# Dr. Babasaheb Ambedkar Technological University 

(Established as a University of Technology in the State of Maharashtra)
(under Maharashtra Act No. XXIX of 2014)
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## Course Structure and Contents

for
M.Tech. in Thermal Engineering/ Thermal \& Fluids Engineering/ Thermal and Heat Power Engineering/ Heat Power Engineering

From $1^{\text {st }}$ Semester- $4^{\text {th }}$ Semester

## Vision

The vision of the Department is to achieve excellence in teaching, learning, research and transfer of technology and overall development of students.

## Mission

Imparting quality education, looking after holistic development of students and conducting needbased research and extension activities.

## Programme Educational Objectives (PEOs)

| No. | PEO |
| :---: | :--- |
| PEO1 | To train student's withindepth and advanced knowledge to become professional <br> and capable of identifying, analyzing and solving complex problems in the areas <br> of thermal and fluids engineering. |
| PEO2 | To enable post graduates to carry out innovative and independent research work, <br> disseminate the knowledge in Academia/Industry/Research Organizations to <br> develop systems and processes in the related field. |
| PEO3 | To prepare the students to exhibit a high level of professionalism, integrity, <br> effective communication skills and environmental and social responsibility. |
| PEO4 | To provide an academic environment that gives adequate opportunity to the <br> students to cultivate life-long independent learning ability for their successful <br> professional career. |

## Programme Outcomes (POs)

At the end of the program, the students will be able to:

| No. | PO |
| :---: | :--- |
| PO1 | Acquire, demonstrate and apply advanced knowledge in the area of thermal and <br> fluids engineering. |
| $\mathbf{P O 2}$ | Identify problems in the field of thermal and fluids engineering, formulate them <br> and solve by using advanced techniques. |
| $\mathbf{P O 3}$ | Conduct independent research and generate new knowledge for the benefit of <br> community, society Industry and country. |
| $\mathbf{P O 4}$ | Apply various numerical methods, a d va n e e d software and engineering tools <br> to model, analyze and solve thermal engineering problems. |
| $\mathbf{P O 5}$ | Work effectively in interdisciplinary teams for solving real life problems in the <br> related field. |
| $\mathbf{P O 6}$ | Apply engineering and scientific principles for the effective management of <br> thermal systems. |
| $\mathbf{P O 7}$ | Effectively communicate through technical reports, presentations and scientific <br> publications with the engineering community as well as society at large. |
| $\mathbf{P O 8}$ | Demonstrate traits of management in handling engineering projects, related <br> finance, and coordinate with workforce towards achieving goals. |
| $\mathbf{P O 9}$ | Demonstrate high level of professional and intellectual integrity,ethics of <br> research and scholarly standards. |
| $\mathbf{P O 1 0}$ | Examine critically the outcomes of one's action sand make corrective measures <br> subsequently. |
| $\mathbf{P O 1 1}$ | Demonstrate the ability to work in team in the laboratory in achieving <br> multidisciplinary tasks required for the project. |
| $\mathbf{P O 1 2}$ | Engage in life-long reflective and independent learning with high level of <br> enthusiasm and commitment. |

## Abbreviations

| PEO: | Program Educational Objectives |
| :--- | :--- |
| PO: | Program Outcomes |
| CO: | Course Outcomes |
| L: | No. of Lecture hours (per week) |
| T: | No. of Tutorial hours (per week) |
| P: | No. of Practical hours (per week) |
| C: | Total number of credits |
| BSH: | Basic Science and Humanity |
| BSC: | Basic Sciences Course |
| PCC: | Professional Core Course |
| OEC: | Open Elective Course |
| PEC: | Professional Elective Course |
| BHC: | Basic Humanity Course |
| ESC: | Engineering Science Course |
| HSMC: | Humanity Science and Management Course |
| NCC: | National Cadet Corps |
| NSS: | National Service Scheme |

## MASTER OF TECHNOLOGY

## (Thermal Engineering/ Thermal \& Fluids Engineering/ Thermal and Heat Power Engineering/ Heat Power Engineering)

Syllabus with effect from July 2018
Semester-I

| Course Code | Type of Course | Name of the Course | Hours/Week |  |  | تِّ | Examination Scheme |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Theory | CA | PR/OR | Total |
|  |  |  | L | T | P |  |  |  |  | TH | Test |
| MTE11 | PCC | Advanced Thermodynamics | 3 | 1 | -- |  | 4 | 60 | 20 | 20 | -- | 100 |
| MTE12 | PCC | Advanced Heat Transfer | 3 | 1 | -- | 4 | 60 | 20 | 20 | -- | 100 |
| MTE13 | PCC | Numerical Methods and Computational Techniques | 3 | 1 | -- | 4 | 60 | 20 | 20 | -- | 100 |
| MTE14A | Elective I | Exergy Analysis of Thermal Systems | 3 | -- | -- | 3 | 60 | 20 | 20 | -- | 100 |
| MTE14B |  | Utilization of Solar Energy |  |  |  |  |  |  |  |  |  |
| MTE14C |  | Advanced I.C. Engines |  |  |  |  |  |  |  |  |  |
| MTE14D |  | Design of Air Conditioning Systems |  |  |  |  |  |  |  |  |  |
| MTE14E |  | Nuclear Power Plants |  |  |  |  |  |  |  |  |  |
| MTE14F |  | Convective Heat Transfer |  |  |  |  |  |  |  |  |  |


| MTE15A | Elective II | Thermal Energy Storage | 3 | -- | -- | 3 | 60 | 20 | 20 | -- | 100 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| MTE15B |  | Energy Conservation and Management |  |  |  |  |  |  |  |  |  |
| ME-XX15C |  | Hydraulic, Pneumatic and Fluidic Control |  |  |  |  |  |  |  |  |  |
| MTE15D |  | Wind Energy |  |  |  |  |  |  |  |  |  |
| MME15E |  | Finite Element Method |  |  |  |  |  |  |  |  |  |
| MTE15F |  | Steam Engineering |  |  |  |  |  |  |  |  |  |
| MTE15G |  | Pumps, Blowers and Compressors |  |  |  |  |  |  |  |  |  |
| BSH16 | HSMC | Communication Skills | 2 | -- | -- | 2 | -- | -- | 25 | 25 | 50 |
| MTE17 | PCC | Thermal Engineering Lab | -- | -- | 3 | 2 | -- | -- | 25 | 25 | 50 |
|  |  | Total | 17 | 3 | 3 | 22 | 300 | 100 | 150 | 50 | 600 |

Semester-II

| Course Code | Type of Course | Name of the Course | Hours/Week |  |  |  | Examination Scheme |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Theory | CA | PR/OR | Total |
|  |  |  | L | T | P |  |  |  |  | TH | Test |
| MTE21 | PCC | Modeling and Analysis in Thermal Engineering | 3 | 1 | -- |  | 4 | 60 | 20 | 20 | -- | 100 |
| MTE22 | PCC | Fluid Dynamics | 3 | 1 | -- | 4 | 60 | 20 | 20 | -- | 100 |
| MTE23A | Elective III | Conservation of Energy in Buildings | 3 | -- | -- | 3 | 60 | 20 | 20 | -- | 100 |
| MTE23B |  | Computational Fluid Dynamics |  |  |  |  |  |  |  |  |  |
| MTE23C |  | Advanced Refrigeration |  |  |  |  |  |  |  |  |  |
| MTE23D |  | Design of Heat Exchangers |  |  |  |  |  |  |  |  |  |
| MTE23E |  | Alternative Fuels for I.C. Engines |  |  |  |  |  |  |  |  |  |
| MTE23F |  | Boundary Layer Theory |  |  |  |  |  |  |  |  |  |
| MTE23G |  | Jet and Rocket Propulsion |  |  |  |  |  |  |  |  |  |
| MTE24A | ElectiveIV | Steam and Gas Turbines | 3 | -- | -- | 3 | 60 | 20 | 20 | -- | 100 |
| ME-XX24A |  | Mechatronics |  |  |  |  |  |  |  |  |  |
| MTE24B |  | Cryogenic Engineering |  |  |  |  |  |  |  |  |  |


| MTE24C |  | Combustion Engineering |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| MMECH24C |  | Nanotechnology |  |  |  |  |  |  |  |  |  |
| MTE24D |  | Numerical Heat Transfer |  |  |  |  |  |  |  |  |  |
| MTE24E |  | Biomass Energy |  |  |  |  |  |  |  |  |  |
| MTE24F |  | Power Plant Practice and Control |  |  |  |  |  |  |  |  |  |
| MTE24G |  | Micro Fluidics |  |  |  |  |  |  |  |  |  |
| MOE25A |  | Research Methodology |  |  |  |  |  |  |  |  |  |
| MOE25B |  | Design of Experiments |  |  |  |  |  |  |  |  |  |
| MOE25C |  | Advanced Optimization Techniques |  |  |  |  |  |  |  |  |  |
| MOE25D | $\begin{aligned} & \text { Elective } \\ & \text { V } \end{aligned}$ | Environmental Engineering and Pollution Control | 3 | -- | -- | 3 | 60 | 20 | 20 | -- | 100 |
| MOE25E |  | Soft Computing Techniques |  |  |  |  |  |  |  |  |  |
| MOE25F |  | Manufacturing Automation |  |  |  |  |  |  |  |  |  |
| MOE25G |  | Modeling and Simulation |  |  |  |  |  |  |  |  |  |
| MTE26 | PCC | Seminar | -- | -- | 4 | 2 | -- | -- | 50 | 50 | 100 |
| MTE27 | PCC | Mini Project | -- | -- | 4 | 2 | -- | -- | 50 | 50 | 100 |
|  |  | Total | 15 | 2 | 8 | 21 | 300 | 100 | 200 | 100 | 700 |

## Semester-III

| Course Code | Type of Course | Name of the Course | Hours/Week |  |  | $\begin{aligned} & \text { ت} \\ & \text { ت} \\ & 0 \end{aligned}$ | Examination Scheme |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Theory | CA | PR/OR | Total |
|  |  |  | L | T | P |  |  |  |  | TH | Test |
|  | PCC | Project Management (Self Study Course) <br> OR <br> Intellectual Property Rights <br> (Self Study Course) |  |  |  |  | 2 | -- | -- | 50 | 50 | 100 |
| MMECH32 |  |  | -- | -- | -- | 2 | -- | -- | 50 | 50 | 100 |
| MTE33 | PCC | Project Stage -I | --- | -- | -- | 10 | -- | -- | 50 | 50 | 100 |
| Total |  |  | -- | -- | -- | 12 | -- | -- | 100 | 100 | 200 |

## Semester-IV

| Course Code | Type of Course | Name of the Course |  | Hours/Week |  |  | $\begin{aligned} & \text { ت} \\ & \\ & 0 \\ & 0 \end{aligned}$ | Examination Scheme |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  | Theory | CA | PR/OR | Total |
|  |  |  |  | L | T | P |  |  |  |  | TH | Test |
| MTE41 | PCC | Project Stage -II |  | --- | -- | -- |  | 20 | -- | -- | 100 | 100 | 200 |
|  | Total |  |  | --- | -- | -- | 20 | -- | -- | 100 | 100 | 200 |

## Semester I

## Advanced Thermodynamics

| MTE11 | Advanced Thermodynamics | PCC | $3-1-0$ | 4 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of thermodynamics to apply in real engineering problems
2. To familiarize the students about the thermodynamic relations and process and their use to analysis the given thermal application
3. To understand the gas equations for properties generation

Course Outcomes:At the end of the course, students will be able to

| CO 1 | Understand properties of pure substances. Represent various processes with steam on <br> property diagrams, Apply and compare equations of state for real gases |
| :--- | :--- |
| CO 2 | Derive Maxwell Relations, Clapeyrons Equation etc. and apply these for evaluation of <br> thermodynamic properties. |
| CO 3 | Evaluate entropy change for flow and non-flow processes under steady and unsteady <br> conditions. |
| CO 4 | Estimate thermodynamic properties of substances in gas or liquid state of ideal and real <br> mixture. |
| CO 5 | Predict intermolecular potential and excess property behavior of multi-component <br> systems. Study irreversible processes. |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 |  | 2 | 1 |  | 1 |  |  |  |  |  |  |
| CO3 | 2 | 1 |  | 1 |  | 1 |  |  |  |  |  |  |
| CO4 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO5 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |
| Note: 1- Means medium contribution 3- Maximum contribution |  |  |  |  |  |  |  |  |  |  |  |  |

## Course Contents

## Unit I

Pure Substance: Introduction, properties and application of thermodynamics to pure substance. Equation of States: Ideal gas equation and its limitations for real gases, other equations of state like Vander walls, Berthelot, Dieterici, Redlich-kwong equations, Bose-Einstein statistic. FermiDirac statistics

## Unit II

Thermodynamic Relations Mathematical theorems, Helmoltz and Gibb's function, T-ds equations, Maxwell's relations, energy equations, variation in heat capacities, Clapeyron relation

## Unit III

Entropy: The essence of entropy, a law of quantum state, quantum state probability, entropy definition, decrease of exergy principal, exergy analysis of thermal systems (Case study), thermal energy reservoir, mechanical energy reservoir, constituent reservoir.

## Unit IV

Composition of gas mixture: mass and molar fraction, P-v-T behavior of gas mixture. Dalton's law of partial pressure, Amagat's law, properties of gas mixture

## Unit V

Irreversible thermodynamics: Reversible and irreversible process, the flux postulate, entropy production; heat flux, thermoelectric phenomenon; thermodynamic analysis of the thermocouple, Onseger's reciprocal relation.

## Unit VI

Thermodynamic Equilibrium and stability; condition for chemical equilibrium; equilibrium and third law; phase equilibrium; chemical reaction, equation of reaction equilibrium; phase rule; chemical potential of ideal gases and fugacity .

## TEXTS/REFERENCES:

1. W.C. Reynolds and H.C. Perkins, Engineering Thermodynamics, McGraw-Hill.
2. P.K. Nag, Engineering Thermodynamics, Tata McGraw-Hill, 2005 Ed.
3. Michel SAAD, Engineering Thermodynamics, McGraw Hill.
4. Jones and Hawkins, Engineering Thermodynamics, Prentice Hall India.
5. J.P.Holman, Engineering Thermodynamics, McGraw-Hill.
6. Y.A,Cengel and M.A.Boles, Thermodynamics: an engineering approach, Tata McGrawHill.
7. S.R.Turns, Thermodynamics Concepts and Applications
8. P.L.Dhar, Engineering Thermodynamics, Elsevier Publication

## Advanced Heat Transfer

| MTE12 | Advanced Heat Transfer | PCC | 3-1-0 | 4 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 20 Marks | 60 Marks | Total |
| 200 Marks |  |  |  |  |

Course Objectives: Objectives of this course are

1. To provide the technical understanding the concepts of heat transfer in the background of real engineering problems
2. To familiarize the students about the importance of heat transfer process apply to industrial applications
3. To understand the heat transfer concepts apply to other domain of thermal engineering in general

Course Outcomes: At the end of the course, students will be able to

| CO1 | Analyze steady state and transient heat conduction problems of real life Thermal systems |
| :--- | :--- |
| CO2 | Analyze extended surface heat transfer problems and problems of phase change <br> heat transfer like boiling and condensation |
| CO3 | Apply the basic principles of classical heat transfer in real engineering application |
| CO4 | Analyze the analytical and numerical solutions for heat transfer problem. |
| CO5 | Understand the basic concepts of turbulence and their impact on heat transfer |
| CO6 | Analyze radiation heat transfer problems of various thermal systems |

Mapping of COs with POs

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 |  |  | 1 |  | 1 |  |  |  |  |  |  |
| CO3 | 1 |  | 2 |  |  |  |  |  |  |  |  |  |
| CO4 | 1 | 1 |  | 2 |  |  |  |  |  |  |  |  |
| CO5 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO6 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |

## Course Contents:

## UNIT-I:

Brief introduction to different modes of heat transfer: conduction: general heat conduction equation-initial and boundary conditions.
Finite difference methods for conduction: id \& 2d steady state and simple transient heat conduction problems-implicit and explicit methods.

## UNIT-II

Transient heat conduction: lumped system analysis, Heisler charts, semi infinite solid, use of shape factors in conduction, 2d transient heat conduction, product solutions.

## UNIT-III:

Forced Convection: Equations of fluid flow-concepts of continuity, momentum equations, derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method, integral analysis.

## UNIT-IV:

External flows: Flow over a flat plate: integral method for laminar heat transfer coefficient for different velocity and temperature profiles. Application of empirical relations to variation geometries for laminar and turbulent flows.
Internal flows: Fully developed flow: integral analysis for laminar heat transfer coefficienttypes of flow-constant wall temperature and constant heat flux boundary conditions hydrodynamic \&thermal entry lengths; use of empirical correlations.

## UNIT-VI:

Free convection: Approximate analysis on laminar free convective heat transfer, Boussinesque approximation, different geometries, combined free and forced convection.
Boiling and condensation: Boiling curve, correlations, Nusselts theory of film condensation on a vertical plate, assumptions \& correlations of film condensation for different geometries.

## UNIT-V:

Radiation heat transfer: Radiation, shape factor, analogy, shields, radiation of gases \& vapors.

## Text/References:

1. YunusA.Cengal, Heat and Mass Transfer - A practical Approach, $3^{\text {rd }}$ edition, Tata McGraw Hill, 2007.
2. Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.
3. S. P.Sukhatme, A Textbook on Heat Transfer
4. Ozisik. M.N., Heat Transfer - A Basic Approach, McGraw-Hill Co., 1985
5. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat \& Mass Transfer, John Wiley \& Sons, 2002.
6. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
7. M.M. Modest, Radiative Heat Transfer, Tata-McGraw-Hill

## Numerical Methods \& Computational Techniques

| MTE13 |  <br> Computational Techniques | PCC | 3-1-0 | 4 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are

1. To inculcate subject knowledge of numerical methods applied to thermal engineering applications
2. To learnt the numerical techniques useful to apply in the areas such as CFD etc.
3. To extent the learning of Numerical method applying the computer programming

Course Outcomes:At the end of the course, student should be able to

| CO1 | Solve a set of algebraic equations representing steady state models formed in engineering <br> problems |
| :--- | :--- |
| CO 2 | Fit smooth curves for the discrete data connected to each other or to use interpolation methods <br> over these data tables |
| CO 3 | Predict the system dynamic behavior through solution of ODEs modeling the system |
| CO4 | Solve PDE models representing spatial and temporal variations in physical systems <br> through numerical methods. |
| CO5 | Demonstrate proficiency of using MATLAB, VB, ANSYS, EES etc., |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 |  | 2 | 1 |  |  |  |  |  |  |  |  |  |
| CO2 |  |  | 1 |  |  |  |  |  |  |  |  |  |
| CO3 | 1 |  |  |  |  | 1 |  |  |  |  |  |  |
| CO4 |  | 1 |  | 2 |  |  |  | 1 |  |  |  |  |
| CO5 |  | 1 |  | 1 |  |  |  |  |  |  | 1 | 2 |

## Course Contents:

## Unit I

Introduction to Numerical Analysis: Objectives, Mathematical Modeling, Programming Concepts, MATLAB, FORTAN etc., Computational Accuracy, Precision, Truncation Errors, Taylor Series
Curve fitting and Regression, Interpolation, Fourier Series concepts

## Unit II

Roots of equations: Bisection, False position, Fixed Point Iteration, Newton-Raphson, Secant methods, Roots of polynomials
Linear Algebraic Equations, Gauss Elimination

## Unit III

Non-linear Systems of Equations, Gauss-Jordan, LU Decomposition and Matrix Inversion, Gauss-Seidel.

## Unit IV

Numerical Integration: Trapezoidal and Simpson's Rules, Gaussian Quadrature.
Numerical Differentiation and finite-difference approximations

## Unit V

Ordinary Differential Equations: Euler's and Runge-Kutta Methods, Boundary-Value, Eigen value and Eigen vector Problems .

## Unit VI

Partial Differential Equations: Elliptic Equations, Laplace Equation and Boundary Conditions, Control Volume Approach, Parabolic Equations, Explicit and Implicit Methods, Crank-Nicolson, Introduction to Finite Element Methods.

## TEXTS / REFERENCES:

1. Steven C. Chapra and Raymond P. Canale, Numerical Method for Engineers, 6th Edition, McGraw-Hill, 2010.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, 5th Edition, PHI Learning, 2012
3. S. P. Venkateshan, Computational Methods in Engineering, 1st Edition, Academic Press, 2013
4. S.K. Gupta, Numerical Methods for Engineers, New Age International, 2009
5. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge, 2007
6. K. Atkinson and W. Han, Elementary Numerical Analysis, 3rd Edition, Wiley-India, 2004.
7. J. D. Hoffman and Steven Frankel, Numerical Methods for Engineers and Scientists, 2nd Edition, McGraw-Hill, 2001
8. S. D. Conte and Carl de Boor, Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edition, McGraw-Hill, 1980

## Exergy Analysis of Thermal Systems

| MTE14A | Exergy Analysis of <br> Refrigeration Systems | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

## Course Objectives: Objectives of this course are

1. To provide the concept, applications, importance of exergy
2. To familiarize the students about the exergy and its applications in real life situations
3. To carry out a exoeconomic analysis on the existed thermal system

## Course Outcomes:

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

| CO1 | Identify and apply concepts, theorems of thermodynamics to the different thermal and fluid <br> engineering system |
| :--- | :--- |
| CO2 | Analyze performance these systems by conducting experiments by applying heat balance method, <br> Carnot cycle method and entropy generation methods. |
| CO3 | Interpret and estimate exergy losses by, exergy calculations, exergetic efficiency, exergy charts. |
| CO4 | Apply and concepts of exergy analyses in Specific applications to the analysis of power stations, <br> refrigeration installations, Cryogenic systems and small capacity units. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |
| CO2 |  |  |  | 2 |  |  |  |  |  |  |  | 1 |
| CO3 | 1 |  |  |  |  |  |  |  |  |  |  | 1 |
| CO4 | 1 |  |  |  |  | 1 |  |  |  |  |  | 2 |

## Course Contents:

UNIT I
Exergy Destruction: Lost available work referred to heat engine cycle, refrigeration cycle, heat pump cycle, non-flow and steady flow processes, Mechanism of exergy destruction, modified Gouy-Stodola theorem, concept of effective temperature

## UNIT II

Exergy Analysis of Simple Processes: Mixing and separation process of fluids of different temperature, heat transfer across a temperature difference, expansion and compression process, combustion process.

## UNIT III

Exergy Analysis of Power Plant Cycles: Maximum power subject to size constraint with fixed heat input and its application to Brayton cycle Steam turbine power plants: External and internal irreversibility, superheater, reheater, vacuum condenser, regenerative feed water heating ,combined feed water heating and reheating.

## UNIT IV

Gas turbine power plant: External and internal irreversibility, regeration, reheater, and intercooler, combined steam and gas turbine power plant.

UNIT V
Exergy analysis of Refrigeration cycle: Joule-Thomson Expansion, Work-Producing Expansion, Brayton Cycle, Optimal Intermediate Cooling, Exergy analysis of Air-conditioning applications: Mixtures of air and water vapour, total flow exergy of humid air \& liquid water, Evaporative cooling process and other aspects,Cryogenic systems and small capacity units.

## UNIT VI

Exergy-economic Analysis: Fundamental of exergy-economics, exergy costing of different thermal components: steam or gas turbine, boiler, cogeneration system.

## TEXTS / REFERENCES:

1. Advanced Engineering Thermodynamics by Adrian Bejan, John Wiley \& Sons, Inc.
2. The Exergy Method of Thermal Plant Analysis by T J Kotas, Krieger Publishing Company
3. Thermal Design and Optimization by Adrian Bejan, George Tsatsaronis, Michael Moran, John Wiley \& Sons, Inc.
4. Advance Thermodynamics for Engineers by Winterbore D E, Arnold Publication
5. Advanced Thermodynamics for Engineers by Kenneth Wark, McGraw Hill Publishing Co. Ltd.
6. Fundamentals of Engineering Thermodynamics by Michel J Moran, Howard N Shapiro, Daisie D Boettner, Margaret B Bailey, John Wiley \& Sons, Inc

## Utilization of Solar Energy

| MTE14B | Utilization of Solar Energy | PEC | $3-0-0$ | 2 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total | 100 Marks |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of solar energy
2. To familiarize the students about the solar energy and its applications in real life situations
3. To carry out a case study on the existed solar energy system

## Course Outcomes:

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

| CO1 | Describe measurement of direct, diffuse and global solar radiations falling on horizontal <br> and inclined surfaces, Basic earth sun angles, Beam and diffuse radiations, Radiation on <br> titled surfaces. |
| :--- | :--- |
| CO2 | Analyze the performance by conducting research on flat plate collector, air heater and <br> concentrating type collector. |
| CO3 | Understand test procedures and apply these while testing different types of collectors. |
| CO4 | Demonstrate and Design various types of thermal energy storage systems. |
| CO5 | Analyze payback period and annual solar savings due to replacement of conventional <br> systems |
| CO6 | Demonstrate the importance of solar energy effectively to increase awareness of it in <br> society. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |
| CO2 |  |  |  | 1 |  |  |  |  |  |  |  |  |
| CO3 |  |  |  | 1 |  |  |  |  |  |  |  | 1 |
| CO4 |  |  |  |  |  |  |  |  | 1 |  |  |  |
| CO5 |  |  |  |  |  | 2 |  |  |  |  |  |  |
| CO6 |  |  | 2 |  | 1 |  |  |  |  |  |  | 1 |

## Course Contents

## Unit-I

Solar Radiation Analysis: Solar constant, Basic earth sun angles, Beam and diffuse radiations, Radiation on titled surfaces (estimation), Measurement of solar radiation (calibration of equipments)

## Unit-II

Heat Transfer for Solar Energy Utilization: Basic models of heat transfer, Radiation characteristics of opaque materials and partially transparent media, Heat transfer analysis for flat plate collectors.

Flat Plate Collectors: Physical principles of conversion of solar radiation into heat, Thermal losses and efficiency of FPC, Practical considerations for flat plate collectors, Applications of FPC - Water heating and Drying

## Unit-III

Focusing Type Collectors: Orientation and sun tracking systems, Types of concentrating collectors - Cylindrical parabolic collector, Compound parabolic collector, Thermal performance of focusing collectors, Testing of solar collectors.

## Unit-IV

Solar cooking, Solar desalination, Solar ponds and Solar space heating Solar Industrial process heating and Solar power generation.

## Unit-V

Solar Green Houses, Solar thermo mechanical power, Solar refrigeration \& air conditioning and Solar High Temperature Applications

## Unit-VI

Energy Storage for Solar Energy Utilization: Importance of storage systems, Different types of thermal storage systems, Alternate storage methods

## Texts / Reference Books:

1. John A Duffie\& William A Beckman : "Solar Energy Thermal processes" - Wiley Inter science publication
2. H P Garg \& J Prakash "Solar Energy - Fundamentals and Applications: - Wiley Inter science
3. G D Rai "Solar Energy Utilization" - Khanna publishers
4. S P Sukhatme "Solar Energy - Principles of thermal Collection \& Storage" - Tata McGraw Hill Publishing company ltd., New Delhi

Advanced I.C. Engine

| MTE14C | Advanced I.C. Engines | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of IC engines
2. To familiarize the students about the IC engines systems, processes, alternative fules etc
3. To understand the environment aspects of IC engines

## Course Outcomes:

| CO1 | Illustrate fundamental and actual thermodynamic cycle analysis in IC engines. |
| :--- | :--- |
| CO2 | Describe and simulate actual heat exchange and gas flows in combustion chamber. |
| CO3 | Analyze combustion and apply remedial measures to avoid abnormal combustion in IC <br> engine. |
| CO4 | Apply various emission control system and modification to take corrective actions to reduce <br> pollution. |
| CO5 | Acquire and use knowledge of genetic algorithm to optimize real life problems. |
| CO6 | Understand Modern trends coming in IC Engine technology. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 |  | 2 |  |  |  |  |  |  |  |  |  |
| CO2 | 1 |  | 1 | 2 |  |  |  |  |  |  |  |  |
| CO3 | 1 | 2 | 1 | 1 |  |  |  | 1 |  |  |  |  |
| CO4 |  |  |  |  |  | 1 |  |  |  | 1 |  | 1 |
| CO5 |  | 1 | 2 |  |  |  |  |  |  |  |  |  |
| CO6 | 1 | 2 |  | 2 |  |  |  |  |  | 1 |  | 2 |

Course Contents

## UNIT I

## Spark Ignition Engines

Mixture requirements, Fuel Induction systems, Stages of combustion, Normal and abnormal combustion, factors affecting knock, Combustion chambers, Engine design, Basic concepts of SI engine simulation technique

UNIT II
Compression ignition engines

Stages of combustion in C.I. Engine, Direct and indirect Injection systems, Combustion chambers, Fuel spray behavior, spray structure, spray characteristics, air motion, engine design, Basic concepts of CI engine simulation technique.

## UNIT III

## Fuels for SI and CI Engine

Qualities of SI \& CI engine fuels, rating of SI \& CI engine fuels, fuel additives for SI \& CI engines, Fuel supply systems for SI and CI engines to use gaseous fuels like hydrogen, CNG, biogas and, other possible fuels.

## UNIT IV

## Super-charging and Turbo-charging

Purpose of supercharging, effects of supercharging on SI \& CI engines performance and its limitations, different types of turbo-charges, methods of turbo charging $\&$ its limitations.

## UNIT V

Engine Emissions \& Control: Air pollution due to IC engines, Emissions-HC, CO, NOx, particulates, $\mathrm{GHGs}\left(\mathrm{CO}_{2}, \mathrm{CH}_{4}\right.$ and $\left.\mathrm{N}_{2} \mathrm{O}\right)$, emission norms, emission control methods-exhaust gas recirculation, three-way catalytic convertor, particulate trap, modern methods.

## UNIT VI

## Recent Trends

Homogeneous Charge Compression Ignition Engine, Lean Burn Engine, Stratified Charge Engine, Electronic Engine Management, Common Rail Direct Injection Diesel Engine, Gasoline Direct Injection Engine, Data Acquisition System -pressure pick up, charge amplifier PC for Combustion and Heat release analysis in Engines.

## Reference Books:

1. E.F. Obert, Internal Combustion Engines and Air Pollution, Intext Educational Publishers, 1973.
2. John B Heywood, Internal Combustion Engine Fundamentals, McGraw Hill
3. M.L. Mathur and R.P.Sharma, Internal Combustion Engines, DhanapatRai Publications, New Delhi.
4. L.C. Litchy, Combustion Engines Processes, McGraw Hill, 1967.
5. V. Ganesan, Int. Combustion Engines, II Edition, TMH, 2002.
6. V. Ganesan, Computer simulation of spark ignition process: University process, Hyderabad 1993.

## Design of Air-Conditioning Systems

| MTE14D | Design of Air-Conditioning <br> System | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of air conditioning
2. To familiarize the students about the air conditioning system design and its applications in real life situations
3. To learn the duct design and load calculation

## Course Outcomes:

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

| CO1 | Demonstrate Air-conditioning processes and psychometric |
| :--- | :--- |
| CO2 | Illustrate Ventilation, Necessity, Natural Ventilation, wind effect, Measurement of thermal comfort <br> indices. |
| CO3 | Formulate and solve problems of cooling, heating load calculations. |
| CO4 | Design Air distribution, duct design for suitable problem. |
| CO5 | Analyze Sound propagation, SPL, PWL, Sound Intensity, room acoustics and apply noise <br> control techniques. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | :---: |
| CO1 | 2 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO3 |  | 2 |  | 2 |  |  |  |  |  |  |  |  |
| CO4 |  | 1 |  |  | 1 | 1 |  |  |  |  |  |  |
| CO5 |  |  |  | 1 |  |  |  |  |  |  |  |  |

## Course Contents

## Unit I

Psychrometry, Air-conditioning processes, Advanced psychrometry, ERSHF, winter airconditioning, Preparation of psychrometric charts.

## Unit II

Ventilation, Necessity, Natural Ventilation, wind effect, stack effect, flow around building, Thermal Comfort, Thermal human model, Measurement of thermal comfort indices.

## Unit III

Solar geometry, Building Heat Transfer, Cooling Load Calculation, CLTD Method Cooling Load and Heat Loss calculations, Concept of energy days, Heating load calculation.

## Unit IV

Room Air Diffusion, Filtration, Duct Design for real life applications such as hospitals, hotels, shopping malls etc., Air Distribution Design.

## Unit V

Noise control, Sound propagation, SPL, PWL, Sound Intensity, room acoustics, sound control in ducts.

## Unit VI

HVAC Equipment, Packaged and Split HVAC Equipment, Heat pump Design and selection, Equipment Selection, Auxiliaries.

## TEXTS / REFERENCES:

1. Handbook of Air Conditioning System Design, Carrier Air Conditioning Co., 1965.
2. ASHRAE Handbooks and ISHRAE Handbooks
3. Thermal Environmental Engineering, James L.Threlkeld, Prentice Hall,
4. Air conditioning engineering, W. P. Jones, ELBS
5. Refrigeration and Air-conditioning, Stoecker and Jones, McGraw Hill
6. Edward Pita, Air Conditioning Principles and Systems,Prentice Hall

## Nuclear Power Plants

| MTE14E | Nuclear Power Plants | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 20 Marks | Total |  |

## Course Objectives:

1. To provide the sufficient knowledge of concept, applications, importance of Nuclear Power plant
2. To familiarize the students about the design of Nuclear Power plant
3. To understand the environment impact and policies about the NPP

## Course Outcomes:

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

| CO1 | Identify various energy sources, Indian Power Scenario, Nuclear Power Scenario in the World <br> Nuclear Power Scenario in India, Scope |
| :--- | :--- |
| CO2 | Describe Nuclear physics, reactor, classification and types of nuclear reactor, economics of <br> power plant. |
| CO3 | Illustrate effect of nuclear radiation on health, safety and licensing |
| CO4 | Analyze heat transfer from nuclear, heat flux radiation. |
| CO5 | Analyze economics of nuclear power plant, load generation. |

## Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 | 2 |  |  |  |  |  | 1 |  |  |  |  |  |
| CO3 |  | 2 |  |  |  |  | 1 |  |  | 1 |  | 2 |
| CO4 |  |  | 1 | 1 |  |  |  |  |  |  |  |  |
| CO5 |  |  | 1 |  |  |  |  |  |  |  |  |  |

## Course Content

## UNIT I

Introduction - World Energy Sources, Indian Power Scenario, Nuclear Power Scenario in the World, Nuclear Power Scenario in India, Scope of the Present Course.

## UNIT-II

Nuclear Power Plant: Nuclear physics, Nuclear Reactor, Classification, Types of reactors, Site selection. Method of enriching uranium. Application of nuclear power plant. Nuclear Power

Plant Safety: Bi-Product of nuclear power generation, Economics of nuclear power plant, Nuclear power plant in India, Future of nuclear power.

## UNIT III

Basic Concepts in Neutron Reactions, Neutron Moderation and Diffusion, Nuclear Reactor Theory. Nuclear Reactor Dynamics and Control., Nuclear Reactor Thermal-Hydraulics.

UNIT-IV
Power Plant Instrumentations: Classification, Pressure measuring instrument, Temperature measurement and Flow Measurement, Analysis of combustion gases, Pollution types, Methods of control.

## UNIT V

Health Physics, Radiation Shielding, Nuclear Reactor Safety and licensing.

## UNIT-VI

Economics Of Power Generation: Factors affecting the economics, Loading factors, Utilization factor, Performance and operating characteristics of power plant, Point economic load sharing, Depreciation. Energy rate, Criteria for optimum loading. Specific economic energy problem

## REFERENCES:

1. Power Plant Engineering / P.K.Naga / TMH
2. Power Plant Technology / El Wakil, McGraw Hill Publication
3. Power Plant Engineering / P.C.Sharma/ Kotearia Publications.

## Convective Heat Transfer

| MTE14F | Convective Heat Transfer | PCC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 20 Marks | Total <br> 60 Marks | 100 Marks |

## Course Objective:

Objectives of this course are:

1. To Understand the concept of fluid mechanics in the back ground of Convection heat transfer.
2. To familiarize the students about the convective heat transfer mathematical analysis of various situations.
3. To understand the analysis of convective heat transfer using software

Course Outcomes: At the end of the course, students will be able to

| CO1 | Describe Applications of Convective Heat transfer in various thermal systems. |
| :--- | :--- |
| CO 2 | Formulate and solve Navier-Stokes equations and energy equations in for various flow <br> patterns and systems. |
| CO 3 | Simulate and distinguish convective heat transfer through laminar and turbulent boundary <br> layer by using computer softwares e.g., MATLAB,CFD,EES etc., |
| CO 4 | Analyze natural and combined convection for flows through various channel by using <br> numerical techniques. |
| CO 5 | Categorize and illustrate flows through porous media with applying energy equation for <br> fully developed flows. |

## Mapping of course outcomes with program outcomes

| $\begin{gathered} \text { POs } \rightarrow \\ \text { COs } \downarrow \end{gathered}$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO 2 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO3 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO4 |  |  |  |  |  |  |  |  |  |  |  |  |


| CO5 |  |  |  |  |  |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

## Course Content: <br> UNIT I

Introduction to Forced, free \& combined convection - convective heat transfer coefficient Application of dimensional analysis to convection - Physical interpretation of dimensionless numbers.
Equations of Convective Heat Transfer: Continuity, Navier-Strokes equation \& energy equation for steady state flows - similarity - Equations for turbulent convective heat transfer Boundary layer equations for laminar, turbulent flows - Boundary layer integral equations.

## UNIT II

EXTERNAL LAMINAR FORCED CONVECTION: Similarity solution for flow over an isothermal plate- integral equation solutions - Numerical solutions - Viscous dissipation effects on flow over a flat plate.
External Turbulent Flows: Analogy solutions for boundary layer flows - Integral equation solutions.

## UNIT III

Internal Laminar Flows: Fully developed laminar flow in pipe, plane duct \& ducts with other cross-sectional shapes - Pipe flow \& plane duct flow with developing temperature field - Pipe flows \& plane duct flow with developing velocity \& temperature fields.
Internal Turbulent Flows: Analogy solutions for fully developed pipe flow -Thermally developing pipe \& plane duct flow.

## UNIT IV

NATURAL CONVECTION: Boussineq approximation - Governing equations - Similarity Boundary layer equations for free convective laminar flows - Numerical solution of boundary layer equations. Free Convective flows through a vertical channel across a rectangular enclosure - Horizontal enclosure - Turbulent natural convection.

## UNIT V

COMBINED CONVECTION: Governing parameters \& equations - laminar boundary layer flow over an isothermal vertical plate - combined convection over a horizontal plate-correlations for mixed convection - effect of boundary forces on turbulent flows - internal flows - internal mixed convective flows - Fully developed mixed convective flow in a vertical plane channel \& in a horizontal duct.

## UNIT VI

CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA: Area weighted velocity - Darcy flow model - energy equation - boundary layer solutions for 2-D forced convection Fully developed duct flow - Natural convection in porous media - filled enclosures - stability of horizontal porous layers.

## REFERENCES:

1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen \& David Naylor /McGraw Hill
2. Convective Heat \& Mass Transfer /Kays \& Crawford/TMH
3. Bejan, Convective Heat Transfer

## Thermal Energy Storage

| MTE15A | Thermal Energy Storage | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total |  |

## Course Objectives:

1. To provide the sufficient knowledge of concept, applications, importance of Thermal energy storage
2. To familiarize the students about the design of thermal energy storage systems
3. To understand the industrial applications of thermal energy storage

## Course Outcomes:

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

| CO1 | Survey litterateur on importance of energy transport and storage of thermal, mechanical, electro <br> chemical energies etc., |
| :--- | :--- |
| CO2 | Interpret and analyze energy storage and conversion performance from one to another. |
| CO3 | Design system for Chemical energy storage (organic fuels) High temperature storage Compresse <br> air energy storage |

## Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 | 2 |  |  |  |  |  |  |  |  |  |  |
| $\mathrm{CO2}$ |  | 1 |  | 1 | 1 |  |  |  |  |  |  |  |
| $\mathrm{CO3}$ |  |  | 1 | 1 |  | 1 |  |  |  |  |  |  |

## Course Contents

Importance and modes of energy transport and storage
Thermal energy storage (sensible and latent heat storage)
Mechanical Energy Storage: gravitational energy storage, elastic energy storage
Electromagnetic energy storage: static field, transient electric field, magnetic materials, radiant storage.

Electro-chemical energy conversion and storage: The electrochemical cell, Fuel cells, batteries.
Chemical energy storage (organic fuels)
High temperature storage
Compressed air energy storage

Thermo chemical storage
Emerging technologies and examples of energy storage
Testing of storage systems
Thermal modeling of energy storage systems
Total energy systems

## Texts / Reference Books:

1. Johannes Jensen \& Bent Sorensen :"Fundamentals of energy storage"
2. Collins : "Batteries Vol. I \& II".
3. S.U.Faulk\& A.J.S SaIkins :"Silver Zinc - Alkaline storage systems".

## Energy Conservation and Management

| MTE15B | Energy Conservation and <br> Management | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of Energy Conservation and management
2. To familiarize the students about the Energy audit and its applications in real life situations
3. To carry out a energy audit on the existed thermal system

## Course Outcomes:

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

| CO1 | Demonstrate energy management principles, identify need, organizing it. carry out energy auditing. |
| :--- | :--- |
| CO2 | Conduct economic analysis of any industry or power plant, obtain conclusion and suggest it to <br> industry. |
| CO3 | Interpret financial appraisal methods, and thermodynamic analysis, and estimate financial budget <br> of visited industry. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO2 |  |  | 1 | 1 |  | 1 |  | 2 |  |  |  |  |
| CO3 |  |  |  | 1 | 1 |  | 1 | 2 |  |  |  | 1 |

## Course Contents

## Unit-I

Energy scenario and its various forms, General energy problem, Energy use patterns, Energy balance.
Energy Management Principles: Need, Organizing, Initiating and managing an energy management program.
Energy Auditing: Elements and concepts, Types of energy audits, Instruments used in energy auditing.

## Unit-II

Economic Analysis: Cash flows, Time value of money, Formulae relating present and future cash flows - single amount, uniform series.

## Unit-III

Financial appraisal methods: Payback period, Net present value, Benefit-cost ratio, Internalrate of return \& Life cycle costs/benefits.
Thermodynamics of energy conservation, Energy conservation in Boilers and furnaces, Energy conservation in Steam and condensate system.

## Unit-IV

Cogeneration: Concepts, Types of cogeneration systems, Performance evaluation of a cogeneration system.
Waste Heat Recovery: Potential, benefits, waste heat recovery equipments.
Space Heating, Ventilation Air Conditioning (HVAC) and water heating of building, Transfer of heat, Space heating methods, Ventilation and air conditioning, Heat pumps, Insulation, Cooling load, Electric water heating systems, Electric energy conservation methods.

## Unit-V

Industrial Insulation: Insulation materials, Insulation selection, Economical thickness of insulation. Industrial Heating: Heating by indirect resistance, direct resistance heating (salt bath furnace), Heat treatment by induction heating in the electric arc furnace industry.

## Unit-VI

Energy Conservation in Electric Utility and Industry: Energy costs and two - part tariff, Energy conservation in utility by improving load factor, Load curve analysis, Energy efficient motors, Energy conservation in illumination systems, Importance of Power factor in energy conservation - Power factor improvement methods, Energy conservation in industries

## Texts / Reference Books:

1. S.C.Tripathy: "Electric Energy Utilization and Conservation", TMG Delhi, 1991.
2. Wayne C. Turner: "Energy Management Handbook", Wiley Interscience Publication, NY, 1982.
3. D.A.Reay: "Industrial Energy Conservation", Pergamon Press. 1980.
4. T.L Boten: "Thermal Energy Recovery", Wiley, 1980.
5. Industrial Energy Conservation Manuals: MIT Press.
6. W.C.Turner, Energy Conservation Handbook.

## Hydraulic, Pneumatic and Fluidic Control

| ME-XX15C | Hydraulic, Pneumatic and <br> Fluidic Control | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Outcomes: At the end of the course, the student will be able to:

| CO1 | Understand the type of control system and their utility |
| :--- | :--- |
| CO 2 | Describe the hydraulic power generation |
| CO 3 | Design pneumatic and hydraulic circuits for a given application |
| CO 4 | Discuss steady state operating forces, transient forces and valve instability |
| CO 5 | Design of pure fluid digital elements, Lumped and distributed parameter fluid <br> systems |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | :---: |
| CO1 | 2 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 | 2 |  |  |  | 1 | 1 |  |  |  |  |  |  |
| CO 3 | 2 | 2 |  | 3 | 3 |  |  |  |  |  |  |  |
| CO 4 | 2 |  |  |  |  | 2 | 3 |  |  | 2 |  | 1 |
| CO 5 | 2 | 2 |  | 2 | 3 |  |  |  |  |  |  |  |

## Course Contents:

## Unit I

Introduction to control system, types of control system and their utility.

## Unit II

Hydraulic power generation and transmission, valve control pressure flow relationship and constructions.

## Unit III

Steady state operating forces, transient forces and valve instability.

## Unit IV

Circuit design, pneumatic valves, hydraulic and pneumatic drives, introduction to fluidic devices and sensors.

## Unit V

Lumped and distributed parameter fluid systems, fluid mechanics of jets, wall attachment and vortex devices.

## Unit VI

Pure fluidic analog amplifiers, analog signal control techniques, design of pure fluid digital elements.

## Texts / References:

1. J.F.Blackburn, G.Rechthof, J.L. Shearer, Fluid Power Control, MIT.
2. B.W.Anderson, The Analysis and Design of Pneumatic Systems, Wiley.
3. K.Foster, G.Parker, Fluidic Components and Circuits, Wiley.
4. A.B.Goodwin, Fluid Power Systems, Macmillan.

## Wind Energy

| MTE15D | Wind Energy | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 200 Marks |  |

Course Objectives: Objectives of this course are

1. To understand history of wind energy and its scope in future.
2. To get practical knowledge about use various wind energy measurement indicators, anemometers
3. To calculate various parameters of wind turbine.

Course Outcomes: At the end of the course, student should be able to

| CO 1 | Identify and describe history of wind energy and its scope in future. |
| :--- | :--- |
| CO 2 | survey and analyze through a literature review world distribution of wind, Weibull <br> statistic, variation in wind energy etc., |
| CO 3 | Conduct an experiment to use various wind energy measurement indicators, <br> anemometers, and apply it to analyze and check data obtained from surveys. |
| CO 4 | Demonstrate and calculate performance parameters wind energy turbine. |
| CO 5 | Illustrate various electrical systems used in wind energy power plant. |
| CO 6 | Examine and justify economics of wind system. |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 | 1 | 1 | 2 |  |  |  |  |  |  |  |  |
| CO2 | 1 |  | 2 |  | 1 | 1 |  |  |  |  | 1 |  |
| CO3 | 2 | 1 | 1 |  |  |  |  |  |  |  |  |  |
| CO4 | 1 |  |  | 2 | 1 | 1 |  |  |  |  |  |  |
| CO5 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO6 | 1 | 1 |  |  | 1 |  |  | 1 |  |  |  |  |

## Course Contents

## Unit I

Introduction: Historical uses of wind, History of wind electric generations.

## Unit II

Wind Characteristics: Metrology of wind, World distribution of wind, Atmospheric stability, Wind speed variation with height, Wind speed statistics, Weibull statistics, Weibull parameters, Rayleigh and normal distribution.
Wind Measurements: Biological indicators, Rotational anemometers, other anemometers, Wind direction.

## Unit III

Wind Turbine Power, Energy and Torque: Power output from an ideal turbine, Aerodynamics, Power output from practical turbines, Transmission and generation efficiency, Energy production and capacity factor, Torque at constant speeds, Drive train oscillations, Turbine shaft power and torque at variable speeds.

Unit IV
Wind Turbine Connected to the Electrical Network: Methods of generating synchronous power, AC circuits, the synchronous generator, per unit calculations, the induction machine, Motor starting, Capacity credit features of electrical network.
Wind turbines with Asynchronous Electric Generators: Asynchronous systems, DC shunt generator with battery load, Per unit calculation, Self excitation of the induction generators, Single phase operation the induction generator, Field modulated generators, Roesel generator.

## Unit V

Asynchronous Load: Piston water pumps, Centrifugal pumps, Paddle wheel heaters, Batteries, Hydrogen economy, and Electrolysis cells.

## Unit VI

Economics of Wind Systems: Capital costs, Economic concepts, Revenues requirements, Value of wind generated electricity

## Text/Reference Books:

1. Garg L Johnson: "Wind Energy Systems" Prentice Hall. Inc, New Jersey - 1985
2. Desire Le Gouriers: "Wind Power Plants: Theory and Design" Pergamon Press - 1982

Finite Element Method

| MME15E | Steam Engineering | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

## Pre-Requisites: None

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

| CO1 | Understand the basics principle of FE method |
| :--- | :--- |
| CO2 | Identify mathematical model for solution of common problems |
| CO3 | Solve structural, thermal problem using FE in 1D Case |
| CO4 | Derive element stiffness matrix by different methods |
| CO5 | Understand the formulation for 2D and 3D case |
| CO6 | Recognize need for and engage in lifelong learning |

## Mapping of course outcomes with program outcomes

| Course | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO2 | 3 | 3 | 1 |  | 1 |  |  |  |  |  |  | 1 |
| CO3 | 2 | 2 | 1 | 2 | 2 |  |  |  | 2 |  |  | 1 |
| CO4 | 3 |  |  |  |  |  |  |  | 2 |  |  |  |
| CO5 | 3 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO6 |  |  | 1 |  |  |  |  |  |  |  |  | 3 |

## Course Contents:

## Unit 1

- 1-D Problems: Introduction to structural analysis and FEM, Introduction to approximate solutions and FEM, summary of linear elastic mechanics.


## Unit 2

- 1-D Problems: Principles of linear elastic mechanics, principles of virtual displacements and minimum potential energy, Rayleigh Ritz method, exact $\mathrm{v} / \mathrm{s}$ approximate solution, beam elements.


## Unit 3

- 2-D Problems: Plane stress and plane strain conditions, triangular elements, constant strain triangle, linear strain triangle, Boundary conditions, body forces and stress recovery, quadrilateral elements.


## Unit 4

- 2-D Problems: Lagrange and Serendipity shape functions, isoparametric formulation, numerical integration, modeling with isoparametric elements, requirements for convergence, patch test, nonconforming elements, reduced integration.


## Unit 5

- 3-D Problems: Axisymmetric solids, governing equations, axisymmetric elements and their applications, mixed formulations, bending of flat plates (Kirchhoff Theory), continuity requirements and boundary conditions.


## Unit 6

- 3-D Problems: Discrete Kirchhoff's elements, thick plate elements, plate bending applications, shells as assemblage of flat plates, finite element formulation for dynamic problems, mass properties, introduction to elastic stability for frames and plates.


## TEXTS / REFERENCES:

1. R. D. Cook, Concepts and Applications of Finite Element Analysis; John Wiley and Sons, second edition, 1981.
2. C.S. Krishnamurti, Finite element method; Tata Mc-Graw Hill Publication.
3. K.J. Bathe, Finite Element Method and Procedures; Prentice hall, 1996.
4. Tirupathi, R., and Chandrupatla, Finite Elements in Engineering; PHI Publication, New Delhi.
5. Bruce Irons and Soharab Ahmed, Techniques of Finite Elements; John Wiley and Sons, New York.
6. K.J. Bathe, Finite Element Method; Prentice Hall, 1987.
7. O.P., Goptha, Finite and Boundary Element Methods in Engineering; Oxford and IBH.

## Steam Engineering

| MTE15F | Steam Engineering | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are
1.To Understand of the working of different boilers and accessories..
2.To analyze thermal systems for energy conservation and waste heat recovery.
3. To design and develop controls and instrumentation.

Course Outcomes: At the end of the course, student should be able to:

| CO1 | Explain working of different boilers and significance of mountings and accessories. |
| :--- | :--- |
| CO2 | Use techniques, skills, and modern engineering tools necessary for boiler performance assessment |
| CO3 | Understand theoretical and practical background in thermal systems, and will have a good <br> understanding of energy conservation fundamentals. Students will have the ability to analyze <br> thermal systems for energy conservation. |
| CO4 | Design a steam piping system, its components for a process and also design economical anc <br> effective insulation. |
| CO5 | Analyze a thermal system for sources of waste heat design a system for waste heat recovery. |
| CO6 | Design and develop controls and instrumentation for effective monitoring of the process. |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| CO1 | 2 |  |  |  | 1 |  |  | 1 |  |  |  |  |
| CO2 | 2 | 1 |  | 3 |  |  |  | 2 |  | 1 |  |  |
| CO3 | 1 | 2 | 1 |  |  | 1 |  |  |  |  |  | 1 |
| CO4 | 2 | 1 |  |  |  | 1 | 2 |  |  |  |  | 1 |
| CO5 | 1 | 1 | 1 |  |  |  |  |  |  |  |  | 1 |
| CO6 | 2 |  |  |  |  |  |  | 2 |  |  |  |  |

## Course Content

## Unit I

Introduction Fundamentals of steam generation, Quality of steam, use of steam table, Mollier Chart Boilers, Types, Mountings and Accessories, Combustion in boilers, Determination of adiabatic flame temperature, quantity of flue gases, Feed Water and its quality, Blow down; IBR, Boiler standards.

## Unit II

Piping \& Insulation Water Line, Steam line design and insulation; Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory types, selection and application of refractory, Heat loss.

## Unit III

Steam Systems Assessment of steam distribution losses, Steam leakages, Steam trapping,Condensate and flash steam recovery system, Steam Engineering Practices; Steam Based Equipment's / Systems.

## Unit IV

Boiler Performance Assessment Performance Test codes and procedure, Boiler Efficiency, Analysis of losses; performance evaluation of accessories; factors affecting boiler performance.

## Unit V

## Energy Conservation and Waste Minimization

Energy conservation options in Boiler; waste minimization, methodology;economic viability of waste minimization.

## Unit VI

Instrumentation \&Control Process instrumentation; control and monitoring. Flow, pressure and temperature measuring and controlling instruments, its selection.

## Texts/References:

1. T. D. Estop, A. McConkey, Applied Thermodynamics, Parson Publication
2. Domkundwar; A Course in Power Plant Engineering; Dhanapat Rai and Sons
3. Yunus A. Cengel and Boles, "Engineering Thermodynamics ", Tata McGraw-HillPublishing Co. Ltd.
4. Book II - Energy Efficiency in Thermal Utilities; Bureau of Energy Efficiency.
5. Book IV - Energy Performance Assessment for Equipment \& Utility Systems; Bureau of Energy Efficiency.
6. Edited by J. B. Kitto\& S C Stultz; Steam: Its Generation and Use; The Babcock and Wilcox Company
7. P. Chatopadhyay; Boiler Operation Engineering: Questions and Answes; Tata McGrawHill Education Pvt Ltd, N Delhi

## Pumps, Blowers and Compressors

| MTE15G | Pumps, Blowers and <br> Compressors | PEC | $3-0-0$ | Exam Scheme |
| :--- | :--- | :--- | :--- | :--- |
| Exam |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

## Course Objectives:

1. To provide the sufficient knowledge of concept, applications, importance of pumps blower and compressors
2. To familiarize the students about the Pumps blowers and compressors and their applications in real life situations
3. To understand the industrial applications of Pumps blowers and compressors

## Course Outcomes:

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

| CO1 | Demonstrate Law of momentum, Vortex theory of Euler's head. Hydraulic performance of pumps, <br> Cavitation, |
| :--- | :--- |
| CO2 | Design of centrifugal pumps, axial flow pump and analyze their performance using <br> engineering software's etc., |
| CO3 | Study types of fans and blowers, calculate their efficiency, stresses, and characteristics, <br> draw performance characteristics. |
| CO4 | Modeling of cooling tower fans Surging Design of blowers and fans. |
| CO5 | Demonstrate and interpret performance analysis of Axial flow and centrifugal flow compressors. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> CO $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO3 | 1 | 1 |  |  |  |  |  |  |  |  |  | 1 |
| CO4 |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| CO5 | 1 |  |  |  |  |  |  |  | 1 |  |  |  |

Course Contents

## Unit I

## Centrifugal and Axial Flow Pumps

Law of momentum, Vortex theory of Euler's head.Hydraulic performance of pumps; Cavitation, Losses in Pumps, Priming, Jet pumps. The centrifugal pump, definitions, pump output and efficiency, multistage centrifugal pumps, axial flow pump, Design of pumps, Pumps in series and parallel.

## Unit II

Power Transmitting Turbo-machines, Introduction, theory, fluid of hydraulic coupling, torque converter.

## Unit III

Rotary fans and blowers Introduction, Centrifugal blower, types of Vane shapes, Size and speed of Machine, Vane shape: efficiency, stresses, and characteristics. Actual performance characteristics, the slip co-efficient, Drum and partial flow fans, Fan laws and characteristics, Losses in fans and blowers.

## Unit IV

Turbo blowers and their characteristics. Cooling tower fan, Surging Design of blowers and fans.

## Unit V

Axial Compressors: Stage velocity triangles, enthalpy - entropy diagrams, flow through blade rows, stage losses and efficiency, work done factor, low hub-tip ratio stages, super sonic and trans sonic stages, performance characteristics and design.

## Unit VI

Centrifugal Compressors: Elements of centrifugal compressor stage, stage velocity diagrams, enthalpy-entropy diagram, nature of impeller flow, slip factor, diffuser, volute casing, stage losses, performance characteristics and design.

## TEXT / REFERENCES:

1. A.J.Stepanoff, Centrifugal and Axial /flow Pumps, Wiley, 1962.
2. A.Kovats, Design and Performance of Centrifugal and Axial Flow Pumps and Compressors, Oxford, Pergamon, 1958.
3. V. Kadambi and Manohar Prasad: "An Introduction to energy conversion VolumeIII,2002
4. S M Yahya: "Turbines, Compressors and Fans", Second Edition.
5. V Ganesan: "Gas Turbines", 2002.
6. R.Yadav, Steam and Gas Turbine, Central Publishing Home, Allahabad.

## Communication Skills

| BSH16 | Communication Skills | HSSC | $2-0-0$ | 2 Credits |
| :--- | :---: | :---: | :---: | :--- |

## Pre-Requisites: None

Course Outcomes: At the end of the course, the student will be able to:

| CO 1 |  |
| :--- | :--- |
| CO 2 |  |
| CO 3 |  |
| CO 4 |  |
| CO 5 |  |
| CO 6 |  |

## Mapping of course outcomes with program outcomes

| Course | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO2 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO3 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO4 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO5 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO6 |  |  |  |  |  |  |  |  |  |  |  |  |

## Course Contents:

## UNIT1

Introduction to communication, Necessityofcommunication skills, Features ofgood communication, Speakingskills, Feedback\&questioningtechnique, Objectivityin argument

UNIT 2
Verbaland Non-verbalCommunication, Useand importanceof non-verbalcommunication while usinga language, Studyofdifferentpictorialexpressionsofnon-verbalcommunicationand theiranalysis

UNIT 3
Academic writing, Different typesofacademic writing, WritingAssignments and Research Papers, Writingdissertations andprojectreports

UNIT 4
Presentation Skills:Designingan effective Presentation, Contents,appearance,themes in a presentation, Tone and Language in a presentation, Roleand Importance ofdifferenttoolsfor effective presentation

UNIT 5
Motivation/Inspiration:Abilitytoshape anddirectworking methods accordingto self-definedcriteria

Abilitytothinkforoneself,Applyoneselfto ataskindependentlywith self-motivation,Motivation techniques:Motivationtechniques based on needs andfield situations

UNIT 6
SelfManagement,SelfEvaluation,Selfdiscipline, Selfcriticism, Recognitionofone'sown limits and deficiencies,dependency, etc.
SelfAwareness, Identifyingone's strengths andweaknesses, Planningand Goalsetting, Managingself- emotions, ego, pride, Leadership andTeamDynamics

## ReferenceBooks:

1. Mitra, Barun, PersonalityDevelopment and SoftSkills, Oxford UniversityPress, 2016
2. Ramesh, Gopalswamy, TheAceof Soft Skills: Attitude, Communication and Etiquette forSuccess, Pearson Education, 2013
3. Covey, Stephen R.,Seven Habits of HighlyEffectivePeople: Powerful Lessons in Personal Change
4. RosenbergMarshallB.,Nonviolent Communication: A Language of Life

## Thermal Engineering Lab

| MTE17 | Thermal Engineering Lab | PCC | $0-3-0$ | 2 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
|  | Continuous Assessment <br> 25 Marks | PR/OR | Total |  |

Course Objectives: Objectives of this course are

1. To apply the theoretical concepts and enhance understanding of the engineering concepts
2. To familiarize the students about the measurements and error calculations during experiments
3. To understand the design of experiments and report writing

Course Outcomes: At the end of the course, student will be able to

| CO1 | Conduct test on heat transfer enhancement set-up, single-cylinder diesel engine, air <br> conditioning set-up, centrifugal pump etc. to study their performance and analyze the <br> results. |
| :--- | :--- |
| CO 2 | Draw and analyze performance curves of these machines/systems. |
| CO 3 | Compare the results obtained with expected theoretical results. |


| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  | 1 |  |  | 2 |  |  |  |  | 2 |  |
| CO 2 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |
| $\mathrm{CO3}$ | 2 |  |  |  |  | 1 |  |  |  |  |  |  |

## Contents

## Experiments on the following set-ups(Any Four):

1. Heat Transfer Enhancement Set-up
2. Computerised Single-Cylinder Diesel Engine Set-up with Alternative Fuel
3. Set-up for Extraction of Vegetable Oil and its Transesterification
4. Air-Conditioning Test-rig
5. Variable speed Centrifugal/Gear Pump Set-ups
6. Unsteady State Heat Transfer Set-up
7. Blower Test-rig

Study includes performance evaluation, calibration of measuring instrument/s and error analysis.It is also expected to conduct innovative experiment/s on the existing set-up with little modifications.

## Modeling and Analysis in Thermal Engineering

| MTE21 | Modeling and Analysis in <br> Thermal Engineering | PCC | Exam Scheme |
| :--- | :--- | :--- | :--- | :--- |
| 4 Credits |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge to learn the thermal modeling of real engineering problems
2. To familiarize the students about the applications of fundamental laws and mathematics principles for thermal modeling
3. To understand the concept of optimization applied to engineering applications

## Course Outcomes:

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

| CO1 | Attempt modeling real life systems of interest in order to predict its dynamic behavior. |
| :--- | :--- |
| CO2 | Use simulation tools to determine dynamic response of system following external inputs. |
| CO3 | Understand capabilities and limitations of various numerical and mathematical models. |
| CO4 | Optimization of thermal systems, formulation, optimization methods. |
| CO5 | Deep understanding on the governing equations for convection heat transfer; knowing <br> the dimensionless parameters |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 |  | 1 |  |  | 2 |  |  |  |  |  |  |  |
| CO2 | 1 | 1 |  | 2 |  |  |  |  |  |  |  |  |
| CO3 |  |  |  | 1 |  |  |  |  |  |  |  |  |
| CO4 | 2 |  |  | 1 | 1 |  |  |  |  |  |  |  |
| CO5 | 1 |  |  |  |  |  |  |  |  |  |  |  |

## Course Contents

## Unit I

Introduction: Engineering Design, design and analysis, Workable and optimum system, formulation Thermal systems, basic characteristics and analysis.

## Unit II

Modeling of Thermal systems: Procedure of mathematical modeling, basic features of modeling, System and types of Model, characteristic of models, Curve fitting, exact fit, best fit.

## Unit III

Modeling and analysis of thermal systems, including - thermodynamics, fluid mechanics, heat and mass transfer, refrigeration and air-conditioning, system components (heat exchangers, expansion devices, pumps, compressors, turbines, boilers).

## Unit IV

Thermal system simulation: Sequential simulation, simultaneous simulation, successive substitution, Newton-Raphson method.

## Unit V

Optimization of thermal systems, formulation, optimization methods; Lagrange Multipliers, Search Methods, Linear programming, Dynamic programming and geometric programming.

## Unit VI

Develop methodologies for the design and optimization of thermal systems. A non-linear equation solver, Engineering Equation Solver (EES), Pinch technology: basic concepts, T-h, h -s diagrams, design of recovery system using pinch technology.

## TEXTS / REFERENCES:

1. Yogesh Jaluria, Design and Optimization of Thermal Systems ,McGraw Hill Companies, Inc.
2. W.F.Stoecker: "Design of Thermal Systems", 3rd Ed., McGraw Hill,1989.
3. B.K.Hodge: "Analysis and Design of Thermal Systems", Prentice Hall Inc., 1990.
4. I.J.Nagrath\&M.Gopal: "Systems Modeling and Analysis", Tata McGraw Hill.
5. D.J. Wide: "Globally Optimal Design", Wiley- Interscience, 1978.
6. R.F.Boehm, Design Analysis of Thermal systems, John Willey and son's
7. A. Bejan,M.moran, Thermal Design and Optimization, John Willey and son's

## Fluid Dynamics

| MTE22 | Fluid Dynamics | PCC | $3-1-0$ | 4 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 20 Marks | 60 Marks | Total |

## Course Objectives: Objectives of this course are

1. To provide the technical understanding of Fluid mechanics in the back ground of mathematics
2. To familiarize the students about the fluid dynamics and its applications to model the real life engineering problems
3. To apply the subject knowledge in the areas like CFD

## Course Outcomes:

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

| CO1 | Understand and define basic fluid dynamic concept like continuum, surface forces, stress tensor and <br> vector fields, Eulerian and langrangian flow. |
| :--- | :--- |
| CO2 | Define the motions of fluid elements and derive continuity equation,stream function and velocity <br> potential. |
| CO3 | Derive and apply Navier-stokes equation to various types of flow systems. |
| CO4 | Apply Boundary layer theory concept, and able to derive solutions by various numerical methods. |
| CO5 | Describe and analyze the different flow, velocity correlation and universal velocity distribution. |
| CO6 | Examine and numerical analysis of PDE and providing techniques for interpreting and analyzing the <br> behavior of numerical schemes. |

Mapping of COs with POs

| PO's $\rightarrow$ <br> CO's $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO3 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO4 | 1 | 1 |  | 2 |  |  |  |  |  |  |  |  |
| CO5 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO6 | 1 | 1 |  | 2 |  |  |  |  |  | 1 |  |  |

Note: 1- Means least contribution,
2- Means medium contribution,
3- Maximum contribution

## Course Contents

## Unit I

Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, Scalar and vector fields, Eulerian and Lagrangian approach.

## Unit II

Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, stream function and velocity potential. Transport theorems, constitutive equations, Unit III
Derivation of Navier Stokes equations for compressible flow. Exact solutions of Navier Stokes equations : plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow over a flat pate, cylinders and spherical bodies, Stoke's first and second problem, Hiemenz flow, flow near a rotating disk, flow in convergent- divergent channels. Slow viscous flow: Stokes and Oseen's approximation, theory of hydrodynamic lubrication.

## Unit IV

Boundary layer: derivation, exact solutions, Non dimensionalization of Boundary layer equation, Blasius (similarity solution), Falkner Skan, Von-karmon integral equation series solution and numerical solutions. Approximate methods. Momentum integral method.

## Unit V

Turbulent flow: algebraic models, hydrodynamic stability, velocity correlations, Reynold's stresses, Prandtl's Mixing Length Theory, Karman's velocity defect law, universal velocity distribution, Plane and axi-symmetric jets, Two equation model(k-epsilon), large eddy simulation.

## Unit VI

Compressible flow: 1D flow, speed of sound, variable c/s flow, converging-diverging nozzle, normal shock relation, past slender bodies, compressible boundary layer.
Computational fluid dynamics: Introduction, fundamentals of numerical analysis of partial differential equations (PDE).

## TEXTS / REFERENCES:

1. F.M.White ,Fluid Mechanics, McGraw-Hill
2. K.Muralidhar and Bishwas, Advanced Engineering Fluid Mechanics, Alpha science international limited
3. Fox and McDonald, Introduction to Fluid Mechanics, J.H. Wiley and Sons.
4. S.M.Yahya, Fundamentals of Compressible Flow, Wiley Eastern Ltd.
5. H. Schlichting, Boundary Layers Theory, McGraw-Hill.
6. J.M.Robertson, Hydrodynamics in Theory and Application, Prentice Hall.
7. A.H.Shapiro, The Dynamics and Thermodynamics of Compressible Fluid Flow, Ronald.

## Conservation of Energy in Buildings

| MTE23A | Conservation of Energy in <br> Buildings | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

## Course Objectives:

- Provide strategic leadership for the implementation of energy management in light of the "culture" of your organization
- Assess current organizational energy management capacity Plan actions to increase capacity
- Provide leadership for in-house assessment of energy use and identification of savings opportunities


## Course Outcomes:

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

| CO1 | Identify and demonstrate the demand supply gap of energy in Indian scenario. |
| :--- | :--- |
| CO2 | Carry out experiment and energy audit of an industry/Organization. Draw conclusion and <br> suggest mitigations to that industry. |
| CO3 | Draw the energy flow diagram of an industry and identify the energy wasted or a waste <br> stream |
| CO4 | Analyze and select appropriate energy conservation method to reduce the wastage of <br> energy. |
| CO5 | Evaluate the techno economic feasibility of the energy conservation technique adopted. |

## Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| CO1 | 1 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |  |  | 1 |  |
| CO3 | 1 |  |  | 1 | 1 |  |  |  |  |  |  |  |
| CO4 | 2 | 1 |  |  |  | 1 |  |  |  |  |  |  |
| CO5 | 2 |  |  | 1 | 1 |  |  |  |  |  |  |  |

## Course Contents

## Unit I

Introduction and a history of conservation of energy in buildings.
Unit II

Climates and buildings. Thermal properties and energy content of building materials. Embodied Energy, concept of green Building, LEED Rating etc.

## Unit III

Windows design and daylight, Window shading, View factor and energy conservation. Alternative cooling solutions

## Unit VI

Energy conservation techniques in Air-conditioning systems. Lighting (Dylighting and Electric lighting). passive and active methods of heating and cooling, Air-conditioning controls

Unit V
Estimation of building loads. Steady state method, Network method, Numerical method, Correlation's,

## Unit VI

Computer packages such as V-Pro for carrying out thermal design of buildings and predicting performance.

## TEXTS / REFERENCES:

1. M.S.Sodha, N.K.Bansal. P.K.Bansal. A.Kumar and M.A.S.Malik, Solar PassiveBuilding, Science and Design,Pergmon Press, 1986.
2. J.R.Williams, Passive Solar Heating, Ann Arbar Science, 1983.
3. R.W.Jones, J.D.Balcomb, C.E.Kosieqiez, G.S.Lazarus, R.D.McFarlandandW.O.Wray, Passive Solar Design Handbook, Vol. 3, Report of U.S. Department of Energy (DOE /CS-0127/3), 1982.
4. J.L.Threlkeld, Thermal Environmental Engineering, Prentice Hall, 1970.

## Computational Fluid Dynamics

| MTE23B | Computational Fluid <br> Dynamics | PEC | $3-0-0$ | Eredits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

## Course Objectives:

1. To Understand the concept of fluid dynamics, CFD techniques, convergence criteria
2. To familiarize the students about the implementation of CFD in fluid mechanics and heat transfer problems
3. To understand the use of software based on CFD

## Course Outcomes:

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

| CO1 | Identify applications of finite volume and finite element methods to solve <br> Navier-Stokes equations. |
| :--- | :--- |
| CO2 | Evaluate solution of aerodynamic flows. Appraise \& compare current CFD software. <br> Simplify flow problems and solve them exactly. |
| CO3 | Design and setup flow problem properly within CFD context, performing solid <br> using CAD package and producing grids via meshing tool. |
| CO4 | Interpret both flow physics and mathematical properties of governing Navier-Stokes equation <br> and define proper boundary conditions for solution. |
| CO5 | Use CFD software to model relevant engineering flow problems. Analyse the CFD <br> results. Compare with available data, and discuss the findings. |

## Mapping of COs with POs:

| POs $\rightarrow$ <br> Cos $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 |  | 2 | 3 | 1 | 1 |  |  |  |  |  |  |
| CO3 | 2 | 1 | 1 | 2 | 1 |  | 1 |  |  |  |  |  |
| CO4 | 1 |  |  | 1 | 1 | 1 |  |  |  |  |  |  |
| CO5 |  |  | 2 | 2 | 2 | 1 |  |  |  | 2 |  | 1 |

## Course Contents

## UNIT I

## Introduction to CFD

Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations

## UNIT II

## Governing Equations

Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.

## UNIT III

## Finite Volume Method

Domain discretization, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach.

## UNIT IV

## Geometry Modeling and Grid Generation

Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance.

## UNIT V

Methodology of CFDHT
Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation.

UNIT VI

## Solution of Navier-Stokes Equations for Incompressible Flows

Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows.

## Reference Books:

1. J. D. Anderson, Computational Fluid Dynamics-The Basics with Applications, Mcgraw Hill.
2. An Introduction to Computational Fluid Flow: The Finite Volume Method, by H.K. Versteeg and W. Malalasekera, Prentice Hall
3. Computational Methods for Fluid Dynamics by Ferziger and Peric, Springer Publication
4. Muralidhar K. and Sundararajan T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi1995.
5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, T \& F.
6. An Introduction to Computational Fluid Mechanics by Chuen-Yen Chow, Wiley Publication.

## Advanced Refrigeration

| MTE23C | Advanced Refrigeration | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 20 Marks | Total <br> 60 Marks | 100 Marks |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of refrigeration
2. To familiarize the students about the refrigeration processes and component design
3. To provide the understanding of the industrial applications of refrigeration

Pre requisite: Refrigeration and Air-conditioning

## Course Outcomes:

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

| CO1 | Formulate and solve vapor compression refrigeration and multi-stage vapor compression systems. |
| :--- | :--- |
| CO2 | Study and identify various types of refrigerants and their properties., such as zeotropic, <br> azeotropic etc., |
| CO3 | Illustrate Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out <br> regulations, action with lubricating oil, retrofitting, refrigerant blends, effects on <br> refrigeration components. |
| CO4 | Design and analyze vapor absorption system |
| CO5 | select refrigerant control techniques,and do piping designing for refrigeration plant |

## Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{CO1}$ | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| $\mathrm{CO2}$ | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO 3 | 1 |  |  |  |  |  |  |  |  |  |  | 1 |
| $\mathrm{CO4}$ |  |  |  |  |  | 1 |  |  |  |  |  | 1 |
| CO 5 | 2 | 1 |  | 1 |  | 2 |  |  |  |  |  |  |

## Course Contents

## Unit I

Vapor compression refrigeration, actual cycle, second law efficiency, multistage compression with inter-cooling, Multi-evaporator systems, Cascade systems.

## Unit II

Performance characteristics and capacity control of reciprocating and centrifugal compressors, screw compressor and scroll compressor, compressor motor selection

## Unit III

Design, selection of evaporators, condensers, system balance, control systems.

## Unit IV

History, Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations, action with lubricating oil, retrofitting, refrigerant blends, effects on refrigeration components. Thermoelectric and nonconventional refrigeration systems, adiabatic de-magnetization.

## Unit V

Vapor absorption refrigeration, $\mathrm{Li}-\mathrm{Br}$ and aqua ammonia system, calculation of mass flow rate and system performance, energy balance, controls, analysis of rectifier and analyzer, single effect and double effect systems, vapor transformer.

## Unit VI

Refrigeration controls, Flow controls, Temperature controls, Expansion devices: design and selection, refrigeration system piping design.

## TEXTS / REFERENCES:

1. Stoecker W. F. and Jones J. P.,Principles of Refrigeration and air-conditioning, McGraw Hill
2. Arora C. P., Refrigeration and air-conditioning, Tata McGraw Hill.
3. Gosney W. B., Principles of refrigeration, Cambridge University Press.
4. Stoecker W. F., H. B. of Industrial refrigeration, McGraw Hill Companies, Inc.
5. Dossat R. J., Principles of Refrigeration, Pearson Education
6. ASHRAE H. B. - Refrigeration
7. ASHARAE H. B. - Fundamental
8. Edward Pita, Air Conditioning Principles and Systems,Prentice Hall

## Design of Heat Exchangers

| MTE23D | Design of Heat Exchanger | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of thermal design of Heat exchanger
2. To familiarize the students about the heat exchanger design and its applications in real life situations
3. To carry out a computer simulation of heat exchanger design

## Course Outcomes:

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

| CO1 | Demonstrate and of heat exchanger design methodology, and design considerations |
| :--- | :--- |
| CO2 | Analyze performance of Heat exchanger by applying basic design theory. |
| CO3 | Design and conduct experiment on one from double pipe, shell and tube, tube fin, plate type ang <br> plate-fin heat exchanger. |
| CO4 | Demonstrate selection criteria of HEX and conduct an independent research to suggest suitable <br> HEX. |
| CO5 | Model and illustrate heat exchanger based on I-law and irreversibility. |
| CO6 | Study and analyze losses in HEX, and upcoming advancements. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 | 1 |  |  |  |  |  |  | 1 |  |  |  |
| CO2 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO3 |  |  | 2 |  |  |  |  |  | 2 |  |  |  |
| CO4 | 2 | 1 |  |  |  |  | 1 |  | 1 |  |  |  |
| CO5 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO6 | 1 |  |  | 1 | 1 |  |  |  |  |  |  |  |

## Course Contents

## Unit I

Introduction: Classification, overview of heat exchanger design methodology, Design specifications, thermo hydraulic design, and other considerations.

## Unit II

Basic design theory: LMTD method, $\varepsilon$-NTU method, P-NTU method, $\psi$-P method and P1-P2 method.

Unit III
Heat exchanger design procedures: Design of double pipe, shell and tube, tube fin, plate type and plate-fin heat exchanger, Design of cryogenic heat exchangers.

## Unit IV

Selection of heat exchangers: selection criteria, general selection guidelines of shell and tube heat exchanger, plate type heat exchanger.

## Unit V

Thermodynamic modeling and analysis: modeling of heat exchanger based on I-law and Irreversibility.

Unit VI
Header design: Flow maldistribution, fouling and corrosion, advances in heat exchangers.

## TEXTS / REFERENCES:

1. R.K.Shah and DeusanP.Sekulic, Fundamentals of heat exchanger design, 2003, John Willeyand Sons.
2. S. Kakac, Heat Exchangers - Thermal Hydraulic Fundamentals and Design, Hemisphere, Mc Graw-Hill.
3. D. Q. Kern and A. D. Kraus; Extended Surface Heat transfer, McGraw-Hill.
4. D. Q. Kern, Process Heat Transfer, McGraw-Hill.
5. W. M. Kays and A. C. London, Compact Heat Exchangers, McGraw-Hill.

Alternative Fuels for IC Engine

| MTE23E | Alternative Fuels for IC Engine | Elective III | $3-0-0$ | 3 Credits |
| :---: | :---: | :---: | :---: | :---: |
| Exam Scheme |  |  |  |  |
| Mid-Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Outcomes: At the end of the course, students will be able to

| CO 1 | Demonstrate Structure of petroleum, Refining process, Products of refining process, <br> Select suitable fuels for use in SI engines. Understand various performances rating in SI <br> engines. |
| :---: | :--- |
| CO 2 | Illustrate properties of petroleum products and classify them on their characteristic. |
| CO 3 | Describe and analyze Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, <br> Hydrogen and their manufacturing procedure. |
| CO 4 | calculate and estimate performance and emission characteristics of alternative fuels |
| CO 5 | Analyze environmental effects of combustion of various fuels, suggest modification in <br> their usage. |

Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO 1 | 2 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO 2 |  | 1 |  |  |  |  |  |  |  |  |  |  |
| CO 3 | 1 | 1 |  | 1 | 1 |  |  |  |  |  |  |  |
| CO 4 |  |  | 1 | 1 |  |  |  |  |  |  |  |  |
| CO 5 | 1 | 1 |  |  | 1 | 1 |  |  |  |  |  |  |

## Course Contents

## Unit I:

Fuels: Introduction, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels and Numericals.

## Unit II:

Properties of petroleum products: Specific gravity, Density, Mokecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloud point, Pour point, Freezing point, Smoke point \& Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulcification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.

## Unit III:

Alternative fuels for I.C. engines: Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing.

## Unit IV:

Single Fuel Engines: Properties of alternative fuels, use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation $\mathrm{v} / \mathrm{s}$ gasoline operation.

## Unit V:

Dual fuel Engine: Need and advantages, the working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuel engine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.

Biodiesels: What are biodiesels, Need of biodiesels, Properties of biodiesels V/s petro diesel, Performance and emission characteristics of biodiesels v/s Petro diesel operation.

## Unit VI:

Availability: Suitability \& Future prospects of these gaseous fuels in Indian context.
Environmental pollution with conventional and alternate fuels, Pollution control methods and packages.

## Texts / Reference Books:

1. R.P Sharma \& M.L.Mathur: "A Course in Internal Combustion Engines", D.Rai\& Sons.
2. O.P. Gupta: "Elements of Fuels, Furnaces \& Refractories", Khanna Publishers, 2000.
3. Domkundwar V.M.: "Internal Combustion Engines", I Edition, Dhanpat Rai \& Co., 1999
4. John B. Heywood: "Internal Combustion Engines Fundamentals", McGraw Hill International Edition,
5. Osamu Hirao\& Richard Pefley: "Present and Future Automotive Fuels", Wiley Interscience Publication. NY. 1988.

## Boundary Layer Theory

| MTE23F | Boundary Layer Theory | PEC | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total |  |

Course Objectives:

1. To Understand the concept of fluid mechanics and physics of boundary layer
2. To familiarize the students about the boundary layer formation over the stream lined body, bluff body and thickness measurement
3. To understand the real life application of BL

Course Outcomes: At the end of the course, student will be able to

| CO 1 | Evaluate exact solution of Navier-stokes equation in boundary layer that exhibit small <br> viscosity by applying mathematical, Numerical techniques. |
| :---: | :--- |
| CO 2 | Demonstrate boundary-layer equations in the spirit of Prandtl, Prandtl boundary-layer <br> equations in two dimensions deduced by order-of-magnitude arguments, skin friction <br> drag. |
| CO 3 | calculate and solve ODE's for classical boundary-layer equations of Prandtl |
| CO 4 | Formulate and develop Exact solutions of the classical boundary-layer equations, |
| CO 5 | Analyze occurrence in steady flows, and at rear stagnation point of impulsively <br> started cylinder, Goldsten singularity. |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 |  | 1 |  | 1 |  | 1 |  |  |  |  |  |  |
| CO2 |  | 2 |  |  |  |  |  |  |  |  |  |  |
| CO3 | 1 |  |  | 2 |  | 1 |  |  |  |  |  |  |
| CO4 |  | 1 |  |  |  |  |  |  |  |  |  |  |
| CO5 | 1 |  |  | 2 |  |  |  |  |  |  |  |  |

## Course Contents

## Unit I

Exact solutions of the Navier-Stokes equation that exhibit a boundary layer at small values of the viscosity.

## Unit II

The boundary-layer equations in the spirit of Prandtl. Scaling, non-depersonalization and Reynolds number. Limitations of potential flow past a cylinder. Prandtl boundary-layer
equations in two dimensions deduced by order-of-magnitude arguments. Blasius solutions, displacement thickness, skin friction, drag.

## Unit III

Introduction to perturbation theory. Regular and singular perturbations. Examples from algebraic equations and ordinary differential equations. The classical boundary-layer equations of Prandtl as the leading term in a matched asymptotic expansion.

## Unit IV

Exact solutions of the classical boundary-layer equations, examples. A selection of those below .Flow past a wedge, Falkner Skan. Far wake of a flat plate. Two-dimensional jet. Lock'mixing layer. Prandtl transformation. Axisymmetric flows: Mangler's transformation. Splitdisc Ekman layer problems: Stewartson layers. Glauert wall jet.

## Unit V

Separation in adverse pressure gradients. Concept of and occurrence in steady flows, and at rear stagnation point of impulsively started cylinder. Form of skin friction near separation point: Goldstein singularity.

## Unit VI

Introduction to interactive boundary layers. Goldstein near wake. Trailing-edge triple deck.

## TEXTS / REFERENCES:

1. Batchelor, G. K. An Introduction to Fluid Mechanics. CUP.
2. Curle, N. The Laminar Boundary-Layer equations. OUP.
3. Curle, N. \& Davies, H. J. Modern Fluid Dynamics, VolI. Incompressible Flow.
4. Hinch, E. J., Perturbation Methods, CUP.
5. H.Schlichting, Boundary Layer Theory. McGraw Hill.
6. Van Dyke, M., Perturbation Methods in Fluid Mechanics. Parabolic Press.
7. Rosenhead, L. (ed). Laminar Boundary Layers. OUP.
8. Nayfeh, A. Introduction to Perturbation Techniques.
9. Sobey, I. J. Introduction to Interactive Boundary Layer Theory OUP.

## JET AND ROCKET PROPULSION

| MTE23G | Jet and Rocket Propulsion | PEC | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 20 Marks | 60 Marks | Total |
|  | 20 100 Marks |  |  |  |

## Course Objectives:

1. To Understand the concept of gas dynamics
2. To familiarize the students about the Jet and rocket propulsion and its whole thermodynamics analysis
3. To understand the applications of Jet propulsion

Course Outcomes: At the end of the program the student will be able to

| CO1 | Apply knowledge of features and capabilities of chemical and non-chemical rocket <br> propulsion systems. |
| :--- | :--- |
| CO 2 | Calculate the design thrust and overall efficiency of turbojet and turbofan engines, with <br> and without afterburners, from given component performance. |
| CO 3 | Calculate the specific impulse and mass flow for a rocket engine with the fluid <br> considered as an ideal gas with constant specific heats. |
| CO 4 | Estimate the specific impulse and mass flow for a rocket engine accounting for <br> chemical reaction and non-constant specific heats. |
| CO5 | Estimate the heat transfer rates in rocket nozzles and in aero-engine turbine <br> components. |
| CO6 | Design simple rocket propulsive system. |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 | 2 |  | 2 |  |  | 1 |  |  |  |  |  |  |
| CO3 | 1 |  | 2 | 2 |  |  |  | 1 |  | 1 |  |  |
| CO4 |  | 2 |  |  |  |  | 1 |  |  |  |  |  |
| CO5 | 1 |  |  |  |  |  |  |  |  |  |  | 1 |
| CO6 | 1 | 2 | 2 | 1 | 1 |  |  |  | 2 |  |  | 2 |

## Course Content

## Unit- I

Velocity triangles; compressor performance maps, Compressor blading; design; multi-staging, Turbines; stage characteristics; degree of reaction, mass flow limits; blade temperature. Turbine cooling; general trends and systems; internal cooling, Film cooling; thermal stresses; impingement cooling; how to do cooling design, Compressor-turbine matching; gas generators, Engine structures; centrifugal stresses; engine arrangements, Critical speeds and vibration, Combustors; afterburners.

## Unit II

Jet climb \& acceleration, calculation of drag and thrust, optimum exhaust velocity, Air breathing and non-air breathing engines, aircraft gas turbine engine, cycles analysis of ideal and real engines, components performance-intake, combustor, nozzle, turbomachinery, etc. limitations of jet engines, Rocket equation; optimum acceleration, Rocket staging.

## UnitIII

Turbojet, turboprop, turbofan engines, ramjet and pulsejet, design parameters; performance parameters like thrust, propulsive efficiency. Models for rocket engines; Inlets or diffusers, Exhaust nozzles, Compressors and fans.

## Unit IV

Modeling of thermal rocket engines; fuels, fuels arrangement, Types of nozzles; connection of flow to nozzle shape, control of mass flow, Modeling of rocket nozzles; effects of nozzle area ratio.

## Unit V

Jet engine and rocket structures, Rocket casing design; structural modeling, Heat transfer and cooling arrangement, Ablative cooling, Thrust vectoring; mass estimates.

## Unit VI

Chemical Rockets, types of propellants and their properties, injectors, thrust chamber, burning rate; Solid propellant gas generators; stability; grain designs; Cryogenic propellant, combustion phenomena, thrust vector control, ignition and inhibitors. Basics of Electrical and Nuclear rockets. Pollutant; motivations for control; formation; strategies for reduction, Aircraft engine noise: principles; regulations, Jet noise, turbomachinery noise, Rotordynamics of the jet engine.

## References:

1. Kerrebrock, J. L. Aircraft Engines and Gas Turbines.2nd ed. MIT Press, 1992.
2. Sutton, G. P., and O. Biblarz. Rocket Propulsion Elements.7th ed. Wiley Interscience, 2000.
3. J Mattingly, Elements of Gas Turbine Propulsion, McGraw-Hill Publications, 1996.
4. G.P. Sutton and O. Biblarz, Rocket Propulsion Elements, John Wiley \& Sons, 2001.
5. G.C.Oates, Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA, New York, 1988.
6. N.A.Cumpsty, Jet Propulsion, Cambridge University Press, 2000.
7. P G Hill and C R Peterson, Mechanics and Thermodynamics of Propulsion, Addison Wesley, 1965.
8. M J Zucrow, Aircraft and Missile Propulsion (Vol.I and II), John Wiley, 1958.
9. W WBathie, Fundamentals of Gas Turbines, John Wiley, 1996.
10. H Cohen, G F C Rogers and H I H Saravanamuttoo, Gas Turbine Theory, Addison Wesley, 1998.

## Steam and Gas Turbines

| MTE24A | Steam and Gas Turbines | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam | Total |  |

## Course Objectives:

1. To provide the sufficient knowledge of working, construction and control of ST and GT
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

## Course Outcomes:

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

| CO1 | Illustrate properties of Steam, Draw P-V, T-s, H-s(Mollier) diagrams for steam, Describe <br> Theoretical steam turbine cycle. |
| :--- | :--- |
| CO2 | Demonstrate and analyze vortex flow, energy lines and reheat factors of steam turbines. Solve <br> problems of finding performance steam turbine power plant. |
| CO3 | Demonstrate simple Brayton cycle for gas turbine analyze its performance on computer simulation, <br> suggest suitable modification and then analyze it. |
| CO4 | Study and apply various Performance Improvement Techniques in steam and gas Turbines |
| CO5 | Design and suggest and analyze cooling accessories and protective material for steam turbine. |

Mapping of COs with POs:

| $\mathrm{POs} \rightarrow$ <br> $\mathrm{COs} \downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{CO1}$ | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO 2 |  | 2 |  |  |  |  |  |  |  |  |  |  |
| $\mathrm{CO3}$ | 1 | 1 |  | 3 | 1 |  |  |  |  |  |  |  |
| $\mathrm{CO4}$ | 2 | 1 |  |  | 2 | 1 |  |  |  |  |  |  |
| CO 5 | 1 | 1 |  | 1 | 1 |  |  |  |  |  |  |  |

## Course Contents

## 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

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, Combuster design, Lubrication, Maintenance and trouble shooting.

## TEXTS / REFERENCES:

1. W.J.Kearton, Steam Turbine Theory and Practice, ELBS.
2. R.Yadav, Steam and Gas Turbine, Central Publishing Home, Allahabad.
3. Jack D. Mattingly., Elements of Gas Turbine propulsion, McGraw - Hill Pub.,
4. Cohen Rogers, Gas Turbine Theory, Longman Publishing.
5. V Ganesan: "Gas Turbines", 2002

## Mechatronics

| ME-XX24A | Mechatronics | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment | End-Sem Exam | Total |  |
| 20 Marks | 20 Marks | 60 Marks | 100 Marks |  |

## Course Objectives:

- To develop an ability to identify, formulate, and solve engineering problems.
- To develop an ability to design a system, component, or process to meet desired needs within realistic constraints.
- To develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.


## Course Outcomes:

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

| CO1 | Define sensor, transducer and understand the applications of different sensors <br> and transducers |
| :--- | :--- |
| CO2 | Explain the signal conditioning and data representation techniques |
| CO3 | Design pneumatic and hydraulic circuits for a given application |
| CO4 | Write a PLC program using Ladder logic for a given application |
| CO5 | Understand applications of microprocessor and micro controller |
| CO6 | Analyze PI, PD and PID controllers for a given application |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | :---: |
| CO1 | 1 | 1 | 1 | 3 | 2 |  |  |  | 2 | 1 |  | 1 |
| CO2 | 3 | 2 |  |  | 3 | 3 | 2 |  |  |  | 1 | 3 |
| CO3 | 1 | 1 |  | 3 | 3 | 2 | 1 |  | 3 |  | 1 | 3 |
| CO4 | 3 | 3 | 1 | 1 | 3 |  | 1 | 1 | 1 |  |  |  |
| CO5 | 3 |  |  | 1 | 3 | 2 | 3 |  |  |  |  | 2 |
| CO6 |  | 3 | 3 |  | 3 | 3 | 1 | 1 | 3 |  |  | 2 |

## Course Content

## Unit I

Introduction to Mechatronic systems, elements, advantages and practical examples of Mechatronic systems.

## Sensors and Transducers:

Various types of sensors and transducers used in Mechatronic system such as pressure sensors, temperature sensors, velocity sensors, Acceleration sensors, proximity sensors, position sensors,
force sensors, Optical encoders, Capacitive level sensor, tuctile sensors, Selection of sensors.

## Unit II

## Signal Conditioning and Data Representation

Types of electronic signals, Need for signal processing, Operational amplifiers: Types, classification and applications, Opto-isolators, Protection devices, Analogue to Digital and Digital to Analog Converters, Interfacing devices, Electro-magnetic Relays, Data representation systems, Displays, Seven segment displays, LCD displays, Printers, Data loggers, Data Acquisition Cards/Systems

## Unit III

Electrical Drives: Types of Electrical Motors, AC and DC motors, DC servomotors, Stepper motors, linear motors, etc.

## Pneumatics and Hydraulics

Components of Pneumatic systems, actuators, direction control valves, pneumatic air preparation, FRL unit, methods of actuation of valves, Sequencing of Pneumatic cylinders using Cascade and shift register methods. Electro-pneumatic valves, Electro- pneumatic circuits using single and double solenoid methods.
Hydraulic cylinders, design of cylinder, Design of Piston and piston rod, Valves, poppet valve, house pipes and design of tubing, Meter-in and Meter-out circuits.

## Unit IV

## Microprocessor and Microcontroller

8085 microprocessor, architecture, various types of registers and their functions in $8085 \mu \mathrm{P}$, Instruction sets, interfacing, applications. 8081 microcontroller, architecture, Instruction sets, various pins and their functions interfacing, applications.

## Programmable Logic Controller

Introduction, Architecture, Types of inputs/outputs, Specifications, guidelines for
Selection of PLCs, Programming: Ladder logic and FBD

## Unit V

## Control Systems

Open and closed loop system; block diagram manipulation/reduction, Transfer function, modeling of Mechanical Systems using spring, Dashpot and Masse quivalence.

## Unit VI

Stability of Systems
On/Off controller, Proportional Control, Integral control, Derivative Control; PI, PD and PID Controllers, Introduction to control using state variable system models, Bode Plots and stability criteria.

## Text Books

1. HMT Limited, Mechatronics, Tata McGraw-Hill, 1998.
2. Bolton, W., Mechatronics; Electronic Control System in Mechanical Engineering, Pearson Education Asia, 1999.
3. Raven, Automatic Control Engineering, McGraw-Hill, NewYork, 1986

## Cryogenic Engineering

| MTE24B | Cryogenic Engineering | PEC | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment | End-Sem Exam | Total |  |
| 20 Marks | 20 Marks | 60 Marks | 100 Marks |  |

## Course Objectives:

- To cover the basic principles of cryogenic engineering.
- To develop an intuitive understanding of cryogenics for the student who are interested to study the science technology of low temperatures.


## Course Outcomes:

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

| CO1 | Demonstrate and identify role of cryogenics in the industrial applications. |
| :--- | :--- |
| CO2 | Describe mechanical, thermal, thermo-electric properties of cryogenic fluids. |
| CO3 | Illustrate Ideal separation, properties of mixtures, Rectifiers column, separation of air, purification. |
| CO4 | List and give details about various types of cryogenic refrigeration system, such as J-T Refrigeration <br> systems, Philips refrigerator, Vuilleumier refrigerator, Solve refrigerator, G-M refrigerator |
| CO5 | Study and describe Insulation and storage systems in cryogenic engineering |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO3 | 1 | 2 |  | 1 | 1 |  |  |  |  |  |  |  |
| CO4 | 1 | 1 |  | 1 | 1 | 1 |  |  |  |  |  |  |
| CO5 | 1 | 2 |  |  | 1 |  |  |  |  |  |  |  |

## Course Contents

## Unit 1

## Introduction:

Industrial applications, research and development, properties of cryogenic fluids-oxygen, nitrogen, air, hydrogen and helium.
Behaviour of Structural Materials at Cryogenic temperature:
Mechanical properties, thermal properties, thermoelectric properties.
Unit 2
Liquefaction of Cryogenic Gases:
Inversion Temperature, Liquefaction Performance Parameters, Ideal cycle, liquefaction of air, Hydrogen and helium, critical components of liquefiers, efficiency, Cryogenic heat exchangers.

## Separation of Gases:

Ideal separation, properties of mixtures, Rectifiers column, separation of air, purification.

## Unit 3

## Cryogenic Refrigeration Systems:

Ideal refrigeration systems, J-T Refrigeration systems, Philips refrigerator, Vuilleumier refrigerator, Solvey refrigerator, G-M regrogerator.

## Unit 4

## Insulation:

Vacuum insulation, fibrous materials, Solid foams, Gas filled power, comparison, critical thickness.

## Unit 5

## Storage:

Size and shape of vessel, portable commercial containers, large stationary container, power, transport, storage system, Liquid level indicators.

## Unit 6

Transfer of Liquefied Gases:
Two phase flow transfer through insulated and uninsulated lines, cryogenic pumps and valves.

## TEXTS:

1. R. F. Barron, Cryogenic Systems, Oxford University Press, 1985.
2. Advanced Cryogenic Engineering, Proceedings of Cryogenic Engineering Conference, Vol 1-145, Plenum press, New York, 1968.

## Combustion Engineering

| MTE24C | Combustion Engineering <br> (Elective-I) | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of combustion engineering apply in real engineering problems
2. To familiarize the students about the combustion process in the back ground of IC engine
3. To understand the simulation of combustion process

## Course Outcomes:

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

| CO1 | Understand and recognize System Conservation Laws, Reynolds Transport Theorem, <br> Governing 3D Partial Differential Equations etc., |
| :--- | :--- |
| CO2 | Formulate and model, General Probability Density Function, Turbulent Pre-mixed and non pre- <br> mixed flames. |
| CO3 | knowledge of fuel thermo-chemistry and fuel quality effects on emissions, engine technologies, <br> engine combustion-related emissions and control technologies |
| CO4 | Extend their knowledge of fuels and engines to different situations of engineering context and <br> professional practice. |
| CO5 | Demonstrate the ability to engage in life-long learning. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 2 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 |  | 2 |  |  |  |  |  |  |  |  |  |  |
| CO3 | 1 |  | 1 |  | 1 |  | 1 |  |  |  |  |  |
| CO4 |  |  |  |  |  | 1 |  |  | 1 |  |  |  |
| CO5 |  |  |  |  |  |  |  |  |  |  |  | 2 |

## Course Contents

## Unit I

Review of energy sources and fossil fuels, role of combustion in energy conservation, comprehensive treatment of combustion principles and their applications.

## Unit II:

Thermochemistry: Stoichiometry and combustion reactions, Enthalpy of formation, Calculation of excess air, Adiabatic flame temperature, Chemical thermodynamics and chemical kinetics, Conservation equations for multi-component systems, System Conservation Laws, Reynolds Transport Theorem, Governing 3D Partial Differential Equations, Shvab-Zeldovich Coupling Functions and Mixture Fraction.

## Unit III

Premixed systems detonation and deflagration, laminar flames,1D propagating flame and flame speed Quenching, flammability, ignition and blow off, effects of different variables on burning velocity, methods for measuring burning velocity, flammability limits, ignition and quenching, detonations, their propagation and structure, flame stability.
Laminar Non-premixed (Diffusion) Flames, laminar diffusion flame jet, Jet flames and the Burke-Schumann Solution, Soot Formation, Counter-flow Flames.

## Unit IV

Turbulent pre-mixed flames, turbulent flames, turbulent combustion, chemical effects on turbulence, transition from laminar to turbulent diffusion flames.
Non-premixed systems: Flamelet Modeling Approaches, General Probability Density Function (PDF) Formulations

## Unit V

Droplet Combustion, Droplet Evaporation, Droplet Combustion, Simple 1-D Analysis for Multiphase Flows

## Unit VI

Combustion of solids: drying, devolatilization and char combustion, Practical aspects of coal combustion. Pollution and environment. Formation and control of pollution in flames, engineering applications; Combustion processes in SI Engines and C.I. Engines, Gas turbine combustors, fluidized bed combustors, Design of burners and Combustion chambers.

## TEXTS/REFERENCES:

1. N.A.Chigier, Energy, Combustion and Environment, McGraw-Hill Co, New York, 1981.
2. Glassman, Combustion, Academic Press, New York, 1977
3. A.MurthyKanury, Introduction to Combustion Phenomena, Gordon and Breach, New York, 1975.
4. S.P.Sharma and Chander Mohan, Fuels and Combustion, Tata McGraw-Hill, 1984.
5. K. K. Kuo, Principles of Combustion, (excellent more advanced reference)
6. Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments,
7. J. Warnatz, U. Mass and R. W. Dibble, Pollutant Formation, by (excellent more advanced reference)
8. F. Williams, Combustion Theory (a classic - more mathematical treatment)
9. S.R. Turns, Introduction to combustion, Tata McGraw-Hill
10. N. Peters ,Turbulent Combustion (a nice up-to-date summary of the state-of-the-art on
11. turbulent combustion modeling for gas phase systems)

## Nanotechnology

| MMECH24C | Nano Technology | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 20 Marks | 100 Marks |

## Course Objectives:

1. To Understand the concept of nano technology and its importance in real engineering applications
2. To familiarize the students about the use of nano technology in industrial world
3. To understand the physics of nana technology

Course Outcomes: At the end of the course, students will be able to

| CO 1 | Demonstrate the understanding of length scales concepts, nanostructures and nanotechnology. |
| :--- | :--- |
| CO 2 | Identify and to compare various synthesis and characterization techniques involved in <br> Nanotechnology. |
| CO 3 | Define and interpret the interactions at molecular scale. |
| CO 4 | Evaluate and analyze the mechanical properties of bulk nano-structured metals and alloys, <br> nano-composites and carbon nanotubes. |
| CO 5 | Compare and analyze the effects of using nanoparticles over conventional methods. |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| ---: | :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| CO1 | 1 | 1 |  |  |  | 2 | 1 |  |  |  | 1 |  |
| CO2 |  | 2 |  |  |  |  | 2 |  |  |  | 1 |  |
| CO3 | 1 | 1 | 1 |  | 2 |  |  |  | 2 | 1 |  | 1 |
| CO4 | 1 | 1 |  |  |  | 2 | 1 |  |  |  | 1 |  |
| CO5 | 1 | 1 | 1 |  | 2 |  |  |  | 2 | 1 |  | 1 |

## Course Contents:

## Unit I

## Scientific Revolutions

Types of Nanotechnology and Nano machines: the Hybrid nanomaterial. Multiscale hierarchical structures built out of Nano sized building blocks (nano to macro).Nanomaterials in Nature: Nacre, Gecko, Teeth. Periodic table, Atomic Structure, Molecules and phases, Energy, Molecular and atomic size, Surfaces and dimensional space: top down and bottom up.

## Unit II

Forces between Atoms and Molecules
Particles and grain boundaries, strong Intermolecular forces, Electrostatic and Vander Waals forces between surfaces, similarities and differences between intermolecular and inter particle forces covalent and coulomb interactions, interaction polar molecules, Thermodynamics of selfassembly.

## Unit III

## Opportunity at the Nano Scale

Length and time scale in structures, energy landscapes, Inter dynamic aspects of inter molecular forces, Evolution of band structure and Fermi surface.

## Unit IV

Quantum dots - Nano wires - Nano tubes - 2D and 3D films - Nano and mesopores, micelles, bilayer, vesicles - bionano machines - biological membranes.

## Unit V

## Influence of NanoStructuring

Influence of Nano structuring on mechanical, optical, electronic, magnetic and chemical properties-gram size effects on strength of metals- optical properties of quantum dots.

## Unit VI

Quantum wires - electronic transport in quantum wires and carbon nano-tubes - magnetic behavior of single domain particles and nanostructures - surface chemistry of Tailored monolayer - self assembling.

## Texts/References:

1. C. C. Koch, "Nanostructured materials: Processing, Properties and Potential Applications", Noyes Publications, 2002.
2. C. C. Koch, I. A. Ovidko, S. Seal and S. Veprek, "Structural Nano crystalline Materials: Fundamentals \& Applications", Cambridge University Press, 2011.

Numerical Heat Transfer

| MTE24D | Numerical Heat Transfer | PEC | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total |  |
| 100 Marks |  |  |  |  |

Pre-Requisites: Heat Transfer

## Course Objectives:

1. To Understand the concept of heat transfer and numerical techniques applied to heat transfer
2. To familiarize the students about the relation of numerical heat transfer and CFD
3. To understand the application of NHT in real life problem

Course Outcomes: At the end of the course, students will be able to:

| CO1 | Learn the concept of Numerical Heat Transfer and its application |
| :--- | :--- |
| CO2 | Explain boundary conditions and partial differential equations and formulation |
| CO3 | Analysis the conduction problems using Numerical technique |
| CO4 | Learn the converge methodology and techniques |
| CO5 | Write programme based 1-D and 2-D conduction problem using NHT |

## Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 3 |  | 1 |  |  | 1 | 2 | 1 |  |  |  |  |
| CO2 | 3 | 1 |  |  |  |  |  |  |  |  |  |  |
| CO 3 | 3 | 3 | 1 |  |  |  |  | 1 |  |  |  |  |
| CO 4 | 3 | 3 | 1 |  | 2 |  |  | 1 |  |  |  |  |
| CO5 |  |  |  | 3 | 3 | 1 | 1 | 2 |  |  |  | 2 |

## Course Contents:

## Unit 1:

## Introduction

Basic approach in solving a problem by Numerical Methods, Finite difference method, Method of discretization, control volume approach, Numerical error, Grid independence test.

## Unit 2:

## Partial Differential Equations

Classification of PDEs,Elliptic, Parabolic and Hyperbolic Equations, Initial and Boundary conditions, Initial and boundary value problems.

## Unit 3:

## Numerical Methods for Conduction Heat Transfer (Part 1)

Application of heat conduction, steady and unsteady heat conduction, Dimensionality in conduction, Basic approach in Numerical Heat conduction, one dimensional steady state problem.

## Unit 4:

Numerical Methods for Conduction Heat Transfer (Part 2)
Two dimensional problems, Transient one dimensional problem, Eular, crank - Nicholson and pure implicit method, stability.

## Unit 5:

## Numerical Methods for Incompressible Fluid Flow

Introduction, Governing equations, Navier Stokes Equations, Stream function velocity method, general algorithm inviscid flow.

## Unit 6:

Numerical Methods for Convection Heat Transfer
Introduction, Convection diffusion, Thermal boundary layer flow, transient free convection.

## Texts:

1. P. S.Ghoshdastidar, "Computer Simulation of Flow and heat transfer", Tata McGraw Hill Publications, New Delhi.
2. SuhasV.Patankar, "Numerical Heat Transfer and Fluid Flow", Tata McGraw Hill Book Company.
3. Varsteeg, Malalasekera, "An introduction to Computational Fluid Dynamics The finite volume method", Pearson Prentice hall.

## References:

1. M. NecatiOzisik, "Finite Difference Methods in Heat transfer", CRC Press.
2. D. A. Anderson, J. C. Tannehill, R. H. Pletcher, "Computational Fluid Dynamics and Heat transfer", Hemisphere Publishing.

## Biomass Energy

| MTE24E | Biomass Energy | PEC | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total |  |

## Course Objectives:

1. To Understand the concept of Biomass its importance, availability, and energy conversion process
2. To familiarize the students about the biomass systems design
3. To understand the industrial applications of Biomass systems through real life problems

## Course Outcomes:

| CO1 | Illustrate relevance of biomass as energy source, enumerate advantages and disadvantages of biomass <br> resources. |
| :--- | :--- |
| CO2 | Survey and identify wasteland in India, suggest suitable biomass resource management. |
| CO3 | Interpret biomass conversion processes, design gasification system and identify its use in SI and CI <br> engines and analyze its performance. |
| CO4 | Conduct an experiment and calculate load capacity, efficiency and identify maintenance, <br> troubleshooting and exhaust emission problems. |
| CO5 | Design and construct down draft gasifier, its Cooling-cleaning systems and Performance evaluation <br> of a Down draft gasifier. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO2 | 1 |  | 2 |  | 1 | 1 |  | 1 |  |  |  |  |
| CO3 | 1 | 1 |  |  | 2 |  |  |  |  |  |  |  |
| CO4 |  |  | 2 | 2 | 1 | 1 |  |  |  |  | 1 |  |
| CO5 | 2 | 1 |  | 1 |  | 1 |  |  |  |  |  |  |

## Course Contents

## Unit I

Introduction: Relevance of biomass as an energy source, Biomass Resources, Cultivated biomass resources, Water-to-biomass resources, Advantages associated with biomass resources, Availability of biomass for energy generation.

## Unit II

Energy plantation: Concept, Objectives and advantages.

Wasteland development: Extent of water lands in India, Nature of waste lands.

## Unit III

Biomass Conversion Processes: Combustion, Biochemical and Thermo chemical.
Gasification: Fuels for gasification, Properties of biomass - size, size distribution, bulk density, volatile matter, ash and ultimate analysis.Air gasification in a down draft gasifier, Types of gasifiers, Gasifier engine system, Use of producer gas in SI \& CI engines, Reasons for decorating, Problems associated with gasifier engine system and its efficiency.

## Unit VI

Design of a Down draft gasifier
Cooling-cleaning systemsMPerformance evaluation of a Down draft gasifier.

## Unit V

Performance of Dual Fuel Engine: Power capacity, Diesel substitution, Thermal efficiency, Smoothness of operation, Load following capability, Maintenance and durability, Exhaust emissions.

## Unit VI

Bio-conversion Process: The process, Types of biogas plants, Design of biogas plants, Factors affecting gas generation rate, Biogas engine for water pumping and electric power generation applications, Government programmes,
Wood fuelled Cooks stoves, Effects of various stove parameters, Effects of various stove components, Current versions of improved stoves, Efficiency of stoves, Utilization of biomass based fuels for thermal and shaft power applications.

## TEXTS / REFERENCES:

1. T.B.Reed: "Biomass Gasification Principles and Technology", Noyes Data Corporation,Energy Technology Review, No.67, U.S.A., 1981.
2. P Vimal\& M S Bhatt: "Wood Energy Systems", K L Publications, New Delhi - 1989
3. S Rao\& B BParulkar: "Energy Technology" Khanna Publishers Delhi - 1999
4. A.Kaupp and J.R.Goss: "State of Art Report for small scale Gas Producer Engine Systems", FriedrVieweg\&SohnVerlags, Gmbh, Braunschweig, 1984

## Power Plant Practice and Control

| MTE24F | Power Plant Practice and <br> Control | PEC | $3-0-0$ | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 60 Marks | Total <br> 100 Marks |  |

Course Outcomes: At the end of the program, the student will be able to

| CO1 | Understand merits and demerits of various power plant and Criteria for selection of power <br> plant and economics |
| :--- | :--- |
| CO2 | Understand various safety devices and controlling devices for power plant |
| CO3 | Comparison of various power plant on efficiencies, working performance, and <br> characteristics |
| CO4 | Plan and design the experimental investigations efficiently and effectively |
| CO5 | Practice statistical software to achieve robust design of experiments. |

## Mapping of course outcomes with program outcomes

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| CO2 |  | 1 |  |  |  |  |  |  |  |  |  |  |
| CO 3 |  | 1 | 1 |  |  |  |  |  |  |  |  |  |
| $\mathrm{CO4}$ |  |  |  |  |  | 1 |  |  |  |  |  |  |
| $\mathrm{CO5}$ |  |  |  | 1 |  |  |  | 1 |  |  |  |  |

## Course Contents

## Unit I

Introduction: Energy reserves and Energy utilization in the world, Electrical power Generation \& consumption in India. Types of power plants, merits and demerits, Criteria for selection of power plant. Power Plant Economics.
Hydro Electric Power Plants: Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, power plants design, construction and operation of different components of hydro-electric power plants, site selection, comparison with other types of power plants.

## Unit II

Steam Power Plant: Layout, Super Heaters, Reheaters, Condensers, Economizers and Feed Water heaters, Operation and performance, Rankine cycle with Superheat, Reheat and

Regeneration. Super critical boilers,Fluidized Bed combustion boiler - Advantages, Waste heat Recovery boilers, Co-generation Power Plant, Emissions and their controls.

## Unit III

Nuclear Power Plant: Overview of Nuclear Power Plant, Nuclear physics Radio activity-fission process Reaction Rates, diffusion theory and Critical heat flux -Nuclear Power Reactors, different types, advantages and limitations, Materials used for Reactors. Hazards in nuclear power plant, remedial measures, safety precautions, methods of waste disposal, different form of waste from power plant.

## Unit IV

Gas Turbine: Layout of Gas Turbine, Basic Gas turbine cycle, cycle improvements, Intercoolers, Reheaters and regenerators, Thermodynamic analysis of Gas turbine, Operations and performance of Gas Turbine. Combined Cycle Power Plant: Binary vapour cycles, Coupled cycles, Combined Power cycle Plants, Advantages and Limitations, Gas turbine,Steam turbine Power Plant and MHD, Steam Power Plant. Water pollution and Solid waste management in power plants, Effluent quality standards

## References

1. Power Plant Engineering, P. K. Nag, McGraw Hill
2. Power Plant Engineering Technology, M.M. Wakil, Mc Graw Hill Publication.
3. Power Plant Engineering, byArrora\&Domkundwar", Dhanpat Rai \& Sons, New Delhi, 2008
4. Power Plant Engineering, by P C Sharmace, S.K. Kataria\& Sons, New Delhi, 2010

## Micro Fluidics

| MTE24G | Micro Fluidics | PEC | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Mid Sem Test | Continuous Assessment <br> 20 Marks | End-Sem Exam <br> 20 Marks | Total <br> 20 Marks | 100 Marks |

## Course Objectives:

1. To Understand the concept of heat transfer and numerical techniques applied to heat transfer
2. To familiarize the students about the relation of numerical heat transfer and CFD
3. To understand the application of NHT in real life problem

Pre-Requisites: Heat Transfer

## Course Outcomes:

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

| CO 1 | Identify Application and changes of micro fluidics in the various engineering aspects |
| :---: | :--- |
| CO 2 | Apply concept coquette flow, poiseuille flow, time phase flow throw micro channel of <br> different c/s areas in real engineering problems. |
| CO 3 | Numerical analysis of capillary flow for a different materials, fluids, cross section and <br> boundary conditions. |
| CO 4 | Describe various electromagnetic field effects on flow of micro fluids, simulate forces DEP <br> force on a dielectric sphere |
| CO 5 | Design various micro fludic components such as channels, pumps, valves, sensors etc., |

## Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  |  | 1 |  |  |  |  |  |  |  |  |
| CO2 | 1 |  |  |  | 1 |  |  |  |  |  |  |  |
| CO3 | 2 |  | 2 | 1 |  | 1 |  |  | 1 |  |  |  |
| CO4 |  | 2 |  |  |  |  |  |  |  |  |  |  |
| CO5 |  |  | 1 |  |  |  |  |  |  |  |  | 1 |

## Course Contents:

UNIT I
Introduction Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

## UNIT II

Micro-scale fluid mechanics Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels. Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel.

## UNIT III

Capillary flows Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.

## UNIT IV

Electrokinetics Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDLlimit, Ideal electroosmotic flow, Ideal EOF with back pressure, Cascade electro-osmotic micropump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere. Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric.

## UNIT V

Microfluidics components Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps. Microvalves, Pneumatic valves, Thermopneumatic valves, Thermomechanical valves,Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves. Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors. Micromixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion. Droplet generators,Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, Tjunction and Cross-junction, Droplet formation, breakup and transport. Microparticle separator, principles of separation and sorting of microparticles, design and applications. Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.

## UNIT VI

Few applications of microfluidics Drug delivery, Diagnostics,Bio-sensing.

## References:

1. Nguyen, N. T., Werely,S. T., Fundamentals and applications of Microfluidics, Artech house Inc., 2002. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
2. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.
3. Tabeling,P., Introduction to microfluidics, Oxford University Press Inc., 2005.
4. Kirby,B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010. 5. Colin,S., Microfluidics, John Wiley \& Sons, 2009

## Research Methodology

| MOE25A | Research Methodology | Open Elective | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Mid Sem Test <br> 20 Marks Continuous Assessment <br> 20 Marks End-Semester Exam <br> 60 Marks Total <br> 100 Marks |  |  |  |  |

## Pre-Requisites: None

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

| CO1 | Understand and Describe importance of research. |
| :--- | :--- |
| CO2 | Classify and select appropriate resources for Research. |
| CO3 | Analyze the contents of literature and identify further scope. |
| CO4 | Formulate a Research Problem. |
| CO5 | Develop effective written and oral Presentation skills. |

## Mapping of course outcomes with program outcomes

| Course | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 2 |  | 3 |  |  |  | 1 |  | 3 |  |  | 2 |
| CO 2 | 2 |  | 2 | 1 |  |  | 1 |  | 1 |  |  | 2 |
| CO3 | 2 |  | 3 | 3 |  |  | 1 |  | 1 | 2 |  | 2 |
| CO4 | 2 | 3 | 3 | 2 |  |  |  |  | 2 | 2 |  | 2 |
| CO5 | 2 |  | 1 | 3 |  |  | 3 |  |  |  |  | 3 |

## Course contents:

## Unit 1

- Research Concepts - concepts - meaning - objectives - motivation. Types of research descriptive research - conceptual research - theoretical research - applied research experimental research.


## Unit 2

- Research process - Criteria for good research - Problems encountered by Indian researchers. Formulation of Research Task - Literature Review - Importance \& Methods - Sources Quantification of Cause Effect Relations - Discussions- Field Study - Critical Analysis of Facts Generated


## Unit 3

- Hypothetical proposals for future development and testing, selection of Research task.


## Unit 4

- Mathematical modelling and simulation - Concepts of modelling - Classification of mathematical models - Modelling with - Ordinary differential equations - Difference equations - Partial differential equations - Graphs - Simulation - Process of formulation of model based on simulation.


## Unit 5

- Interpretation and report writing - Techniques of interpretation - Precautions in interpretation - Significance of report writing - Different steps in report writing - Layout of research report Mechanics of writing research report - Layout and format - Style of writing - Typing References - Tables - Figures - Conclusion - Appendices.


## TEXTS/REFERENCES

1. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
2. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
3. C. R. Kothari, Research Methodology, New Age Publishers.
4. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.

## Design of Experiments

| MOE25B | Design of Experiments | Open Elective | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Semester Exam <br> 60 Marks | Total |  |

## Pre-Requisites: None

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

| CO1 | Define Taguchi, factorial experiments, variability, orthogonal array, quality loss. |
| :--- | :--- |
| CO2 | Plan and design the experimental investigations efficiently and effectively. |
| CO3 | Understand strategy in planning and conducting experiments. |
| CO4 | Evaluate variability in the experimental data using ANOVA. |
| CO5 | Practice statistical software to achieve robust design of experiments. |

## Mapping of course outcomes with program outcomes

| Course Outcomes | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 |
| CO2 | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| CO3 | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| CO4 | 3 | 3 | 1 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| CO5 | 2 | 3 | 1 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 |

## Course Contents:

## Unit 1

- Introduction: Modern quality control, quality in engineering design, history of quality engineering.
- The Taguchi Approach to quality: Definition of quality, loss function, off-line and on-line quality control, Taguchi`s quality philosophy.


## Unit 2

- Full Factorial Designs: Experimentation as learning process, traditional scientific experiments, three factor design, replicating experiments, factor interactions, normal plots of estimated effects, mechanical plating experiments, two factor design, four factor design, Taguchi design and western design.


## Unit 3

- Fractional Factorial Design: Fractional factorial design based on eight run experiments, folding over an eight run experimental design, Fractional factorial design in sixteen run, folding over an sixteen run experimental design, blocking two level designs, other two level designs.


## Unit 4

- Evaluating Variability: Necessity to analyze variability, measures of variability, the normal distribution, using two level designs to minimize variability, signal-to-noise ratio, minimizing variability and optimizing averages.
- Taguchi Inner and Arrays: Noise factors, experimental designs for control and noise factors, examples.


## Unit 5

- Experimental Design for Factors at Three and Four level: Necessity to use more than two level, factors at four levels, factors at three levels.
- Analysis of Variance in Engineering Design: Hypothesis testing concepts, using estimated effects as test statistics, analysis of variance for two level designs, when to use analysis of variance.


## Unit 6

- Computer Software for Experimental Design: Role of computer software in experimental design, summery of statistical packages, example of use of software packages.
- Using Experiments to improve Processes: Engineering design and quality improvement, steps to implementing use of engineering design.


## TEXTS / REFERENCES:

1. D.C.Montgomery, Design and Analysis of Experiments, $5^{\text {th }}$ Edition, John Wiley and Sons, NewYork, 2004.
2. R.H.Lochner and J.E.Matar, Designing for Quality: An Introduction to the Best of Taguchi and Western Methods of Statistical Experimental Design, Chapman and Hall, London, 1983.

# Advanced Optimization Techniques 

| MOE25C | Advanced Optimization Techniques | Open Elective | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |


| Mid Sem Test | Continuous Assessment | End-Semester Exam | Total |
| :--- | :--- | :--- | :--- |
| 20 Marks | 20 Marks | 60 Marks | 100 Marks |

Prerequisite: None
Course Outcomes: At the end of the course the student will be able to:

| CO1 | Enables to acquire mathematical methods and apply in engineering disciplines. |
| :--- | :--- |
| CO2 | Apply methods of optimization to solve a linear, non-linear programming problem <br> by various methods |
| CO3 | Optimize engineering problem of nonlinear-programming with/without constraints, <br> by using this techniques |
| CO4 | Use of dynamic programming problem in controlling in industrial managements. |
| CO5 | Simulate Thermal engineering system problem. Understand integer programming <br> and stochastic programming to evaluate advanced optimization techniques. |

## Mapping of course outcomes with program outcomes

| Course Outcomes | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 1 | 1 |  |  |  |  |  | 1 |  | 1 |  | 1 |
| CO2 | 2 | 1 | 1 |  |  |  |  | 1 |  |  |  |  |
| CO3 |  | 2 |  |  |  |  |  |  | 1 |  |  |  |
| CO4 | 1 |  |  |  | 2 | 1 |  |  |  | 2 |  | 1 |
| CO5 |  |  | 1 | 2 | 1 | 1 | 2 |  | 1 | 2 |  | 1 |

## Course Contents:

## Unit 1

SINGLE VARIABLE NON-LINEAR UNCONSTRAINED OPTIMITION: One dimensional Optimization methods, Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic \& cubic interpolation methods.

## Unit 2

MULTI VARIABLE NON-LINEAR UNCONSTRAINED OPTIMIZATION: Direct search method -Univariant Method - pattern search methods - Powell's - Hook - Jeeves, Rosenbrock search methods - gradient methods, gradient of function, steepest decent method, Fletcher reeves method.
Variable metric method.

## Unit 3

GEOMETRIC PROGRAMMING: Polynomials - arithmetic - geometric inequality unconstrained G.P- constrained G.P

DYNAMIC PROGRAMMING: Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

## Unit 4

LINEAR PROGRAMMING: Formulation - Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. Simulation: Introduction - Types - Steps - application - inventory - queuing - thermal system.

## Unit 5

INTEGER PROGRAMMING: Introduction - formulation - Gomory cutting plane algorithm Zero or one algorithm, branch and bound method.
STOCHASTIC PROGRAMMING: Basic concepts of probability theory, random variables Distributions - mean, variance, Correlation, co variance, joint probability distribution stochastic linear, dynamic programming.

## TEXTS/REFERENCES:

1. Optimization theory \& Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan \& Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. Operation Research/H.A. Taha/TMH
5. Optimization in operations research/R.L Rardin
6. Optimization Techniques/Benugundu \& Chandraputla/Person Asia
7. Optimization Techniques /Benugundu \& Chandraputla / Pearson Asia

## Environmental Engineering and Pollution Control

| MOE25D | Environmental Engineering and Open Elective <br> Pollution Control | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- | | Mid Sem Test <br> 20 Marks | Continuous Assessment <br> 20 Marks | End-Semester Exam <br> 60 Marks |
| :--- | :--- | :--- |

## Course Objectives:

1. To Understand the need of pollution control, its impact, control
2. To familiarize the students about the pollution control techniques
3. To carry out the real life problem

## Course Outcomes:

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

| CO1 | Identify effects of industrialization on environmental pollution in various field. |
| :--- | :--- |
| CO2 | Describe photochemical smog, acid Rain, Greenhouse effect, ozone depletion, global warming. |
| CO3 | Suggest pollution control techniques for vehicles, refrigeration, industries, chemical and <br> power plant. |
| CO4 | Do Case study on any industry and analyze carbon exertion rate, water pollution, soil <br> pollution etc. |
| CO5 | Design pollution control devices for vehicle, analyze and find out replacement CFC <br> refrigerant with HC refrigerant. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 | 2 |  |  |  |  |  |  |  |  |  |  |
| CO2 | 2 |  |  |  |  |  |  |  |  |  |  | 1 |
| CO3 |  |  |  | 1 |  |  | 2 | 1 |  |  |  | 1 |
| CO4 | 2 |  |  |  |  | 2 |  |  | 1 |  |  |  |
| CO5 |  |  |  |  |  | 1 |  |  |  |  |  | 2 |

## Course Content

## Unit I

Impact of industrialization and modernization - pollution and pollutants. Air pollution and its effects - air pollution - sources - pollutants - organic and inorganic pollutants - gaseous pollutants- nitrogen oxides - particulate pollutants - effect of pollutants on plants - animals and human beings.

## Unit II

photochemical oxidants - photochemical smog - acid Rain - Green house effect - ozone depletion - global warming -Environmental pollution techniques for air pollution - monitoring
and Control measures of air pollution - dust control equipment - Electrostatic precipitators and scrubbers.

## Unit III

Water pollution and its effects structure - water pollution - sources -Pollutants - industrial effluents - domestic wastes - agrochemicals -Heavy metals - effect of pollutants on plants animals and human beings Bod - eutrophication - waste water treatment - indicator orgnisms Oxidation pond - water pollution analysis and monitoring - drinking Water standards. Soil pollution and its effects - soil pollution - sources - solid waste Disposal and their effects pesticides - types and effect of pollutants on Plants - animals and human beings biomagnification - fertilizers and its Effect of pollutants on plants - animals and human beings -

## UNIT IV

soil pollution Control measures - soil microbes and function - biofertilizer. Noise pollution and its effects - noise pollution - sources - noise Exposure level and standards - impacts - noise control and abatement Measures.

## Unit V

Marine pollution - sources and control of marine pollution - criteria Employed for disposal of pollutants in marine system - coastal Management. Radioactive pollution and its impacts radioactive - sources - effect of Pollutants of plants - animals and human beings - prevention and control Measures of radioactive pollution.

## Unit VI

Assessment and control of pollution - environmental standards - Assessment of pollution effects due to air - water - soil and radioactive Pollution - biotechnology in pollution control - microbial role in Pollution control - biomonitoring and bioremediation - pollution control Legislations for air - water - land etc. Biotechnology in pollution control - bioremediation (organic and Inorganic pollutants) - bioleaching and biomineralization.

## Text/References

1. Environmental Pollution Analysis:Khopkar.
2. Environmental Science - A study of Inter relationships, E. D. Enger, B. E. Smith, 5th ed., W C B publication.
3. Environmental Pollution Control Engineering: C. S. Rao
4. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.
5. J.N.B. Bell (2002) Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, New Delhi.

## Soft Computing Techniques

| MME25E | Soft Computing Techniques | Elective | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Mid Sem Test Continuous Assessment End-Semester Exam Total <br> 20 Marks 20 Marks 60 Marks 100 Marks |  |  |  |  |

## Pre-Requisites: None

Course Outcomes: At the end of the course, the student will be able to:

| CO1 | Classify different optimization and evolutionary algorithms. |
| :--- | :--- |
| CO2 | Apply optimization techniques to real life problems. |
| CO3 | Learn and apply neural network prediction algorithm to solve engineering problems. |
| CO4 | Understand and apply fuzzy based logic function for predicting results. |
| CO5 | Acquire and use knowledge of genetic algorithm to optimize real life problems. |
| CO6 | Study different hybrid soft computing methods and its applications. |

## Mapping of course outcomes with program outcomes

| Course | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |  |  |  |  |  |  |  |  |
| CO1 | 2 |  | 2 |  |  |  |  |  |  | 1 |  | 2 |  |  |  |  |  |  |  |  |
| CO2 | 2 | 2 | 2 | 2 |  |  |  |  |  | 1 |  | 2 |  |  |  |  |  |  |  |  |
| CO3 | 2 | 2 | 2 | 2 |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |
| CO4 | 2 | 2 | 2 | 2 |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |
| CO5 | 2 | 2 | 2 | 2 |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |
| CO6 | 2 | 2 | 2 | 2 |  |  |  |  |  | 1 |  | 1 |  |  |  |  |  |  |  |  |

## Unit 1

## - INTRODUCTION

Soft Computing: Introduction of soft computing, Evolutionary Algorithms vs. Convectional optimization techniques, various types of soft computing techniques, applications of soft computing.
Artificial Intelligence: Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies. Knowledge representation issues, Prepositional and predicate logic, monotonic and non-monotonic reasoning, forward Reasoning, backward reasoning.

## Unit 2

- OPTIMIZATION CONCEPTS

Objective functions, constraints, Search space, local optima, global optima, fitness functions, search techniques, etc.

## Unit 3

## - NEURAL NETWORKS

Artificial neural network: Introduction, characteristics- learning methods - taxonomy Evolution of neural networks- basic models - important technologies - applications.
McCulloch-Pitts neuron - linear separability - hebb network - supervised learning network: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron, BPN, RBF, TDNN- associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, iterative autoassociative memory network \& iterative associative memory network - unsupervised learning networks: Kohonenself organizing feature maps, LVQ - CP networks, ART network.

## Unit 4

- FUZZY LOGIC

Fuzzy logic: Introduction - crisp sets- fuzzy sets - crisp relations and fuzzy relations: cartesian product of relation - classical relation, fuzzy relations, tolerance and equivalence relations, non-iterative fuzzy sets.
Membership functions: features, fuzzification, methods of membership value assignmentsDefuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules-decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems-overview of fuzzy expert system-fuzzy decision making.

## Unit 5

- GENETIC ALGORITHM

Genetic algorithm- Introduction - biological background - traditional optimization and search techniques - Genetic basic concepts.
Genetic algorithm and search space - general genetic algorithm - operators - Generational cycle - stopping condition - constraints - classification genetic programming - multilevel optimization - real life problem- advances in GA.

## Unit 6

- HYBRID SOFT COMPUTING TECHNIQUES \& APPLICATIONS

Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - simplified fuzzy ARTMAP - Applications: A fusion approach of multispectral images with SAR, optimization of traveling salesman problem using genetic algorithm approach, soft computing based hybrid fuzzy controllers.

## TEXTS/REFERENCES:

1. J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI /Pearson Education 2004.
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and

Genetic Algorithm: Synthesis \& Applications", Prentice-Hall of India Pvt. Ltd., 2006.
4. George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications" Prentice Hall, 1997.
5. David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning" Pearson Education India, 2013.
6. James A. Freeman, David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991.
7. Simon Haykin, "Neural Networks Comprehensive Foundation" Second Edition, Pearson Education, 2005.

## Manufacturing Automation

| MOE25F | Manufacturing Automation | Open Elective | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Mid Sem Test <br> 20 Marks Continuous Assessment <br> 20 Marks End-Semester Exam <br> 60 Marks Total <br> 100 Marks |  |  |  |  |

## Pre-Requisites:

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

| CO1 |  |
| :--- | :--- |
| CO2 |  |
| CO3 |  |
| CO4 |  |
| CO5 |  |
| CO6 |  |

Mapping of course outcomes with program outcomes

| Program <br> Outcomes $\rightarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Course <br> Outcomes $\downarrow$ |  |  |  |  |  |  |  |  |  |  |  |  |
| CO1 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO2 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO3 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO4 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO5 |  |  |  |  |  |  |  |  |  |  |  |  |
| CO6 |  |  |  |  |  |  |  |  |  |  |  |  |

## Course Contents:

UNIT 1
Product cycle, manufacturing functions, types of automation, degree of automation, technical, economic and human factors in automation.

UNIT 2
Technologies- mechanical, electrical, hydraulic, pneumatic, electronic, hybrid systems, comparative evaluation.

## UNIT 3

Development of small automation systems using mechanical devices, synthesis of hydraulic circuits.

UNIT 4
Circuit optimization techniques, illustrative examples of the above types of systems.

## UNIT 5

Industrial logic control systems logic diagramming, programmable controllers.

## UNIT 6

Applications, designing for automation, cost-benefit analysis.

## Texts/References:

1. A.N.Gavrilov, Automation and Mechanization of Production Processes in Instrument Industry, Pergaman Press, Oxford, 1967.
2. G.Pippengerm, Industrial Hydraulics, MGH, New York, 1979.
3. F.Kay, Pneumatics for Industry, The Machining Publishing Co., London,1969.
4. Ray, Robots and Manufacturing Assembly, Marcel Dekker, New York, 1982.

## Modeling and Simulation

| MOE25G | Modeling and Simulation | Open Elective | 3-0-0 | 3 Credits |
| :--- | :--- | :--- | :--- | :--- |


| Mid Sem Test |  |  |  |
| :--- | :--- | :--- | :--- |
| 20 Marks | Continuous Assessment <br> 20 Marks | End-Semester Exam <br> 60 Marks | 100 Marks |$.$

Pre-Requisites: None
Course Outcomes: At the end of the course, the student will be able to:

| CO1 | Define simulation, its limitations and applications. |
| :--- | :--- |
| CO2 | Apply simulation to queuing and inventory situations. |
| CO3 | Acquire knowledge to generate the random numbers for simulation models. |
| CO4 | Analyze the data and verify model of simulation. |
| CO5 | Learn software's and programming languages for developing simulation model. |
| CO6 | Discuss case studies in manufacturing simulation. |

## Mapping of course outcomes with program outcomes

| Program <br> Outcomes $\rightarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Course <br> Outcomes $\downarrow$ |  |  |  |  |  |  |  |  |  |  |  |  |
| CO1 | 2 |  |  |  |  |  |  |  |  |  |  | 1 |
| CO2 | 2 |  |  | 1 |  |  |  |  |  |  |  |  |
| CO3 | 2 | 2 | 1 | 2 |  |  |  |  |  |  |  | 1 |
| CO4 | 2 | 2 | 1 | 2 |  |  |  |  |  | 2 | 1 |  |
| CO5 | 2 | 2 | 2 | 3 |  |  |  |  |  | 1 |  | 2 |
| CO6 | 2 |  |  |  |  |  | 2 |  |  | 1 |  |  |

## Course Contents:

## Unit 1

Introduction to systems and modeling - discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation.

## Unit 2

Discrete event simulation and their applications in queueing and inventory problems.

## Unit 3

Random number generation and their techniques - tests for random numbers. Random variable generation.

## Unit 4

Analysis of simulation data. - Input modeling - verification and validation of simulation models - output analysis for a single model.

## Unit 5

Simulation languages and packages - FORTRAN, C, C++, GPSS, SIMAN V, MODSIM III, ARENA, QUEST, VMAP - Introduction to GPSS - Case studies.

## Unit 6

Simulation of manufacturing and material handling system, Caste studies.

## Texts/References:

1. Jerry Banks and John S, Carson II "Discrete Event System Simulation", Prentice Hall, 1984.
2. Geoffrey Gordon., "System Simulation", Prentice Hall, 1978.
3. Francis Neelamkovil, "Computer Simulation and Modelling", John Willey and sons, 1987.

## Seminar

| MTE26 | Seminar | PCC | $0-0-4$ | 2 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
| Continuous Assessment <br> 25 Marks | Final Evaluation <br> 25 Marks | Total <br> 50 | 5 Marks |  |

Course Objectives: Objectives of this course are

1. To understand the open literature
2. To familiarize the students about collection of technical literature, reading and understanding
3. To learn the report writing and presentation

## Course Outcomes:

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

| CO1 | To enable students to aware about recent areas and technologies in thermal engineering and <br> related area. |
| :--- | :--- |
| CO2 | To enable students, comprehend importance of system up gradation, improvement and <br> application of new findings for human life. |
| CO3 | To enable students to write technical report and presenting seminar work. |
| CO4 | To enable students to aware about recent areas and technologies in thermal engineering and <br> related area. |


| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{CO1}$ | 1 |  |  |  |  |  |  | 1 |  |  |  |  |
| CO 2 |  | 1 |  |  |  |  |  |  | 1 | 2 |  | 1 |
| CO 3 |  | 2 |  |  | 1 |  | 1 | 2 |  |  | 1 |  |
| CO 4 |  |  |  |  |  |  |  | 1 |  | 1 |  | 1 |

## Course Contents/Objectives

The seminar shall consist of the preparation of the report by the candidate on the topic mutually decided by himself and the supervisor. The topic should be a problem in the field of Thermal Engineering and should have the sufficient research orientation. The recent development in the field of the chosen topic needs to be understood by the candidate. The report has to be presented in front of the examiners committee and other faculty members and students of the department. The committee should be set by the PG coordinator and Head, Mechanical Engineering for evaluation of seminar.

## Mini Project

| MTE27 | Mini Project | PCC | 0-0-4 | 2 Credits |
| :---: | :---: | :---: | :---: | :---: |
| Exam Scheme |  |  |  |  |
| Continuous Assessment 25 Marks |  | End-Sem Evaluation 25 Marks |  | Total 50 Marks |

Course Objectives: Objectives of this course are

1. To apply the basic engineering laws through a modeling/ model/setup
2. To understand the report writing and result analysis
3. To understand the problem formulation

## Course Outcomes:

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

| CO1 | Identify methods and materials to carry out experiments/develop code. |
| :--- | :--- |
| CO2 | Reorganize the procedures with a concern for society, environment and ethics. |
| CO3 | Analyze and discuss the results to draw valid conclusions. |
| CO4 | Prepare a report as per recommended format and defend the work |
| CO5 | Explore the possibility of publishing papers in peer reviewed journals/conference <br> proceedings. |

## Mapping of course outcomes with program outcomes

| Course <br> Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| CO1 | 2 | 2 | 1 |  | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 |
| CO2 | 1 | 1 | 2 | 2 |  |  | 2 | 2 | 1 | 2 | 1 | 2 |
| CO3 | 2 | 2 |  | 3 |  |  |  |  | 2 | 2 |  | 1 |
| CO4 |  |  |  | 2 |  |  |  | 2 | 2 | 3 |  | 1 |
| CO5 |  | 1 |  | 2 | 2 |  |  | 2 | 2 | 3 |  | 1 |

## Contents/Objectives

To train students in identification, analysis, finding solutions and execution of live thermal engineering problems. It is also aimed to enhance the capabilities of the students.

Individual students are required to choose a topic of their interest. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects or shall be based on industrial visits. Students can also choose live problems from Thermal and Fluids Engineering as their mini project. At the end of the semester, the students should submit a report duly authenticated by the respective guide, to the head of the department.

Mini Project will have internal 50 marks for continuous evaluation and final evaluation for 50 marks.
Internal marks will be awarded by respective guides as per the stipulations given below.
Attendance, regularity of student ( 20 marks)
Individual evaluation through viva voce / test (30 marks)

## Total (50 marks)

Semester end examination will be conducted by a committee consisting of three faculty members. The students are required to bring the report completed in all respects duly authenticated by the respective guide and head of the department, before the committee. Students individually will present their work before the committee. The committee will evaluate the students individually and marks shall be awarded as follows.
Report $=25$ marks
Concept/knowledge in the topic $=15$ marks
Presentation $=10$ marks
Total marks $=\mathbf{5 0}$ marks

Semester-III
Project Management

| MMECH31 | Project Management | PCC | $\mathbf{0 - 0 - 0}$ | 2 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Continuous Assessment <br> 50 Marks PR/OR <br> 50 Marks Total <br> $100 ~ M a r k s ~$ |  |  |  |  |

## Pre-Requisites: None

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

| CO1 |  |
| :--- | :--- |
| CO2 |  |
| CO3 |  |
| CO4 |  |
| CO5 |  |
| CO6 |  |

## Mapping of course outcomes with program outcomes

| Course | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |  |  |  |  |  |  |  |  |
| CO1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CO2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CO3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CO4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CO5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| CO6 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

## Course Contents:

## Unit-1

- Introduction to Project management: Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Work definition: Defining work content, Time Estimation Method, Project Cost Estimation and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure, LRC, Gantt charts, CPM/PERT Networks.


## Unit-2

- Developing Project Plan (Baseline), Project cash flow analysis, Project scheduling with
resource constraints: Resource Leveling and Resource Allocation. Time Cost Trade off: Crashing Heuristic.


## Unit-3

- Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, Project Procurement Management. Post-Project Analysis.


## TEXT BOOKS/REFERENCES:

1. Shtub,BardandGloberson,ProjectManagement:Engineering,Technology,andImplementatio n,Prentice Hall, India
2. Lock, Gower, Project Management Handbook.

## Intellectual Property Rights

| MMECH32 | Intellectual Property Rights | PCC | 0-0-0 | 2 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Continuous Assessment PR/OR  Total <br> 50 Marks 50 Marks  100 Marks |  |  |  |  |

## Pre-Requisites: None

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

| CO1 | Enumerate and demonstrate fundamental terms such as copy-rights ,Patents ,Trademarks etc., |
| :--- | :--- |
| CO2 | Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration <br> Processes to register own project research. |
| CO3 | exhibit the enhance capability to do economic analysis of IP rights, technology and innovation <br> related policy issues and firms' commercial strategies. |
| CO4 | Develop awareness at all levels (research and innovation) of society to develop patentable <br> technologies. |
| CO5 | Apply trade mark law, copy right law, patent law and also carry out intellectual property <br> audits |
| CO6 | Manage and safeguard the intellectual property and protect it against unauthorized use |

## Mapping of course outcomes with program outcomes

| Course | Program Outcomes |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 2 | 1 |  |  |  |  | 1 |  | 1 |  |  |  |
| CO2 | 1 |  | 2 |  |  |  | 1 |  | 2 |  |  | 2 |
| CO3 |  |  |  |  |  | 1 |  | 1 |  |  |  |  |
| CO4 |  |  |  |  |  | 1 |  |  | 1 |  |  |  |
| CO5 |  |  | 1 |  |  |  |  |  | 1 |  |  | 1 |
| CO6 |  |  |  |  |  |  |  |  |  |  |  |  |

## Course Contents:

## Unit-1

- Introduction to IPR; Overview \& Importance; IPR in India and IPR abroad; Patents ;their definition; granting; infringement ;searching \& filing; Utility Models an introduction;


## Unit-2

- Copyrights ; their definition; granting; infringement ;searching \& filing, distinction between related and copy rights; Trademarks ,role in commerce ,importance , protection, registration; domain names;


## Unit-3

- Industrial Designs ; Design Patents; scope; protection; filing infringement; difference between Designs \& Patents' Geographical indications , international protection; Plant varieties; breeder's rights, protection; biotechnology\& research and rights managements; licensing, commercialization; ; legal issues, enforcement ;Case studies in IPR.


## TEXT BOOKS/REFERENCES:

1. Prabuddha Ganguli, IPR: Unleashing the Knowledge Economy, published by Tata McGraw Hill 2001.

## Project Stage-I

| MTE33 | Project Stage-I | PCC | 0-0-0 | 10 Credits |
| :---: | :---: | :---: | :---: | :---: |
| Exam Scheme |  |  |  |  |
| $\begin{array}{\|l\|} \hline \text { Continuou } \\ 50 \text { Marks } \\ \hline \end{array}$ |  | $\begin{aligned} & \text { End } \\ & 50 \mathrm{M} \end{aligned}$ | er Evaluation | $\begin{aligned} & \hline \text { Total } \\ & 100 \text { Marks } \\ & \hline \end{aligned}$ |

Course Objectives: Objectives of this course are

1. To learn the literature survey
2. To familiarize the students about understanding the open literature, preparation of literature review etc
3. To understand the problem formulation based on the literature review

## Course Outcomes:

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

| CO1 | Identify problems and to plan methodologies to solve problems. |
| :--- | :--- |
| CO 2 | Carry out exhaustive literature review, study \&evaluate collected literature critically <br> and identify the gaps based on the review. |
| CO3 | Select the specific problem for the study as a project |
| CO4 | Demonstrate technical writing while preparing project report and present it to <br> evaluation committeeto demonstrate presentation skills acquired. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | ---: |
| $\mathrm{CO1}$ | 1 |  |  |  |  |  |  |  | 1 |  |  | 1 |
| CO 2 |  | 3 |  |  |  |  |  |  |  | 2 |  | 1 |
| CO 3 |  | 2 |  |  |  |  | 1 | 1 |  | 2 | 2 | 2 |
| CO 4 | 2 |  |  |  |  |  |  |  | 1 |  |  |  |

## Course Contents:

Project (stage-I) should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel set by Head and PG coordinator/Faculty Advisor. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

## Semester IV

## Project Stage-II

| MTE41 | Project Stage-II | PCC | $0-0-0$ | 20 Credits |
| :--- | :--- | :--- | :--- | :--- |
| Exam Scheme |  |  |  |  |
|  | Continuous Assessment <br> 100 Marks | PR/OR <br> $100 M a r k s ~$ | Total |  |

Course Objectives: Objectives of this course are

1. To develop the setup/model based on the literature survey
2. To familiarize the students about the carrying out experimentation/ computer programming/ software
3. To understand the report writing, analysis of result, preparation of manuscript etc.

## Course Outcomes:

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

| CO1 | Solve identified technical problem using acquired knowledge and skill. |
| :--- | :--- |
| CO2 | Use latest equipment, instruments, software tools, infrastructure and learning resources <br> available to solve the identified project problem.Procure resources, if required. |
| CO3 | Interpret theoretical/experimental findings using available tools |
| CO4 | Compare the results obtained with results of similar studies |
| CO5 | Draw conclusions based on the results. |

Mapping of COs with POs:

| POs $\rightarrow$ <br> COs $\downarrow$ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CO1 | 1 |  |  |  |  |  |  |  | 1 |  |  | 1 |
| CO2 |  | 3 |  |  |  |  |  |  |  | 2 |  | 1 |
| CO3 |  | 2 |  |  |  |  | 1 | 1 |  | 2 | 2 | 2 |
| CO4 | 2 |  |  |  |  |  |  |  | 1 |  |  |  |
| CO5 |  | 1 |  |  |  |  |  | 1 |  |  |  | 2 |

## Course Contents/Objective

The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. The dissertation should be presented in standard format as provided by the department/guide. The candidate has to prepare a detailed project report consisting of introduction of the problem,
problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. The work has to be presented before the panel of examiners consisting of an approved external examiner, internal examiner/guide as decided by the Head and PG coordinator/Faculty Advisor. The candidate has to be in regular contact with his guide throughout the project duration.

