| *Unit III: Displacement and angular velocity measuring instruments*<br>Potentiometer, linear variable differential transformer, Strain gauge, proximity probe. Mechanical and electric tachometer; Seismic instrument- Accelerometer; Force, torque & power measurement force measurement-Elastic force transducer, piezoelectric force transducer, hydraulic and pneumatic method. |
| *Unit IV: Torque measurement*<br>Torque measurement using shaft deflection, using induced strain, torque reaction method. Power measurement- Absorption dynamometer, mechanical & hydraulic method, transmission dynamometer, torque meter. |
| Unit V: Temperature and pressure measurement<br>Thermal expansion method, Liquid-in-glass thermometer, pressure thermometer, bimetal type thermometer resistance thermometer, RTD, thermostat, thermocouple, quartz thermometer, radiation thermometer. Measuring static pressure- Piezometer, manometer; Measuring dynamic& static pressure- Pressure transducer, bellow-type, diaphragm-type, piezoelectric, bourdon tube pressure gauge; Flow Measurement. |
| *Unit VI: Flow measurement*<br>Venturi meter, nozzle, orifice meter, pitot tube; Positive displacement flow meter- Rotary-vane meter, rotameter; Special methods- Turbine flow meter, ultrasonic flow meter, magnetic flow meter, hot wire anemometer, open channel flow meter, laser doppler flow meter. Examples of Instrumentation: Boiler power plant instrumentation; Air conditioning plant control; Industrial robotics system. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Instrumentation and Measurement: B C Nakra, KK Choudhry, Tata McGraw Hill, New Delhi.<br>2. Instrumentation for Engineering Measurements: J W Dally John Wiley & Sons, New Delhi |
| **REFERENCE BOOKS** | 1. Experimental Methods for Engineers: J P Holman McGraw Hill, New York.<br>2. Mechanical Measurements: Thomas Beckwith and Lewis Buck Narosa Publishing House, New Delhi. |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 100 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 05 |
| 2. | Sessional Test | 2 | 15 |
| 3. | Group Discussion | 4 | 05 |
| 4. | End Semester Exam | 1 | 75 |

**MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES**

**Theory:**

| Assessments | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Class Test | x | x | | |
| Quiz | | | X | |
| Assignment | x | x | | x |

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## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | a | b | c | D | e | f | g | H | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 2 | 3 | | 2 | 4 | 4 | | 3 | | 2 | 1 |

## EVALUATION

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

- Problems encountered in the content delivery;
- Suggested remedies / corrective measures;
- Approved refinement decisions due for implementation;
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**INSTRUMENTATION & MEASUREMENTS LAB**

| **L** | **T** | **P** |
|---|---|---|
| 0 | 0 | 2 |

| | |
|---|---|
| MODULE CODE | MECH5156 |
| CREDIT POINTS | 1 |
| FORMATIVE ASSESSMENT MARKS | 25 |
| SUMMATIVE ASSESSMENT MARKS | 25 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**OBJECTIVES:**

1. To prepare students to perform the analysis of any electromechanically system.
2. To empower students to understand the working of electrical equipment used in everyday life.
3. To prepare the students for advanced courses in robotics.

**LEARNING OUTCOMES:**

1. Ability to formulate and then analyze the working of any electrical machine using mathematical model under loaded and unloaded condition.
2. Able to analyze the response of any electrical machine.
3. Ability to troubleshoot the operation of an electrical machine
4. Ability to select a suitable measuring instrument for a given application.
5. Able to estimate and correct deviations in measurements due to the influence of the instrument and due to the accuracy of the instrument.

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**LIST OF EXPERIMENTS**

Experiments on measurement of linear displacement and motion by LVDT; temperature measurement by RTD Thermistor and Thermocouple; pressure and fluid flow. Applications of plotters and recorders, Inductive Pick up Strain Gauge based cantilever, the load measurement by load cell and strain gauge based cantilever.

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## METHODS OF TEACHING AND STUDENT LEARNING

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## ASSESSMENT METHODOLOGIES:

This subject will be evaluated for a total of 50 marks for practical.

**Practical:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1 | Internal Assessment | 2 | 25 |
| 2 | External Assessment | 1 | 25 |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | a | b | c | D | E | f | g | h | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 5 | 2 | 2 | 4 | 2,5 | | 4,5 | | 3 | | 2,5 |

## EVALUATION

At the end of semester, Subject teacher will submit an evaluation report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the subject with respect to its strengths as well as those areas which could be improved. The review report contains the following:

- Approved refinement decisions due for implementation,
- Actions taken based on previous subject review,
- Problems encountered in the subject delivery,
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**Special Problem** **L T P**
**0 0 2**

| | |
|---|---|
| MODULE CODE | MECH5157 |
| CREDIT POINTS | 1 |
| FORMATIVE ASSESMENT MARKS | 25 |
| SUMMATIVE ASSESMENT MARKS | 25 |
| END SEMESTER EXAM DURATION | 3 hrs |
| LAST REVISION DATE | |

A special problem is an individual study in a specialized area under the direction of a faculty of the Department. Student will select a problem after discussing with guide and completes it under his/her supervision. Each special problem must culminate in a written final report, which is to be submitted to the committee appointed by the Head of the Department who will evaluate the performance and award the marks.

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**NUMERICAL ANALYSIS & OPTIMIZATION** **L T P**

4 0 0

| | |
|---|---|
| MODULE CODE | MATH0302 |
| CREDIT POINTS | 4 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
2. To develop and promote research interest in applying optimization techniques in problems of engineering and technology.
3. To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

**LEARNING OUTCOMES:**

1. Able to understand the special Featuresunderstand the bases of linear programming, unconstrained optimization, and constrained optimization.
2. Exposure to analyze the behavior of these numerical methods and in particular to be able to discuss their stability, their order of convergence and their conditions of application.
3. Ability to analyze a problem and identify the computing requirements appropriate for its solution.
4. Ability to acquire knowledge of mathematics and computing to the design and analysis of optimization methods.

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***MODULE* CONTENT:**

| |
|---|
| *Unit I: ERRORS IN NUMERICAL CALCULATIONS*<br>Introduction, Numbers and their accuracy, Absolute, relative and percentage errors and their analysis, General error formula. |
| *Unit II: INTERPOLATION AND CURVE FITTING*<br>Taylor series and calculation of functions, Introduction to interpolation, Lagrange approximation, Newton Polynomials, Chebyshev Polynomials, Least squares line, curve fitting, Interpolation by spline functions. |
| *Unit III: NUMERICAL DIFFERENTIATION AND INTEGRATION*<br>Approximating the derivative, Numerical differentiation formulas, Introduction to Numerical quadrature, Newton-Cotes formula, Gaussion- Quadrature. Direct methods, Gaussian elimination and pivoting, Matrix inversion, UV factorization, iterative methods for linear systems, Bracketing methods for locating a root, Initial approximations and convergence criteria, Newton- Raphson and Secant methods. |
| *Unit IV: SOLUTION OF DIFFERENTIAL EQUATIONS*<br>Introduction to differential equations, Initial value problems, Euler s methods, Runge-Kutta methods, Taylor series method, Predictor- Corrector methods, Finite-difference method. Solution of hyperbolic, parabolic and elliptic equations, Eigen value problem, Power and inverse power methods, Jacobi s method for Eigen value problems. |
| *Unit V: OPTIMIZATION METHODS*<br>Optimal problem formulation, Engineering optimization problems; optimization algorithms: Single-variable optimization algorithms, optimality criteria, Bracketing methods, Region-elimination methods, Point estimation method. |
| *Unit VI: MULTI- VARIABLE OPTIMIZATION ALGORITHMS*<br>Optimality criteria, Uni-directional search, Direct search methods: Evolutionary methods, Simplex search method, Gradient based methods: Cauchy s method, Newton's method, Application to Mechanical Engg. Problems, Non- traditional optimization algorithms, Genetic algorithms (GA), GA for constrained optimization, other GA operators, Multi objective Optimization, Concept of Pareto Optimality, Global optimization. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Numerical Methods for Mathematics, Science and Engineering by John H.Mathews, PHI New Delhi.<br>2 Applied Numerical Methods Carnahan, B.H., Luthar, H.A. and Wilkes, J.O., Pub.- J. Wiley, New York |
| **REFERENCE BOOKS** | 1. Numerical Solution of Differential Equations, by M.K. Jain,<br>Published by Wiley Eastern, New York.<br>2. Introductory Methods of Numerical Analysis by S.D. Sastry, Published by Prentice Hall of India |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

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**MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES**

**Theory:**

| Assessments | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Class Test | | x | | x |
| Quiz | x | | X | |
| Assignment | x | | | x |

**MAPPING OF COURSE LEARNING OUTCOMES**

| Program Outcomes | a | b | c | d | e | f | G | H | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 4 | 3 | 2 | 3 | | 3 | | 3 | | 2 | 1 |

**EVALUATION**

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

- Problems encountered in the content delivery;
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**SEMESTER - II**

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| MODULE CODE | CATEGORY | MODULE | L | T | P | C | INTERNAL MARKS | EXTERNAL MARKS | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| MECH5158 | PC | ADVANCED GAS DYNAMICS | 4 | 0 | 0 | 4 | 50 | 100 | 150 |
| MECH5159 | PC | HEAT TRANSFER-II | 3 | 0 | 0 | 3 | 25 | 75 | 100 |
| MECH5160 | PC | HEAT TRANSFER-II LAB | 0 | 0 | 2 | 1 | 25 | 25 | 50 |
| MECH5161 | PC | STEAM & GAS TURBINES | 4 | 0 | 0 | 4 | 50 | 100 | 150 |
| MECH5162 | SP | SEMINAR | 0 | 0 | 2 | 1 | 25 | 25 | 50 |
| RESM0101 | PC | RESEARCH METHODOLOGY | 4 | 0 | 0 | 4 | 50 | 100 | 150 |
| | PE | ELECTIVE-I | 4 | 0 | 0 | 4 | 50 | 100 | 150 |
| **TOTAL** | | | **19** | **0** | **4** | **21** | **275** | **525** | **800** |

**L = Lecture**

**T = Tutorial**

**P = Practical**

**C = Credit Point**

**ELECTIVES**

| MODULE CODE | PROGRAM ELECTIVE I |
|---|---|
| MECH5263 | THERMAL & NUCLEAR POWER PLANTS |
| MECH5264 | WIND ENERGY TECHNOLOGY |

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**ADVANCED GAS DYNAMICS**

| L | T | P |
|---|---|---|
| 4 | 0 | 0 |

| | |
|---|---|
| MODULE CODE | MECH5158 |
| CREDIT POINTS | 4 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To understand fundamental of compressible flow.
2. To present and analyse the basic equation for one dimensional flow.
3. Analyse the heat transfer in fanno flow and Rayleigh flow.
4. Analyse two and multi-dimensional compressible flow.

**LEARNING OUTCOMES:**

1. Able to classify the different fluid flow regimes.
2. Able to understand the underlying physical mechanisms of compressible fluid flow.
3. Enhance the knowledge of mathematics to derive comprisable flow relations for solution of fluid flow problems.
4. Enhance the knowledge of various flow parameters in different flow regimes with various flow conditions.
5. Able to understand the concepts of normal shock; oblique shock; fanno flow and Rayleigh flow for solving the real world engineering problems.

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***MODULE* CONTENT:**

| |
|---|
| *Unit I: Compressible flow*<br>Introduction to compressible viscous flow; Governing equations. |
| *Unit II: 1-D Compressible flow*<br>Speed of sound and Mach number; Basic equations for one dimensional flows; Isentropic relations. |
| *Unit III: Nozzle and Diffusers*<br>Flow though nozzle and diffusers; Flow with friction- Fanno flow, flow with heat transfer, Rayleigh flow. |
| *Unit IV: Shock waves*<br>Normal and oblique shocks; Mach waves; Prandtl–Meyer expansion; Rankine–Hugnoit relation; Application of method of characteristics applied to two dimensional cases – simple supersonic wind tunnel; Design of supersonic wind tunnel and nozzle. |
| *Unit V: Multi-dimensional flow*<br>Design performance of nozzles; Quasi-one dimensional flow; Multi-dimensional flow; Compressible boundary layers. |
| *Unit VI: Applications*<br>Interaction and intersection of shocks; P-M expansions and boundary layers; Reflection of shocks and Prandtl–Meyer expansion from solid surfaces and fluid surfaces; Application to simple problems related to propulsion and flow through turbo machines. |

**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Fundamentals of Compressible Flow: S M Yahya New Age Publishers, New Delhi.<br>2. Gas Dynamics: T Radhakrishnan Prentice Hall, New Delhi<br>3. Fluid Mechanics: A K Mohanty Prentice Hall of India, New Delhi. |
| **REFERENCE BOOKS** | 1. The Dynamics of Compressible flow: A F Shapiro The Ronald Press Company, New York.<br>2. Mechanics of Fluids: Shames Mcgraw Hill, New York.<br>3. Boundary layer theory: H SchlichtingMcgraw Hill, New York. |

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## METHODS OF TEACHING AND STUDENT LEARNING

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## ASSESSMENT METHODOLOGIES:

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

## MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES

**Theory:**

| Assessments | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Class Test | | x | | x | |
| Quiz | x | | x | | x |
| Assignment | x | | | x | x |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | a | b | c | D | e | f | g | h | i | j | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 4,5 | | 2 | 3,4 | | 3,4 | | 3 | | 2,5 | |

## EVALUATION

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At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

- Problems encountered in the content delivery;
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**HEAT TRANSFER-II** **L T P**

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3 0 0

| | |
|---|---|
| MODULE CODE | MECH5159 |
| CREDIT POINTS | 3 |
| FORMATIVE ASSESMENT MARKS | 25 |
| SUMMATIVE ASSESMENT MARKS | 75 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To study heat transfer rates from a small circular wire for forced and free convection.
2. To introduce the use of appropriate dimensionless groups for convective heat transfer.
3. To determine an empirical relationship for heat transfer in forced convection.

**LEARNING OUTCOMES:**

1. Ability to understand and solve conduction, convection and radiation problems.
2. Ability to design and analyze the performance of heat exchangers and evaporators.
3. Ability to design and analyze reactor heating and cooling systems.

**MODULE CONTENT:**

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| |
|---|
| *Unit-I: Fundamentals of Convection*<br>Physical Mechanism of Convection, Classification of Fluid Flows, Velocity Boundary Layer, Thermal Boundary Layer, laminar and Turbulent Flows, Heat and Momentum Transfer in Turbulent Flow, Differential Convection Equations and their Solutions, Analogies between Momentum and Heat Transfer. |
| *Unit-II: External and Internal Forced Convection*<br>Drag and Heat Transfer in External Flow, Parallel Flow over Flat Plates, Flow across Cylinders and Spheres, Flow over Tube Banks. Introduction, Average velocity and temperature, The entrance Region, General Thermal Analysis, Laminar Flow in Tubes, Turbulent Flow in Tubes. |
| *Unit-III: Natural Convection*<br>Physical Mechanisms, Equation of Motion and the Grashov Number, Natural Convection over Surfaces, Natural Convection from Finned Surfaces and PCBs, Natural Convection inside Enclosures, Combined Natural and Forced Convection. |
| *Unit-IV: Boiling and Condensation*<br>Boiling Heat Transfer, Pool Boiling, Condensation Heat Transfer,Film Condensation, Dropwise condensation. |
| *Unit-V: Basics of Heat Exchangers*<br>Types, Overall Heat Transfer Coefficient, Analysis of Heat Exchangers, The LMTD Method, The Effectiveness- NTU Method, Selection of Heat Exchangers. |
| *Unit-VI: Fundamentals of Mass Transfer*<br>Introduction, Analogy between Heat and Mass Transfer, Mass Diffusion, Boundary Conditions, Mass Convection, Simultaneous Heat and Mass Transfer.Heat Pipe -Introduction, Working of Heat pipe, Different types of Heat Pipe, Detail of Heat PipeComponents, Advantages of Heat Pipe, Application of Heat Pipe, Performance of Heat Pipe,Limitation of Heat Pipe, and Analysis of Heat Pipe. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Y A Cengel – Heat & Mass Transfer, 4th Edition, McGraw-Hill Publishers, 2010<br>2. Mills, A. F., *Heat and Mass Transfer*, Irwin, Chicago, Ill., 1995. |
| **REFERENCE BOOKS** | 1. Vincenti, W. G., and Kruger, C. H., Introduction to physical gas dynamics, Wiley, New York, 1965.<br>2. Kays, W. M., and Crawford, M. E., Convective heat and mass transfer, McGraw-Hill, NewYork, 1993.<br>3. Bejan, A., Convection heat transfer, J. Wiley, New York, 1995. |

**METHODS OF TEACHING AND STUDENT LEARNING**

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**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 05 |
| 2. | Sessional Test | 2 | 15 |
| 3. | Group Discussion | 4 | 05 |
| 4. | End Semester Exam | 1 | 75 |

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## MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES

**Theory:**

| **Assessments** | **1** | **2** | **3** |
|---|---|---|---|
| Class Test | | X | x |
| Quiz | | X | x |
| Assignment | x | | |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | A | b | c | d | e | f | g | H | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 3 | | 2 | 2 | 1 | 3 | | 3 | | 2 | |

## EVALUATION

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- Problems encountered in the content delivery;
- Suggested remedies / corrective measures;
- Approved refinement decisions due for implementation;
- Actions taken based on previous course review; and
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**HEAT TRANSFER-II LAB**

| L | T | P | |
|---|---|---|---|
| | 0 | 0 | 2 |

| | |
|---|---|
| MODULE CODE | MECH5160 |
| CREDIT POINTS | 1 |
| FORMATIVE ASSESSMENT MARKS | 25 |
| SUMMATIVE ASSESSMENT MARKS | 25 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**OBJECTIVES:**

1. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries
2. To evaluate radiation view factors using tables and the view factor relationships.
3. To understand the basic concepts of radiation heat transfer to include both black body radiation and gray body radiation.
4. To understand the fundamentals of the relationship between fluid flow, convection heat transfer and mass transfer.

**LEARNING OUTCOMES:**

1. Able to understand the basic lawsof heat transfer.
2. Account for the consequence of heat transfer in thermal analyses of engineering systems.
3. Able to analyze problems involving steady state heat conduction in simple geometries.
4. Able to develop solutions for transient heat conduction in simple geometries.
5. Ability to obtain numerical solutions for conduction and radiation heat transfer problems.

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**LIST OF EXPERIMENTS**

| | |
|---|---|
| 1. | Study of variation of emissivity of test plate with absolute temperature. |
| 2. | To demonstrate the super thermal conductivity of heat pipe. |
| 3. | To plot the temperature v/s time response of the three pipes (test pipe, copper pipe, and stainless pipe). |
| 4. | To plot the temperature distribution along the length of test pipe, copper pipe, stainless pipe. |
| 5. | Solar radiation. |
| 6. | To study and evaluate- performance of solar cell. |
| 7. | To determine natural convective heat transfer coefficient and to calculate and to plot variation of natural convective heat transfer coefficient along the vertical tube. |

**METHODS OF TEACHING AND STUDENT LEARNING**

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**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 50 marks for practical.

**Practical:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1 | Internal Assessment | 2 | 25 |
| 2 | External Assessment | 1 | 25 |

**MAPPING OF COURSE LEARNING OUTCOMES**

| Program Outcomes | A | B | c | d | e | f | g | h | I | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 5 | 4 | 2,3 | 4 | 1,2 | | 4,5 | | 3 | 2 | 5 |

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## EVALUATION

At the end of semester, Subject teacher will submit an evaluation report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the subject with respect to its strengths as well as those areas which could be improved. The review report contains the following:

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**STEAM & GAS TURBINES**

| **L** | **T** | **P** |
|---|---|---|
| 4 | 0 | 0 |

| | |
|---|---|
| MODULE CODE | MECH5161 |
| CREDIT POINTS | 4 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To provide the sufficient knowledge of working, construction and control of ST and GT. To understand the design of burners and furnaces.
2. To familiarize the students about the industrial applications of ST and GT.
3. To understand the analysis of GT and ST employing real life data.

**LEARNING OUTCOMES:**

1. Able to Illustrate properties of Steam, Draw P-V ,T-s ,H-s (Mollier) diagrams for steam and to describe theoretical steam turbine cycle.
2. Ability to demonstrate and analyse vortex flow, energy lines and reheat factors of steam turbines.
3. Ability to solve problems of finding performance steam turbine power plant.
4. Study and apply various Performance improvement Techniques in steam and gas Turbines.
5. Design and suggest and analyse cooling accessories and protective material for steam turbine.

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**MODULE CONTENT:**

| |
|---|
| *Unit-I:* Introduction, properties of steam, steam quality, Theoretical steam turbine cycle. The flow of steam through Impulse and Impulse–Reaction turbine blades, compounding of steam turbine. |
| *Unit-II:* Vortex flow in steam turbines, Energy lines, State point locus, Reheat factor and design procedure. Governing and performance of steam turbine, Effect of operating variables on thermal efficiency. |
| *Unit-III:* Steam nozzles, Turbine blade-Design, Selection of blade profile, blade cooling techniques, material, protective coating. |
| *Unit-IV:*<br>Gas turbine Introduction, simple open cycle gas turbine, Actual Brayton cycle, Means of Improving the efficiency and the specific output of simple cycle, Regeneration, Reheat, Intercooling. |
| *Unit-V:* Closed-cycle gas turbine, turbine velocity diagram and work done, Performance improvement, Effect of operating variables on thermal efficiency. |
| *Unit-VI:* Fuel supply techniques and control, Combustor design, Lubrication, Maintenance and trouble shooting. |

**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. R.Yadav, *Steam and Gas Turbine*, Central Publishing Home, Allahabad.<br>2. V Ganesan: "*Gas Turbines*", 2002 |
| **REFERENCE BOOKS** | 1. W.J.Kearton, *Steam Turbine Theory and Practice*, ELBS.<br>2. Cohen Rogers, *Gas Turbine Theory*, Longman Publishing.<br>3. Jack D. Mattingly., *Elements of Gas Turbine propulsion*, McGraw – Hill Pub. |

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## METHODS OF TEACHING AND STUDENT LEARNING

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

## ASSESSMENT METHODOLOGIES:

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

## MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES

**Theory:**

| Assessments | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Class Test | | x | x | | |
| Quiz | | x | x | | x |
| Assignment | x | | | x | x |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | A | b | c | d | e | f | g | h | i | j | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 3,4 | | 2 | 2 | 1,5 | 3 | | 3 | 4 | 2 | |

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**EVALUATION**

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

- Problems encountered in the content delivery;
- Suggested remedies / corrective measures;
- Approved refinement decisions due for implementation;
- Actions taken based on previous course review; and
- Report discussed and analysed; actions taken as a result of this process and are communicated to the main stakeholders.

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**Seminar**

| **L** | **T** | **P** |
|---|---|---|
| **0** | **0** | **2** |

| | |
|---|---|
| MODULE CODE | MECH5162 |
| CREDIT POINTS | 1 |
| FORMATIVE ASSESMENT MARKS | 25 |
| SUMMATIVE ASSESMENT MARKS | 25 |
| END SEMESTER EXAM DURATION | 3 hrs |
| LAST REVISION DATE | |

Every student will be required to submit a report and present a seminar talk on a topic guided by a faculty.

The Head of the Department will constitute a committee to evaluate the presentation and award marks.

**Note: The award will be scaled to 25 marks.**

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**Research Methodology** **L T C**

**4 0 4**

| | |
|---|---|
| MODULE CODE | RESM0101 |
| CREDIT POINTS | 4 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

The aim of teaching this subject is to impart knowledge primarily related to research methodology so that learner will be able to understand the research design and represent the research work. Some of the objectives of the course are:

1. To acquire basic knowledge research.
2. To get familiar with different types of research design.
3. To understand the basic of data collection.
4. To get familiar with the different techniques of data analysis.
5. To acquire basic knowledge of technical writing.
6. To get the knowledge of using tools and techniques in research.

**LEARNING OUTCOMES:**

1. Able to understand importance of research and its type.
2. Able to understand research papers and type of research design.
3. Able to formulate the research problem.
4. Able to choose the appropriate data analysis tool.
5. Able to justify with the type of research by publishing it at appropriate platform.
6. Able to use different types of softwares and techniques in research writing.

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**MODULE CONTENTS:**

| |
|---|
| *Unit I: Introduction to Research and Problem Definition*<br>Meaning, Objective and importance of research, Types of research, steps involved in research, defining research problem. |
| *Unit II: Research Design*<br>Research Design: Concept and Importance in Research, Features of a good research design, Exploratory Research Design: concept, types and uses, Descriptive Research Designs: concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. Literature Survey. |
| *Unit III: Data collection*<br>Classification of Data, Methods of Data Collection, Sampling, Sampling techniques procedure and methods, Ethical considerations in research<br>Problem Identification & Formulation: Hypothesis, Qualities of a good Hypothesis, Null Hypothesis & Alternative. |
| *Unit IV: Data analysis*<br>Statistical techniques and choosing an appropriate statistical technique, Data processing softwares (e.g. SPSS etc.), Interpretation of results<br>Data Preparation: Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis (Cross tabulations and Chi-square test) |
| *Unit V:Technical Writing and reporting of research*<br>Types of research report: Dissertation and Thesis, research paper, review article, short communication, conference presentation etc., Referencing and referencing styles.<br>Research Journals, Indexing and citation of Journals, Impact factor of Journals, Ethical issues related to publishing, Intellectual property Plagiarism and Self-Plagiarism. |
| *Unit VI: Use of Tools and Techniques for Research*<br>Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases.<br>methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. C. R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques , New Age International publishers, Third Edition.<br>2. Ranjit Kumar, Research Methodology: A Step- by- Step Guide for Beginners, 2nd Edition, SAGE, 2005<br>3. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition |
| **REFERENCE BOOKS** | 1. Creswell, John W. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications, 2013.<br>2. Business Research Methods – Alan Bryman& Emma Bell, Oxford University Press.<br>3. Select references from the Internet |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 150 marks.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

**MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES**

**Theory:**

| **Assessments** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| Class Test | x | x | x | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Quiz | x | x | | | | x |
| Assignment | | x | x | x | x | x |

**MAPPING OF COURSE LEARNING OUTCOMES**

| Program Outcomes | a | B | c | d | e | f | g | h | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 3,4 | 5 | 3,5 | | | | | | 4 | | |

**EVALUATION**

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

- Problems encountered in the content delivery;
- Suggested remedies / corrective measures;
- Approved refinement decisions due for implementation;
- Actions taken based on previous course review; and
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**THERMAL & NUCLEAR POWER PLANTS**

| L | T | P |
|---|---|---|
| 4 | 0 | 0 |

| | |
|---|---|
| MODULE CODE | MECH5263 |
| CREDIT POINTS | 4 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. Analyse the fuel gases for comparative analysis.
2. To understand the accessories of steam power plant.
3. To understand the cycles for gas turbine power plant.
4. To understand the important feature for site selection.
5. To acquire knowledge about the power plant instrument like for pressure measurement and temperature measurement.

**LEARNING OUTCOMES:**

1. Ability to design of mechanical systems and interdisciplinary engineering applications and business solutions using suitable optimization technique.
2. Exposure to apply numerical or iterative techniques in power systems for optimal power flow solutions.
3. Able to optimize the parameters in control systems for desired steady state or transient response.
4. Able to optimize the cost function in deciding economic factors of power systems.
5. Ability to design of electrical systems optimally using suitable techniques like Univariate method, steepest descent method etc.
6. Ability to develop communication and teamwork skills in the collaborative project.

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***MODULE* CONTENT:**

| |
|---|
| *Unit I: Introduction to Sources of energy*<br>Types of power plants; Direct energy conversion system; Energy sources in India; Recent developments in power generation; Combustion of coal; Volumetric analysis: Gravimetric analysis; Flue gas analysis. |
| *Unit II: Steam power plants*<br>Introduction-general layout of steam power Plant; Modern coal-fired steam power plants; Power plant cycles; Fuel handling; Combustion equipment- ash handling, dust collectors. |
| *Unit III: Steam Generators*<br>Steam generators- types, accessories, feed water heaters, performance of boilers, water treatment, cooling towers, steam turbines, compounding of turbines, steam condensers, jet & surface condensers; Supercritical and ultra-supercritical power plants. |
| *Unit IV:Gas turbine power plant*<br>Cogeneration; Combined cycle power plants; Analysis; Waste-heat recovery; IGCC power plants; Fluidized bed combustion – advantages and disadvantages; Multi- generation. |
| *Unit V: Nuclear power plants and plant safety*<br>Recapitulation of relevant topics of Nuclear Physics; Nuclear Reactors- classification, types of reactors; Site Selection; Methods of fuel enrichment- uranium and thorium. By-products of nuclear power generation; Economics of nuclear power plants; Nuclear power plants in India; Future of nuclear power; Nuclear waste disposal; Introduction to fusion. |
| *Unit VI: Power plant instrumentation*<br>Classification; Pressure measuring instruments; Temperature measurement and Flow measurement; Analysis of combustion gases; Pollution – types, methods to Control. |

**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Power Plant Engineering, Black and Veatch, Springer, New York.<br>2. Power Plant Engineering: A K Raja, A P Srivastava, M Dwivedi. New Age Publishers, New Delhi. |
| **REFERENCE BOOKS** | 1. Thermal Power Plant Performance Analysis, Gilberto Francisco Martha de Souza, Springer, London.<br>2. Boiler Operation Engineering: P Chattopadhyay, Tata McGraw-Hill, New Delhi |

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## METHODS OF TEACHING AND STUDENT LEARNING

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

## ASSESSMENT METHODOLOGIES:

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

## MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES

**Theory:**

| Assessments | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Class Test | | x | | x | x | |
| Quiz | x | | x | | | x |
| Assignment | x | | | x | | x |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | A | b | C | D | e | f | g | h | i | j | k |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 5 | | 2 | 3,6 | | 3,4 | | 3 | | 6,5 | 2 |

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## EVALUATION

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

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- Suggested remedies / corrective measures;
- Approved refinement decisions due for implementation;
- Actions taken based on previous course review; and
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**WIND ENERGY TECHNOLOGY**

| L | T | P |
|---|---|---|
| 4 | 0 | 0 |

| | |
|---|---|
| MODULE CODE | MECH5264 |
| CREDIT POINTS | 4 |
| FORMATIVE ASSESMENT MARKS | 50 |
| SUMMATIVE ASSESMENT MARKS | 100 |
| END SEMESTER EXAM DURATION | 3 hrs. |
| LAST REVISION DATE | |

**INSTRUCTIONS:** The Question paper will comprise of seven questions distributed over three sections A, B and C. Section A comprises of very short answer type questions and is compulsory. Section B and Section C comprise of short answer type and Long answer type questions and will have internal choices.

**OBJECTIVES:**

1. To understand the working principle of wind turbine.
2. To evaluate the performance of wind turbine.
3. To evaluate of design aspect of wind turbine blade.
4. To evaluate the energy generated by wind turbine and to draw power curve.

**LEARNING OUTCOMES:**

1. Ability to apply knowledge of mathematics, science, and engineering.
2. Ability to design and conduct experiments, as well as to analyze and interpret data.
3. Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
4. An ability to function on multi-disciplinary teams.
5. Able to identify, formulate, and solve engineering problems.
6. An understanding of professional and ethical responsibility.

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**MODULE CONTENT:**

| |
|---|
| *Unit I: Introduction to wind energy*<br>Introduction and History of wind energy; Current status and future prospects; basics of wind energy conversion – power available in the wind spectra, wind turbine power and torque, classification of wind turbines, characteristics of wind rotors, aerodynamics of wind turbines, rotor design, rotor performance. |
| *Unit II: Analysis of wind regimes*<br>Wind turbulence; Acceleration effect; Time variation; Measurement of wind; Ecological indicators; Anemometers- Cup anemometer, propeller anemometer, pressure plate anemometer, pressure tube anemometers, sonic anemometer; Wind direction; Analysis of wind data – Average wind speed; Distribution of wind velocity, statistical models for wind data analysis, weibull distribution, Rayleigh distribution; Energy estimation of wind regimes – Weibull based approach, Rayleigh based approach. |
| *Unit III: Wind energy conversion system wind electric generators*<br>Introduction- Tower, rotor, gear box, power regulation, safety brakes, generator, induction generator, synchronous generator, fixed and variable speed operations, grid integration, wind farms, offshore wind farms; Wind pumps – wind powered piston pumps; limitations of wind driven piston pumps; hysteresis effect; Mismatch between the rotor and pump characteristics; dynamic loading of the pump's lift rod; Double acting pump, wind driven rotor-dynamic pumps, wind electric pumps. |
| *Unit IV: Performance evaluation of wind energy*<br>Power curve of the wind turbine; Energy generated by the wind turbine; Weibull based approach; Rayleigh based approach; Capacity factor; Matching the turbine with wind regime; Performance of wind powered pumping systems; Wind driven piston pumps; Wind driven rotor-dynamic pumps; Wind electric pumping systems. |
| *Unit V: Environmental analysis of wind energy*<br>Wind energy and environment – Environmental benefits of wind energy; life cycle analysis, net energy analysis; life cycle emission; environmental problems of wind energy; Avian issues; Noise emission; visual impact. |
| *Unit VI: Economics analysis of wind energy*<br>Economics of wind energy - Factors influencing the wind energy economics; Site specific factors; Machine parameters; Energy parameters; Incentives and exemptions; The present worth; Approach, Cost of wind energy: Initial investment; Operation and maintenance costs; Present value of annual costs; Benefits of wind energy; Yardsticks of economic merits; Net present value, Benefit cost ratio, Payback period, Internal rate of return; Tax deduction due to investment depreciation. |

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**RECOMMENDED BOOKS:**

| | |
|---|---|
| **TEXT BOOKS** | 1. Wind Energy: Sathyajith Mathew Springer Pixyjack press Masonville, USA.<br>2. *Wind Energy* Resource Survey in India: Mani, Anna, S Rangarajan, Allied Publisher, New Delhi<br>3. Wind energy engineering: Parmodjain, McGraw Hill, New York. |
| **REFERENCE BOOKS** | 1. *Wind Power Wind Turbine Engineering*Design:David M Eggleston, Forrest S Stoddard,VanNostrand Reinhold Company, New York.<br>2. Wind energy technology: John F Walker, N Jenkins,John Wiley and sons, New Delhi.<br>3. Fundamental of wind energy: Nicholas P Cheremisinoff, Arbor Science Publishers, Michigan. |

**METHODS OF TEACHING AND STUDENT LEARNING**

The subject is delivered through lectures, on-line support, text book / course material reading and practical exercises. Some videos will be shown to demonstrate certain concepts and research areas will be discussed. Resource material is provided with the help of PDM Educational Directory Services (PEDS).

**ASSESSMENT METHODOLOGIES:**

This subject will be evaluated for a total of 150 marks for theory.

**Theory:**

| Assessment # | Type Of Assessment | Per Semester | Maximum Mark |
|---|---|---|---|
| 1. | Class Test | 4 | 10 |
| 2. | Sessional Test | 2 | 30 |
| 3. | Group Discussion | 4 | 10 |
| 4. | End Semester Exam | 1 | 100 |

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## MAPPING OF ASSESSMENT METHODS AGAINST THE LEARNING OUTCOMES

**Theory:**

| Assessments | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Class Test | | x | | x | | x |
| Quiz | x | | x | | x | |
| Assignment | x | | | x | | x |

## MAPPING OF COURSE LEARNING OUTCOMES

| Program Outcomes | A | b | C | d | e | f | g | h | i | j | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Learning Outcomes | 5 | | 2 | 3,6 | | 3,4 | | 3 | | 6,5 | 2 |

## EVALUATION

At the end of semester, course faculty will submit an evaluation / review report. The purpose of this report is to identify aspects that will be highlighted by students and faculty's feedback for the course with respect to its strengths as well as those areas which could be improved. The review report contains the following areas:

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