

# **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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## **Department of Mechanical Engineering**

**Proposed Course Structure & Contents**

**for**

**M.Tech. Program in Thermal Engineering**

**From Ito IV Semester**

**Finalized in BoS meeting held on 7th April, 2017**

## 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 need-based research and extension activities.

## Programme Educational Objectives (PEOs)

| No.  | PEO  |
|------|--|
| PEO1 | To train student's within depth and advanced knowledge to become professional and capable of identifying, analyzing and solving complex problems in the areas of Thermal engineering.                        |
| PEO2 | To enable post graduates to carry out innovative and independent research work, disseminate the knowledge in Academia/Industry/Research Organizations to develop systems and processes in the related field. |
| PEO3 | To prepare the students to exhibit a high level of professionalism, integrity, effective communication skills and environmental and social responsibility.   |
| PEO4 | To provide an academic environment that gives adequate opportunity to the students to cultivate life-long independent learning ability for their successful 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 engineering.  |
| PO2  | Identify problems in the field of Thermal engineering, formulate them and solve by using advanced techniques.  |
| PO3  | Conduct independent research and generate new knowledge for the benefit of community, society Industry and country.                                      |
| PO4  | Apply various numerical methods, advanced software and engineering tools to model, analyze and solve thermal engineering problems.                       |
| PO5  | Work effectively in interdisciplinary teams for solving real life problems in the related field.   |
| PO6  | Apply engineering and scientific principles for the effective management of thermal systems.   |
| PO7  | Effectively communicate through technical reports, presentations and scientific publications with the engineering community as well as society at large. |
| PO8  | Demonstrate traits of management in handling engineering projects, related finance, and coordinate with workforce towards achieving goals.               |
| PO9  | Demonstrate high level of professional and intellectual integrity, ethics of research and scholarly standards.   |
| PO10 | Examine critically the out comes of one's action sand make corrective measures subsequently.   |
| PO11 | Demonstrate the ability to work in team in the laboratory in achieving multidisciplinary tasks required for the project.                                 |
| PO12 | Engage in life-long reflective and independent learning with high level of enthusiasm and commitment.  |

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**Department of Mechanical Engineering**  
**M.Tech (Thermal Engineering)**  
**Semester- I**  
**Syllabus effective from 2017 – 2018**

| Sr. No.      | Course Code | Name of the Course                           | Contact hours |           |           | Credits   |
|--------------|-------------|--|---------------|-----------|-----------|-----------|
|              |             |  | L             | T         | P         |           |
| 01           | MTE1101     | Advanced Thermodynamics                      | 3             | 1         | -         | 4         |
|              | MTE1102     | Advanced Heat Transfer                       | 3             | 1         |           | 4         |
| 02           | MTE1103     | Numerical Methods & Computational Techniques | 3             | 1         | -         | 4         |
| 03           | MTE11E1     | Elective – I                                 | 3             | -         | -         | 3         |
| 04           | MTE11E2     | Elective – II                                | 3             | -         | -         | 3         |
| 05           | MTE1106     | Communication Skills                         | 2             | -         | -         | 2         |
| 06           | MTE1107     | Thermal Engineering Lab                      | -             | -         | 3         | 2         |
| <b>Total</b> |             |  | <b>17</b>     | <b>03</b> | <b>03</b> | <b>22</b> |

**Semester - II**

| Sr. No.      | Course Code | Course                                       | Contact hours |           |           | Credits   |
|--------------|-------------|--|---------------|-----------|-----------|-----------|
|              |             |  | L             | T         | P         |           |
| 01           | MTE1201     | Modeling and Analysis in Thermal Engineering | 3             | 1         | -         | 4         |
| 02           | MTE1202     | Fluid Dynamics                               | 3             | 1         |           | 4         |
| 03           | MTE12E3     | Elective – III                               | 3             | -         | -         | 3         |
| 04           | MTE12E4     | Elective – IV                                | 3             | -         | -         | 3         |
| 05           | MTE12E5     | Elective - V (Open)                          | 3             | -         | -         | 3         |
| 06           | MTE1206     | Mini-project                                 | -             | -         | 3         | 2         |
| 07           | MTE1207     | Seminar                                      | -             | -         | 3         | 2         |
| <b>Total</b> |             |  | <b>15</b>     | <b>02</b> | <b>06</b> | <b>21</b> |

### Semester – III

| Sr. No.      | Course Code | Course                      | Contact hours |          |          | Credits   |
|--------------|-------------|-----------------------------|---------------|----------|----------|-----------|
|              |             |                             | L             | T        | P        |           |
| 01           | MTE2301     | Project Management and IPR* | -             | -        | -        | 2         |
| 02           | MTE2302     | Project Stage – I           | -             | -        | -        | 10        |
| <b>Total</b> |             |                             | <b>-</b>      | <b>-</b> | <b>-</b> | <b>12</b> |

\*Self-study course

### Semester –IV

| Sr. No.      | Course Code | Course            | Contact hours |          |          | Credits   |
|--------------|-------------|-------------------|---------------|----------|----------|-----------|
|              |             |                   | L             | T        | P        |           |
| 01           | MTE 2401    | Project Stage –II | -             | -        | -        | 20        |
| <b>Total</b> |             |                   | <b>-</b>      | <b>-</b> | <b>-</b> | <b>20</b> |

### List of Elective Courses

#### Semester-I: Elective (I & II)

##### Course Code

##### List of Courses

- |                       |  |
|-----------------------|--|
| 1. MTE11E1a/MTE11E2a  | Combustion Engineering                   |
| 2. MTE11E1b/MTE11E2b  | Utilization of Solar Energy              |
| 3. MTE11E1c/MTE11E2c  | Exergy Analysis of Thermal Systems       |
| 4. MTE11E1d/MTE11E2d  | Energy Conservation and Management       |
| 5. MTE11E1e/MTE11E2e  | Design of Heat Exchangers                |
| 6. MTE11E1f/MTE11E2f  | Design of Air-Conditioning Systems       |
| 7. MTE11E1g/MTE11E2g  | Advanced Refrigeration                   |
| 8. MTE11E1h/MTE11E2h  | Hydraulic, Pneumatic and Fluidic Control |
| 9. MTE11E1i/MTE11E2i  | Advanced IC Engines                      |
| 10. MTE12E3j/MTE12E4j | Pumps, Blowers and Compressors           |
| 11. MTE12E3k/MTE12E4k | CAD-CAE                                  |
| 12. MTE12E3l/MTE12E4l | Nuclear Power Plants                     |
| 13. MTE12E3m/MTE12E4m | Thermal Energy Storage                   |
| 14. MTE12E3n/MTE12E4n | Steam Engineering                        |

## **Semester-II: Elective (III &IV)**

| <b>Course Code</b>     | <b>List of Courses for</b>          |
|------------------------|-------------------------------------|
| 1. MTE12E3a/MTE12E4a   | Cryogenic Engineering               |
| 2. MTE11E1b/MTE11E4b   | Steam and Gas Turbines              |
| 3. MTE12E3c/MTE12E4c   | Biomass Energy                      |
| 4. MTE12E3d/MTE12E4d   | Conservation of Energy in Buildings |
| 5. MTE12E3e/MTE12E4e   | Computational Fluid Dynamics        |
| 6. MTE12E3f/MTE12E4f   | Alternative Fuels for IC Engines    |
| 7. MTE12E3g/MTE12E4g   | Numerical Heat Transfer             |
| 8. MTE12E3h/MTE12E4h   | Micro-Fluidics                      |
| 9. MTE12E3i/MTE12E4i   | Nano Technology                     |
| 10. MTE12E3j/MTE12E4j  | Boundary Layer Theory               |
| 11. MTE12E3k/MTE12E4k  | Advanced Optimization Techniques    |
| 12. MTE12E3l/MTE11E4l  | JET & Rocket Propulsion             |
| 13. MTE12E3m/ MTE13E4m | Convective Heat Transfer            |
| 14. MTE12E3n/MTE12E4n  | Wind Energy                         |

## **Semester-II: Open Elective –V**

| <b>Course Code</b> | <b>List of Courses</b>                    |
|--------------------|---|
| 1. MOE12E5a        | Research Methodology                      |
| 2. MOE12E5b        | Design of Experiments                     |
| 3. MOE12E5c        | Environmental Engg. and Pollution Control |

## MTE1101 Advanced Thermodynamics

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE1101                | Advanced Thermodynamics           | PCC                      | 3-1-0 | 4 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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, student will be able to:

|     |  |
|-----|--|
| CO1 | Understand properties of pure substances. Represent various processes with steam on property diagrams, Apply and compare equations of state for real gases |
| CO2 | Derive Maxwell Relations, Clapeyrons Equation etc. and apply these for evaluation of thermodynamic properties.   |
| CO3 | Evaluate entropy change for flow and non-flow processes under steady and unsteady conditions   |
| CO4 | Estimate thermodynamic properties of substances in gas or liquid state of ideal and real mixture.  |
| CO5 | Predict intermolecular potential and excess property behavior of multi-component systems. Study irreversible processes.                                    |

### Mapping of COs with POs

| POs →<br>COs↓ | 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 least contribution,

2- 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. Fermi-Dirac statistics

### **Unit II**

**Thermodynamic Relations** Mathematical theorems, Helmholtz 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 McGraw-Hill.
7. S.R.Turns, *Thermodynamics Concepts and Applications*
8. P.L.Dhar , *Engineering Thermodynamics, Elsevier Publication*

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## MTE1102 Advanced Heat Transfer

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE1102                | Advanced Heat Transfer            | PCC                      | 3-1-0 | 4 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class Test<br>20 Marks | Continuous Assessment<br>20 Marks | End-Sem Exam<br>60 Marks |       | Total<br>100 Marks |

**Course Objectives:** Objective 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, student should 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 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

| PO's →<br>CO's ↓ | 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:** 1d & 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 various geometries for laminar and turbulent flows.

**Internal flows:** Fully developed flow: integral analysis for laminar heat transfer coefficient-types of flow-constant wall temperature and constant heat flux boundary conditions hydrodynamic & thermal entry lengths; use of empirical correlations.

## UNIT-V

**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, Nusselt's theory of film condensation on a vertical plate, assumptions & correlations of film condensation for different geometries.

## UNIT-VI

**Radiation heat transfer:** Radiant heat exchange in grey, non-grey bodies, with transmitting, reflecting and absorbing media, specular surfaces, gas radiation-radiation from flames. Radiative heat transfer through participating medium.

## Text/References

1. Yunus A. Cengel, *Heat and Mass Transfer – A practical Approach*, 3<sup>rd</sup> edition, Tata McGraw - Hill, 2007.
2. Holman J.P., *Heat Transfer*, Tata McGraw 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

## MTE1103 Numerical Methods & Computational Techniques

|                        |  |                          |       |                    |
|------------------------|--|--------------------------|-------|--------------------|
| MTE1103                | Numerical Methods & Computational Techniques | PCC                      | 3-1-0 | 4 Credits          |
| <b>Exam Scheme</b>     |  |                          |       |                    |
| Class 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 will be able to:

|     |  |
|-----|--|
| CO1 | Solve a set of algebraic equations representing steady state models formed in engineering problems                     |
| CO2 | Fit smooth curves for the discrete data connected to each other or to use interpolation methods over these data tables |
| CO3 | Predict the system dynamic behavior through solution of ODEs modeling the system                                       |
| CO4 | Solve PDE models representing spatial and temporal variations in physical systems through numerical methods.           |
| CO5 | Demonstrate proficiency of using MATLAB,VB,ANSYS,EES etc.,   |

### Mapping of COs with POs:

| POs →<br>COs↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1           |     | 2   | 1   |     |     |     |     |     |     |      |      |      |
| CO2           |     |     | 1   |     |     |     |     |     |     |      |      |      |
| CO3           | 1   |     |     |     |     | 1   |     |     |     |      |      |      |
| CO4           |     | 1   |     | 2   |     |     |     |     |     |      |      |      |
| CO5           |     | 1   |     | 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

## MTE1106 Communication Skills

|                        |                                   |                   |                   |           |
|------------------------|-----------------------------------|-------------------|-------------------|-----------|
| MTE1106                | COMMUNICATION SKILLS              | PCC               | 2-0-0             | 2 Credits |
| <b>Exam Scheme</b>     |                                   |                   |                   |           |
| Class Test<br>-- Marks | Continuous Assessment<br>25 Marks | PR/OR<br>25 Marks | Total<br>50 Marks |           |

**Course Objective :** Objective of this course are

1. To learn the subject applied to technical paper writing
2. To enhance the oral and written communication
3. To enhance the project writing, report writing and presentations

### Course Outcomes:

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

|     |   |
|-----|---|
| CO1 | Students are found to be confident while using English                |
| CO2 | Engage in analysis of speeches or discourses and several articles     |
| CO3 | Identify and control anxiety while delivering speech                  |
| CO4 | Write appropriate communications(Academic/Business)                   |
| CO5 | Prepared to take the examinations like GRE/TOFEL/IELTS                |
| CO6 | Identify and control the tone while speaking                          |
| CO7 | Develop the ability to plan and deliver the well-argued presentations |

### Mapping of course outcomes with program outcomes

| POs →<br>COs↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1           | 2   |     | 1   |     | 2   |     | 2   | 1   |     |      | 2    | 3    |
| CO2           | 2   |     |     |     |     |     | 1   | 2   |     | 1    | 2    | 3    |
| CO3           |     |     |     |     | 1   |     | 1   | 2   |     |      | 2    | 3    |
| CO4           | 2   |     | 1   |     | 1   |     | 3   | 1   | 2   | 1    | 2    | 3    |
| CO5           | 1   |     |     |     |     |     |     |     |     |      |      | 1    |
| CO6           |     |     |     |     | 2   |     | 2   | 2   |     |      | 2    | 3    |
| CO7           |     |     | 2   | 1   | 2   | 2   | 3   | 3   | 1   | 1    | 3    | 3    |

## Course Content

### Unit I: Communication and Communication Processes

Introduction to Communication, forms and functions of Communication , Barriers to Communication and overcoming them, Verbal and Non-verbal Communication, Ways of Effective Communication.

### Unit II: Oral Communication

Use of Language in Spoken Communication, Features of Good Communication, Principles and Practice of Group Discussion, Public Speaking (Addressing Small Groups and Making

Presentation), Interview Techniques, Appropriate Use of Non-verbal Communication, Presentation Skills, Telephonic Etiquettes, Extempore, Elocution, Describing Experiences and Events.

### **Unit III: Study of Sounds in English**

Introduction to phonetics, Study of Speech Organs, Study of Phonemic Script, Articulation of Different Sounds in English, Stress Mark.

### **Unit IV: English Grammar**

Grammar: Forms of Tenses, Articles, Prepositions, Use of Auxiliaries and Modal Auxiliaries, Synonyms and Antonyms, Common Errors, Sentence Formation and Sentence Structures, Use of Appropriate Diction.

### **Unit V: Writing Skills**

Features of Good Language, Difference between Technical Style and Literary Style, Writing Emails, Formal and Informal English, Business Writing, Advertisements, Essay Writing, (Technical, Social, and Cultural Topics), Technical Reports: Report Writing: Format, Structure and Types, Writing Memorandum, Circulars, Notices, Agenda and Minutes, Technical Manuals, Brochures

Letter Writing: Types, Parts, Layouts, Letters and Applications, Use of Different Expressions and Style, Writing Job Application Letter and Resume.

### **Unit VI: Reading Skills & Listening Skills**

**Reading:** Introduction to Reading, Barriers to Reading, Types of Reading: Skimming, Scanning, Fast Reading, Strategies for Reading, Comprehension.

**Listening :**Importance of Listening, Types of Listening, Barriers to Listening.

### **Text book:**

1. Mohd. Ashraf Rizvi, *Communications Skills for Engineers*, Tata McGraw Hill

### **Reference Books:**

1. Sanjay Kumar, PushpLata, *Communication Skills*, Oxford University Press, 2016
2. Meenakshi Raman, Sangeeta Sharma, *Communication Skills*, Oxford University Press, 2017
3. Teri Kwal Gamble, Michael Gamble, *Communication Works*, Tata McGraw Hill Education, 2010

## MTE1107 Thermal Engineering Lab

|                          |                                   |                                |       |                   |
|--------------------------|-----------------------------------|--------------------------------|-------|-------------------|
| MTE1107                  | PG Thermal Engineering Lab        | PCC                            | 0-3-0 | 2 Credits         |
| <b>Exam Scheme</b>       |                                   |                                |       |                   |
| Class Test<br>---- Marks | Continuous Assessment<br>25 Marks | End-Sem Evaluation<br>25 Marks |       | Total<br>50 Marks |

**Course Objective:** Objective 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 conditioning set-up, centrifugal pump etc. to study their performance and analyze the results. |
| CO2 | Draw and analyze performance curves of these machines/systems.  |
| CO3 | Analyze and apply the results obtained from the tests.  |

| POs →<br>COs↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1           | 1   |     | 1   |     |     | 2   |     |     |     |      | 2    |      |
| CO2           | 1   |     |     | 1   |     |     |     |     |     |      |      |      |
| CO3           | 2   |     |     |     |     | 1   |     |     |     |      |      |      |

### Experiments from 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.

## MTE1201 Modeling and Analysis in Thermal Engineering

|                        |  |                          |       |                    |
|------------------------|--|--------------------------|-------|--------------------|
| MTE1201                | Modeling and Analysis in Thermal Engineering | PCC                      | 3-1-0 | 4 Credits          |
| <b>Exam Scheme</b>     |  |                          |       |                    |
| Class 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 the dimensionless parameters |

Mapping of COs with POs :

| PO's →<br>CO's ↓ | 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

\*\*\*\*\*

## MTE1206 Mini-Project (Semester II)

|                       |                                  |                                |       |                   |
|-----------------------|----------------------------------|--------------------------------|-------|-------------------|
| <b>MTE1206</b>        | Mini Project                     | PCC                            | 3-1-0 | 4 Credits         |
| <b>Exam Scheme</b>    |                                  |                                |       |                   |
| Class Test<br>--Marks | Continuous Assessment<br>--Marks | End-Sem Evaluation<br>50 Marks |       | Total<br>50 Marks |

Course Objective: Objective 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 proceedings. |

### Mapping of course outcomes with program outcomes

| Course 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    |

### Course Contents

To train students in identification, analysis, finding solutions and execution of live problems in thermal engineering. 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 Mechanical 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 marks 50 and Semester-end examination marks 50.

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 = 50 marks

## MTE1202 Fluid Dynamics

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| <b>MTE1101</b>         | <b>Fluid Dynamics</b>             | PCC                      | 3-1-0 | 4 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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 should be able to:

|     |   |
|-----|---|
| CO1 | Understand and define basic fluid dynamic concept like continuum, surface forces ,stress tensor and vector fields, Eulerian and langrangian flow. |
| CO2 | Define the motions of fluid elements and derive continuity equation,stream function and velocity 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 behavior of numerical schemes.                  |

Mapping of COs with POs

| POs →<br>COs↓ | 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    |      |      |

### 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 plate, 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, Advance 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.

## MTE1207 Seminar

|                        |                                   |                   |                   |           |
|------------------------|-----------------------------------|-------------------|-------------------|-----------|
| MTE1107                | Seminar                           | PCC               | 0-0-4             | 2 Credits |
| <b>Exam Scheme</b>     |                                   |                   |                   |           |
| Class Test<br>-- Marks | Continuous Assessment<br>25 Marks | PR/OR<br>25 Marks | Total<br>50 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 should be able to:

|     |  |
|-----|--|
| CO1 | To enable students to aware about recent areas and technologies in thermal engineering and related area.                     |
| CO2 | To enable students comprehend importance of system up gradation, improvement and 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 related area.                     |

Mapping of COs with POs:

| POs →<br>COs ↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1            | 1   |     |     |     |     |     |     | 1   |     |      |      |      |
| CO2            |     | 1   |     |     |     |     |     |     | 1   | 2    |      | 1    |
| CO3            |     | 2   |     |     | 1   |     | 1   | 2   |     |      | 1    |      |
| CO4            |     |     |     |     |     |     |     | 1   |     | 1    |      | 1    |

### Course Contents:

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.

## MTE2301 Project Management and Intellectual Property Rights

|                        |   |                   |                    |           |
|------------------------|---|-------------------|--------------------|-----------|
| MTE2301                | Project Management and Intellectual Property Rights | PCC               | 0-0-4              | 2 Credits |
| <b>Exam Scheme</b>     |   |                   |                    |           |
| Class Test<br>-- Marks | Continuous Assessment<br>50 Marks                   | PR/OR<br>50 Marks | Total<br>100 Marks |           |

**Course Objectives: Objectives of this course are**

1. To provide the sufficient knowledge importance of IPR
2. To familiarize the students about the filing the patent and project scheduling, procurement, specifications etc
3. To understand the report writing and filing patent

**Course Outcomes:**

At the end of the course, 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 Processes to register own project research.                  |
| CO3 | Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies. |
| CO4 | Develop awareness at all levels (research and innovation) of society to develop patentable technologies.   |
| CO5 | Apply trade mark law, copy right law, patent law and also carry out intellectual property audits   |
| CO6 | Manage and safeguard the intellectual property and protect it against unauthorized use   |

Mapping of COs with POs:

| POs →<br>COs↓ | 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

#### A. Project Management:

Unit-I

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-II

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-III

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

### **B. IPR:**

#### Unit-IV

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

#### Unit-V

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

#### Unit-VI

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. Shtub, Bardand Globerson, Project Management: Engineering, Technology, and Implementation, Prentice Hall of India
2. Lock, Gower, Project Management Handbook.
3. Prabuddha Ganguli, IPR: Unleashing the Knowledge Economy, published by Tata McGraw Hill 2001.



## MTE2302 Project Stage-I

|                        |                                   |                               |       |                    |
|------------------------|-----------------------------------|-------------------------------|-------|--------------------|
| MTE2302                | <b>Project Stage-I</b>            | PCC                           | 0-0-0 | 10 Credits         |
| <b>Exam Scheme</b>     |                                   |                               |       |                    |
| Class Test<br>-- Marks | Continuous Assessment<br>---Marks | Final Evaluation<br>100 Marks |       | Total<br>100 Marks |

**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 should be able to:

|     |  |
|-----|--|
| CO1 | Identify problems and to plan methodologies to solve problems.   |
| CO2 | Carry out exhaustive literature review, study & evaluate collected literature critically 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 evaluation committee to demonstrate presentation skills acquired. |

Mapping of COs with POs:

| POs →<br>COs ↓ | 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   |      |      | 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. 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.



## MTE2401 Project Stage-II

|                        |                                   |                               |        |                    |
|------------------------|-----------------------------------|-------------------------------|--------|--------------------|
| MTE2401                | <b>Project Stage-II</b>           | PCC                           | 0-0-40 | 20 Credits         |
| <b>Exam Scheme</b>     |                                   |                               |        |                    |
| Class Test<br>-- Marks | Continuous Assessment<br>-- Marks | Final Evaluation<br>100 Marks |        | Total<br>100 Marks |

**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 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:

| PO's →<br>CO's ↓ | 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

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.

-----End-----

### MTE11E1a/2a    **Combustion Engineering**

|                        |  |                          |       |                    |
|------------------------|--|--------------------------|-------|--------------------|
| MTE11E1a/2a            | Combustion Engineering<br>(Elective-I) | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |  |                          |       |                    |
| Class 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, Governing 3D Partial Differential Equations etc.,                            |
| CO2 | Formulate and model, General Probability Density Function, Turbulent Pre-mixed and non pre-mixed flames.  |
| CO3 | knowledge of fuel thermo-chemistry and fuel quality effects on emissions, engine technologies, engine combustion-related emissions and control technologies |
| CO4 | Extend their knowledge of fuels and engines to different situations of engineering context and professional practice.                                       |
| CO5 | Demonstrate the ability to engage in life-long learning.  |

Mapping of COs with POs:

|       |     |     |     |     |     |     |     |     |     |      |      |      |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| POs → | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| COs ↓ |     |     |     |     |     |     |     |     |     |      |      |      |
| 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 turbulent combustion modeling for gas phase systems)

## MTE11E1b/2b Utilization of Solar Energy

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1b/2b            | Utilization of Solar Energy       | PEC                      | 3-0-0 | 2 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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 and inclined surfaces, Basic earth sun angles, Beam and diffuse radiations, Radiation on titled surfaces. |
| CO2 | Analyze the performance by conducting research on flat plate collector, air heater and 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 systems  |
| CO6 | Demonstrate the importance of solar energy effectively to increase awareness of it in society.  |

Mapping of COs with POs:

| POs →<br>COs ↓ | 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

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## MTE11E1c/2c Exergy Analysis of Thermal System

|                        |  |                          |       |                    |
|------------------------|--|--------------------------|-------|--------------------|
| MTE11E1c/2c            | Exergy Analysis of Refrigeration Systems | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |  |                          |       |                    |
| Class 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 an 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 engineering system  |
| CO2 | Analyze performance these systems by conducting experiments by applying heat balance method, 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, refrigeration installations, Cryogenic systems and small capacity units. |

Mapping of COs with POs:

| POs →<br>COs ↓ | 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, regeneration, 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.

## MTE11E1d/2d Energy Conservation and Management

|                        |                                    |                          |       |                    |
|------------------------|------------------------------------|--------------------------|-------|--------------------|
| MTE11E1d/2d            | Energy Conservation and Management | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                    |                          |       |                    |
| Class 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 will 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 industry.               |
| CO3 | Interpret financial appraisal methods, and thermodynamic analysis, and estimate financial budget of visited industry. |

Mapping of COs with POs:

| POs →<br>COs ↓ | 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, Internal-rate 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.

## MTE11E1e/2e Design of Heat Exchangers

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1e/2e            | Design of Heat Exchanger          | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class Test<br>20 Marks | Continuous Assessment<br>20 Marks | End-Sem Exam<br>60 Marks |       | Total<br>100 Marks |

**Course Objectives:** 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 should 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 and plate-fin heat exchanger. |
| CO4 | Demonstrate selection criteria of HEX and conduct an independent research to suggest suitable 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 →<br>COs ↓ | 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,  $\epsilon$ -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.

## MTE11E1f/2f      Design of Air Conditioning System

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1f/2f            | Design of Air Conditioning System | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 will be able to:

|     |  |
|-----|--|
| CO1 | Demonstrate Air-conditioning processes and psychometric  |
| CO2 | Illustrate Ventilation, Necessity, Natural Ventilation, wind effect, Measurement of thermal comfort 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 control techniques.     |

Mapping of COs with POs:

| PO's →<br>CO's ↓ | 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 air-conditioning, 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



## MTE11E1g/2g    Advanced Refrigeration

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1g/2g            | Advanced Refrigeration            | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class Test<br>20 Marks | Continuous Assessment<br>20 Marks | End-Sem Exam<br>60 Marks |       | Total<br>100 Marks |

**Pre requisite: Refrigeration and Air-conditioning**

**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

**Course Outcomes:**

At the end of the course, student will 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, azeotropic etc.,   |
| CO3 | Illustrate Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations action with lubricating oil, retrofitting, refrigerant blends, effects on 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 →<br>COs ↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1            | 1   | 1   |     |     |     |     |     |     |     |      |      |      |
| CO2            | 1   |     |     |     |     |     |     |     |     |      |      |      |
| CO3            | 1   |     |     |     |     |     |     |     |     |      |      | 1    |
| CO4            |     |     |     |     |     | 1   |     |     |     |      |      | 1    |
| CO5            | 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, Li-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. ASHARA E H. B. – Fundamental
8. Edward Pita, *Air Conditioning Principles and Systems*, Prentice Hall

**MTE11E1h/2h****Hydraulic, Pneumatic and Fluidic Control**

|                        |  |                          |       |                    |
|------------------------|--|--------------------------|-------|--------------------|
| MTE11E1h/2h            | Hydraulic, Pneumatic and Fluidic Control | PEC                      | 3-1-0 | 4 Credits          |
| <b>Exam Scheme</b>     |  |                          |       |                    |
| Class 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 hydraulic and pneumatics
2. To familiarize the students about the hydraulic and pneumatic and its applications in real life situations
3. To carry out a case study on the existed mechanical system

**Course Outcomes:**

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

|     |   |
|-----|---|
| CO1 | Describe control system and list types of control system and demonstrate their utility.                               |
| CO2 | construct and design Hydraulic, Pneumatic or Fluidic Control valve, forces acting on valves indifferent type of flows |
| CO3 | Operate and maintain various hydraulic devices such as hydraulic brake, power steering, jack etc.                     |
| CO4 | Design hydraulic circuits by selecting suitable components for a given application.                                   |
| CO5 | Operate and maintain various hydraulic devices such as hydraulic brake, power steering, jack etc                      |
|     | Install, maintain, and troubleshoot various hydraulic systems.  |

Mapping of COs with POs:

| POs →<br>COs↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1           | 1   | 2   |     |     |     |     |     |     |     |      |      |      |
| CO2           | 2   |     | 1   |     | 2   | 1   |     |     |     |      |      |      |
| CO3           | 2   | 1   |     |     |     |     |     |     |     |      |      |      |
| CO4           | 1   |     |     |     | 1   |     |     |     |     |      |      |      |
| CO5           |     |     |     |     | 1   | 1   |     |     |     |      |      |      |
| CO6           | 2   |     |     |     | 1   |     |     |     |     |      |      |      |

**Course Contents****Unit1**

Introduction to control system.Types of control system and their utility.

**Unit2**

Hydraulic power generation and transmission, valve control pressure flow relationship and constructions, steady state operating forces, transient forces and valve instability.

### **Unit3**

Circuitdesign.Pneumaticvalves.Hydraulic and pneumatic drives.

### **Unit4**

Introduction to fluidic devices and sensors lumped and distributed parameter fluid systems.

### **Unit5**

Fluid mechanics of jets, wall attachment and vortex devices.Pure fluidic analog amplifiers.Analog signal control techniques. Design of pure fluid digital elements

### **Unit6**

Maintenance and trouble shooting

### **TEXTS / REFERENCES:**

- J.F.Blackburn, G.Rechthof, J.L. Shearer, *Fluid Power Control*,MIT, 1960
- B.W.Anderson, *The Analysis and Design of Pneumatic Systems*, Wiley, 1967.
- K.Foster, G.Parker, *Fluidic Components and Circuits*, Wiley, 1970.
- A.B.Goodwin, *Fluid Power Systems*, Macmillan, 1976.

## MTE11E1i/2i ADVANCED I.C. ENGINES

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1i/2i            | Advanced I.C. Engines             | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 fuels 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 engine.              |
| CO4 | Apply various emission control system and modification to take corrective actions to reduce 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 →<br>COs ↓ | 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**

**Unit1**

**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.

**Unit2**

**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.

### **Unit3**

#### **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.

### **Unit4**

#### **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.

### **Unit5**

**Engine Emissions & Control:** Air pollution due to IC engines, Emissions-HC, CO, NO<sub>x</sub>, particulates, GHGs (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O), emission norms, emission control methods-exhaust gas recirculation, three way catalytic convertor, particulate trap, modern methods.

### **Unit6**

#### **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.

## MTE11E1j/2j Pumps, Blowers and Compressors

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1j/2j            | Pumps, Blowers and Compressors    | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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, Cavitation,                       |
| CO2 | Design of centrifugal pumps, axial flow pump and analyze their performance using engineering software's etc.,                 |
| CO3 | Study types of fans and blowers, calculate their efficiency, stresses, and characteristics, 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 →<br>COs↓ | 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 1

#### 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 2**

### **Power Transmitting Turbo-machines**

Introduction, theory, fluid of hydraulic coupling, torque converter.

## **Unit 3**

**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 4**

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

## **Unit 5**

**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 6**

**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:**

- A.J.Stepanoff, *Centrifugal and Axial /flow Pumps*, Wiley, 1962.
- A.Kovats, *Design and Performance of Centrifugal and Axial Flow Pumps and Compressors*, Oxford, Pergamon, 1958.
- V. Kadambi and Manohar Prasad: “*An Introduction to energy conversion Volume III*”, 2002
- S M Yahya: “*Turbines, Compressors and Fans*”, Second Edition.
- V Ganesan: “*Gas Turbines*”, 2002.
- R.Yadav, *Steam and Gas Turbine*, Central Publishing Home, Allahabad.

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## MTE11E1k/2k CAD-CAE

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1k/2k            | CAD-CAE                           | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class Test<br>20 Marks | Continuous Assessment<br>20 Marks | End-Sem Exam<br>60 Marks |       | Total<br>100 Marks |

### Course Pre-requisites

Numerical Methods & Computational Techniques (PC3), Structured or Object Oriented Programming (FORTRAN / C / C++ / Java / VB )

### Course Objectives: Objectives of this course are

1. To provide the sufficient knowledge of concept, applications, importance of CAD -CAE
2. To familiarize the students about the CAD - CAE and their applications in real life situations
3. To understand the industrial applications of CAD CAE and solving industrial problem

### Course Outcomes:

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

|     |   |
|-----|---|
| CO1 | Demonstrate - Polynomial and spline interpolation, Bezier curves, B-spline to surface representation, patches and composite surfaces. |
| CO2 | Design and create Solid model assembly of thermal and fluid engineering system in CAD software.                                       |
| CO3 | Analyze simple Engineering problem by selecting appropriate Mesh generation.  |
| CO4 | Modeling and Meshing of Thermal and Fluid Flow equipment in CAD.  |
| CO5 | Simulate and demonstrate Thermal and Fluid systems by using ANSYS, EES, MATLAB etc.   |
| CO6 | Understand and simulate computer aided manufacturing.   |

Mapping of COs with POs:

| PO's →<br>CO's ↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1              | 2   |     |     |     |     |     |     |     |     |      |      |      |
| CO2              |     | 1   |     | 1   | 1   |     |     |     |     |      |      |      |
| CO3              |     | 2   |     | 1   |     |     |     |     |     |      |      |      |
| CO4              | 1   | 1   |     | 1   |     |     |     |     |     |      |      | 1    |
| CO5              | 1   | 1   |     | 3   |     |     |     |     |     |      |      |      |
| CO6              | 1   | 1   |     |     |     |     |     |     |     |      |      | 1    |

## **Course Contents**

### **Unit I**

Overview of CAD Applications, Curves - Polynomial and spline interpolation, Bezier curves, B-splines, Introduction to surfaces representation, patches and composite surfaces  
Solid Modeling: Representation of Solids, Topology, Wireframe, Boundary representation (B-Rep), CSG, Solid modeling operations

### **Unit II**

Computer Graphics: Mathematical principles for 2D and 3D visualization, Matrix transformations, Modeling, viewing, projection and rendering, OpenGL graphics library  
Meshing – Mesh topology, Data structures, Introduction to Mesh generation algorithms, Surface meshes, Element types and quality criteria

### **Unit III**

CAD data formats and exchange, Hands-on lab sessions: Modeling and Meshing of Thermal and Fluid Flow equipment

### **Unit IV**

Numerical solutions and techniques for thermal and fluid flow and heat transfer.

### **Unit V**

Development of algorithm and programming (coding by using C/C++/VB/ FORTRAN etc., ) of the thermal, fluid flow and combustion related problems.

### **Unit VI**

Computational Fluid Dynamics: Lab simulations for Fluid Flow and Heat transfer (case study)

### **TEXTS / REFERENCES:**

1. Kunwoo Lee, Principles of CAD/CAM/CAE
2. Chris McMahon and Jimmie Browne, CAD/CAM – Principle Practice and Manufacturing Management, Addison Wesley England, Second Edition, 2000
3. Groover M.P. and Zimmers E. W., CAD/CAM: Computer Aided Design and Manufacturing, Prentice Hall International, New Delhi, 1992.
4. Software Engineering – Ian Sommerville, Pearson Education

## MTE11E11/21 Nuclear Power Plant

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E11/21            | Nuclear Power Plant               | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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, Nuclear Power Scenario in India, Scope |
| CO2 | Describe Nuclear physics, reactor, classification and types of nuclear reactor, economics of 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 →<br>COs↓ | 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, Sites 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 Engineering / R.K.Rajput/ Lakshmi Publications.
3. Power Plant Engineering / P.C.Sharma/ Kotearia Publications.
4. Power Plant Technology / Wakil.

## MTE11E1m/2m Thermal Energy Storage

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| <b>MTE11E1m/2m</b>     | <b>Thermal Energy Storage</b>     | PCC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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 literature on importance of energy transport and storage of thermal ,mechanical , electro-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 Compressed air energy storage         |

Mapping of COs with POs:

| POs →<br>COs↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1           | 2   | 2   |     |     |     |     |     |     |     |      |      |      |
| CO2           |     | 1   |     | 1   | 1   |     |     |     |     |      |      |      |
| CO3           |     |     | 1   | 1   |     | 1   |     |     |     |      |      |      |

### Course Contents

#### UNIT I

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

#### UNIT II

Electromagnetic energy storage: static field, transient electric field, magnetic materials, radiant storage.

#### UNIT III

Electro-chemical energy conversion and storage: The electrochemical cell, Fuel cells, batteries.

Chemical energy storage (organic fuels)

#### **UNIT IV**

High temperature storage ,Compressed air energy storage ,Thermo chemical storage

#### **UNIT V**

Emerging technologies and examples of energy storage, testing of storage systems

#### **UNIT VI**

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 Salkins : “Silver Zinc - Alkaline storage systems”.

## MTH11E1n/2n Steam Engineering

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| <b>MTH11E1n/2n</b>     | Steam Engineering                 | PEC                      | 3-0-0 | 3 Credits          |
| Exam Scheme            |                                   |                          |       |                    |
| Class 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 understanding of energy conservation fundamentals. Students will have the ability to analyze thermal systems for energy conservation. |
| CO4 | Design a steam piping system, its components for a process and also design economical and effective insulation.  |
| CO5 | Analyze a thermal system for sources of waste heat design a systems for waste heat recovery.   |
| CO6 | Design and develop controls and instrumentation for effective monitoring of the process.   |

Mapping of COs with POs:

| PO's →<br>CO's ↓ | 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 Equipments / 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, economical 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-Hill Publishing 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 Answers; Tata McGrawHill Education Pvt Ltd, N Delhi



## MTE12E3a/4a Cryogenic Engineering

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3a/4a            | Cryogenic Engineering             | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 the concept of cryogenics, liquefaction of gases, cryocoolers, gas separation
2. To familiarize the students about the cryogenic engineering and its industrial applications
3. To understand the design of cryogenic system components

### 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 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 →<br>COs↓ | 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 I

##### 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 II

##### 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 III****Cryogenic Refrigeration Systems:**

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

**Unit IV****Insulation:**

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

**Unit V****Storage:**

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

**Unit VI****Transfer of Liquefied Gases:**

Two phase flow transfer through insulated and uninsulated lines, cryogenic pumps and valves.

**TEXTS:**

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

## MTE12E3b/4b Steam and Gas Turbine

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3b/4b            | Steam and Gas Turbine             | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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 Theoretical steam turbine cycle .                               |
| CO2 | Demonstrate and analyze vortex flow, energy lines and reheat factors of steam turbines. Solve problems of finding performance steam turbine power plant. |
| CO3 | Demonstrate simple brayton cycle for gas turbine analyze its performance on computer simulation, 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:

| POs →<br>COs↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1           | 1   | 1   |     |     |     |     |     |     |     |      |      |      |
| CO2           |     | 2   |     |     |     |     |     |     |     |      |      |      |
| CO3           | 1   | 1   |     | 3   | 1   |     |     |     |     |      |      |      |
| CO4           | 2   | 1   |     |     | 2   | 1   |     |     |     |      |      |      |
| CO5           | 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

## MTE12E3c/4c Biomass Energy Systems

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3c/3c            | Biomass Energy Systems            | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 the concept of Biomass its importance, availability, and energy conversion process
  2. To familiarize the students about the biomass systems design
- To understand the industrial applications of Biomass systems through real life problems

### Course Outcomes:

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

|     |  |
|-----|--|
| CO1 | Illustrate relevance of biomass as energy source, enumerate advantages and disadvantages of biomass 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 engines and analyze its performance . |
| CO4 | Conduct an experiment and calculate load capacity, efficiency and identify maintenance, troubleshooting and exhaust emission problems.     |
| CO5 | Design and construct down draft gasifier, its Cooling–cleaning systems and Performance evaluation of a Down draft gasifier.                |

Mapping of COs with POs:

| POs →<br>COs↓ | 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 systems M Performance 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 B Parulkar: “*Energy Technology*” Khanna Publishers Delhi – 1999
4. A. Kaupp and J.R. Goss: “*State of Art Report for small scale Gas Producer Engine Systems*”, Friedr Vieweg & Sohn Verlags, Gmbh, Braunschweig, 1984

## MTE12E3d/4d Conservation of Energy in Buildings

|                        |                                     |                          |       |                    |
|------------------------|-------------------------------------|--------------------------|-------|--------------------|
| MTE12E3d/4d            | Conservation of Energy in Buildings | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                     |                          |       |                    |
| Class 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 the importance of energy conservation, opportunities and challenges in buildings
2. To familiarize the students about the energy conservations through live examples and case studies
3. To understand the use of software for energy conservations in building

### 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 suggest mitigations to that industry. |
| CO3 | Draw the energy flow diagram of an industry and identify the energy wasted or a waste stream                                 |
| CO4 | Analyze and select appropriate energy conservation method to reduce the wastage of energy.                                   |
| CO5 | Evaluate the techno economic feasibility of the energy conservation technique adopted.                                       |

Mapping of COs with POs:

| POs →<br>COs↓ | 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 (Daylighting 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 Passive Building, Science and Design*, Pergamon Press, 1986.
2. J.R.Williams, *Passive Solar Heating*, Ann Arbor Science, 1983.
3. R.W.Jones, J.D.Balcomb, C.E.Kosieqiez, G.S.Lazarus, R.D.McFarland and W.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.



## MTE12E3e/4e Computational Fluid Dynamics

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3e/4e            | Computational Fluid Dynamics      | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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 should be able to:

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

Mapping of COs with POs:

| POs →<br>Cos ↓ | 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 and Governing Equations of CFD

Historical background, impact of CFD, derivation, discussion of physical meanings and presentation of forms particularly suitable to CFD.

#### UNIT II

### **Basic Aspects of Discretization**

Introduction to FDM, FEM and FVM, detailed treatment of FDM, explicit and implicit methods, errors and stability analysis.

### **Grids with Appropriate Transformations**

Adaptive grids and unstructured meshes, uniform and non-uniform grids, Numerical errors.

## **UNIT III**

### **CFD Techniques**

The Lax-Wendroff Technique, MacCormack's Technique, Space marching, Relaxation Technique, Numerical dissipation and dispersion, artificial viscosity, The ADI Technique, Pressure correction Technique: Application to incompressible viscous flow, the SIMPLE algorithm, Computation of Boundary layer flow, Finite difference approach.

## **UNIT IV**

### **Numerical Solution of Governing equations:**

Numerical solution of elliptical equations, Linear system of algebraic equations, Iterative solution of system of linear equation, Model Equations, Wave equations, Numerical solution of parabolic equations, Stability analysis, Solutions of convection, Diffusion equation, Conservative and non-conservative schemes, Navier-Stokes equations, Basics of grid generation, Numerical solution of hyperbolic equations.

## **UNIT V**

### **Convection Heat Transfer**

Steady One-Dimensional and Two-Dimensional Convection, Diffusion, Unsteady one-dimensional convection, Diffusion, Unsteady two-dimensional convection, Diffusion.

## **UNIT VI**

**Incompressible Couette Flow:** Solution by implicit method and the pressure correction method, Governing Equations, Stream Function, Vorticity method, Determination of pressure for viscous flow.

**Numerical Solution of 2D Supersonic Flow:** Prandtl-Meyer Expansion Wave.

**Supersonic Flow over a Flat Plate:** Numerical Solution by solving complete Navier Stokes equation.

### **Reference Books:**

1. J. D. Anderson, Computational Fluid Dynamics-The Basics with Applications, Mcgraw Hill.
2. Fletcher C.A.J., Computational Techniques for Fluid Dynamics, Volumes I and II, Springer, Second Edition 2000
3. C. Hirsch, Numerical Computation of Internal and External Flows, Volumes I and II, John Wiley & Sons, 2001
4. Muralidhar K. and Sundararajan T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi 1995.
5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, T & F.
6. Ghoshdastidar, Computational fluid dynamics.

**MTE12E3f/4fK****Alternative Fuels for IC Engines**

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3f/4f            | Alternative Fuels for IC Engines  | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 the need of alternative fuels, environment impact, types of alternative fuels, preparation of alternative fuels
2. To familiarize the students about engine alteration to use alternative fuels
3. To understand the current status of alternative fuels

**Course Outcomes:**

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

|     |  |
|-----|--|
| CO1 | Demonstrate Structure of petroleum, Refining process, Products of refining process, Select suitable fuels for use in SI engines. Understand various performances rating in SI engines. |
| CO2 | Illustrate properties of petroleum products and classify them on their characteristic.   |
| CO3 | Describe and analyze Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen and their manufacturing procedure.   |
| CO4 | calculate and estimate performance and emission characteristics of alternative fuels   |
| CO5 | Analyze environmental effects of combustion of various fuels, suggest modification in their usage.   |

Mapping of COs with POs:

| POs    | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| → COs↓ |     |     |     |     |     |     |     |     |     |      |      |      |
| CO1    | 2   | 2   |     |     |     |     |     |     |     |      |      |      |
| CO2    |     | 1   |     |     |     |     |     |     |     |      |      |      |
| CO3    | 1   | 1   |     | 1   | 1   |     |     |     |     |      |      |      |
| CO4    |     |     | 1   | 1   |     |     |     |     |     |      |      |      |
| CO5    | 1   | 1   |     |     | 1   | 1   |     |     |     |      |      |      |

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**Course Contents**
**UNIT I****Introduction**

Need for alternate fuel, availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like Electric vehicle, hybrid, fuel cell and solar cars.

**UNIT II**

## **Alcohols**

Properties as engine fuel, alcohols and gasoline blends, performance in SI engine, methanol and gasoline blends, combustion characteristics in CI engines, emission characteristics, DME, DEE properties performance analysis, performance in SI & CI Engines.

## **UNIT III**

### **CNG, LPG, Hydrogen and Biogas**

Availability of CNG, properties, modification required to use in engines, performance and emission characteristics of CNG, LPG and Biogas using in SI & CI engines, Hydrogen; storage and handling, performance and safety aspects.

## **UNIT IV**

### **Vegetable Oils**

Various vegetable oils for engines, transesterification, biodiesel and its properties, performance, emission and combustion characteristics of engine.

## **UNIT V**

### **Electric and Hybrid Vehicle**

Layout of an electric vehicle, advantage and limitations, specifications, system components, electronic control system, high energy and power density batteries, hybrid vehicle.

## **UNIT VI**

### **Fuel Cell and Solar**

Fuel cell vehicles, specifications, system components, selection of fuel cell, thermal management, maintenance, advantage and limitations,  
Solar powered vehicles, specifications, system components, advantage and limitations,

## **Reference Books:**

1. M.K. Gajendra Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilisation in Combustion Engines, CRC Press, 2013.
2. Richard L. Bechfold, Alternative Fuels Guide Book - SAE International Warrendale 1997.
3. B. P. Pundir, Engine Emissions, Alpha Science International Limited, 2007
4. B. P. Pundir, IC Engines Combustion and Emissions, Alpha Science International Limited, 2010.
5. Nagpal, Power Plant Engineering, Khanna Publishers - 1991.

## MTE12E3g/4g Numerical Heat Transfer

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3g/4g            | Numerical Heat Transfer           | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class Test<br>20 Marks | Continuous Assessment<br>20 Marks | End-Sem Exam<br>60 Marks |       | Total<br>100 Marks |

**Pre-Requisites:** Heat Transfer

**Course Objectives:** Objectives of this course are

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 course outcomes with program outcomes

| POs →<br>COs ↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1            | 3   |     | 1   |     |     | 1   | 2   | 1   |     |      |      |      |
| CO2            | 3   | 1   |     |     |     |     |     |     |     |      |      |      |
| CO3            | 3   | 3   | 1   |     |     |     |     | 1   |     |      |      |      |
| CO4            | 3   | 3   | 1   |     | 2   |     |     | 1   |     |      |      |      |
| CO5            |     |     |     | 3   | 3   | 1   | 1   | 2   |     |      |      | 2    |

### Course Contents:

#### Unit I -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 II

##### Partial Differential Equations

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

#### Unit III

### **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 IV**

#### **Numerical Methods for Conduction Heat Transfer (Part 2)**

Two dimensional problems, Transient one dimensional problem, Euler, crank – Nicholson and pure implicit method, stability.

### **Unit V**

#### **Numerical Methods for Incompressible Fluid Flow**

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

### **Unit VI**

#### **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. Suhas V. 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. Necati Ozisik, “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.

## MTE12E3h/4h    Micro Fluidics

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3h/4h            | <b>Micro Fluidics</b>             | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class Test<br>20 Marks | Continuous Assessment<br>20 Marks | End-Sem Exam<br>60 Marks |       | Total<br>100 Marks |

**Pre-Requisites:** Heat Transfer

**Course Objectives:** Objectives of this course are

1. To Understand the concept of fluid dynamics and micro channels
2. To familiarize the students about the importance of micro fluidic and its applications in real life problems such as design drug delivery system, micro channel reactors
3. To understand the industrial applications of Micro Fluidic

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

|     |  |
|-----|--|
| CO1 | Identify Application and changes of micro fluidics in the various engineering aspects  |
| CO2 | Apply concept coquette flow, poiseuille flow, time phase flow throw micro channel of different c/s areas in real engineering problems. |
| CO3 | Numerical analysis of capillary flow for a different materials, fluids, cross section and boundary conditions.                         |
| CO4 | Describe various electromagnetic field effects on flow of micro fluids, simulate forces DEP force on a dielectric sphere               |
| CO5 | Design various micro fluidic components such as channels, pumps, valves, sensors etc.,   |

### Mapping of course outcomes with program outcomes

| POs →<br>COs↓ | 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 EDL limit, Ideal electroosmotic flow, Ideal EOF with back pressure, Cascade electroosmotic 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, T-junction 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., Wereley, S. T., Fundamentals and applications of Microfluidics, Artech house Inc., 2002.
2. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
3. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.
4. Tabeling, P., Introduction to microfluidics, Oxford University Press Inc., 2005.
5. Kirby, B. J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010.
6. Colin, S., Microfluidics, John Wiley & Sons, 2009





## MTE12E3i/4i Nano Technology

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3i/4i            | Nano Technology                   | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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:

|     |   |
|-----|---|
| CO1 | Demonstrate the understanding of length scales concepts, nanostructures and nanotechnology.                                     |
| CO2 | Identify and to compare various synthesis and characterization techniques involved in Nanotechnology.                           |
| CO3 | Define and interpret the interactions at molecular scale.   |
| CO4 | Evaluate and analyze the mechanical properties of bulk nano-structured metals and alloys, nano-composites and carbon nanotubes. |
| CO5 | Compare and analyze the effects of using nanoparticles over conventional methods.   |

### Mapping of course outcomes with program outcomes

| POs →<br>COs↓ | 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 self-assembly.

### **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.

**MTE12E3j/4j****Boundary Layer Theory**

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3j/4j            | Boundary Layer Theory             | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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 should be able to:

|     |  |
|-----|--|
| CO1 | Evaluate exact solution of Navier-stokes equation in boundary layer that exhibit small viscosity by applying mathematical, Numerical techniques.                               |
| CO2 | Demonstrate boundary-layer equations in the spirit of Prandtl, Prandtl boundary-layer equations in two dimensions deduced by order-of-magnitude arguments, skin friction drag. |
| CO3 | calculate and solve ODE's for classical boundary-layer equations of Prandtl  |
| CO4 | Formulate and develop Exact solutions of the classical boundary-layer equations,   |
| CO5 | Analyze occurrence in steady flows, and at rear stagnation point of impulsively started cylinder, Goldsten singularity.  |

Mapping of COs with POs:

| POs →<br>COs ↓ | 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-dimensionalisation 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's mixing layer. Prandtl transformation. Axisymmetric flows: Mangler's transformation. Split-disc 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*, Vol. I. 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.

## MTE12E3k/4k Advanced Optimization Techniques

|                        |                                   |                          |                    |           |
|------------------------|-----------------------------------|--------------------------|--------------------|-----------|
| MTE12E3k/4k            | Advanced Optimization Techniques  | PEC                      | 3-0-0              | 3 Credits |
| <b>Exam Scheme</b>     |                                   |                          |                    |           |
| Class 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 the concept of optimization and its importance in the back ground of real life engineering systems
2. To familiarize the students about the optimization techniques and their implementations
3. To carry out the case study using optimization technique

**Course Outcomes:** At the end of the program 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 by various methods   |
| CO3 | Optimize engineering problem of non linear-programming with/without constraints, by using this techniques   |
| CO4 | Use of dynamic programming problem in controlling in industrial managements.  |
| CO5 | Simulate Thermal engineering system problem. Understand integer programming andstochastic programming to evaluate advanced optimization techniques. |

### Mapping of course outcomes with program outcomes

| POs →<br>COs↓ | 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- I

Engineering application of optimization, terminology, design variables, constraints, objective functions,variable bounds, problem formulation

#### **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 - II**

### **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, Fletcherreevesmethod.

**Variable**metric method.

## **UNITIII**

**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- IV**

**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- V**

**INTEGER PROGRAMMING:** Introduction – formulation – Gomory cutting plane algorithmZero 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 stochasticlinear, dynamic programming.

### **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

## MTE12E3I/4I JET & ROCKET PROPULSION

|                        |                                   |                          |                    |         |
|------------------------|-----------------------------------|--------------------------|--------------------|---------|
| MTE12E3m/4m            | Jet & Rocket Propulsion           | PEC                      | 3-0-0              | 3Credit |
| <b>Exam Scheme</b>     |                                   |                          |                    |         |
| Class 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 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 propulsion systems.  |
| CO2 | Calculate the design thrust and overall efficiency of turbojet and turbofan engines, with and without afterburners, from given component performance. |
| CO3 | Calculate the specific impulse and mass flow for a rocket engine with the fluid considered as an ideal gas with constant specific heats.              |
| CO4 | Estimate the specific impulse and mass flow for a rocket engine accounting for chemical reaction and non-constant specific heats.                     |
| CO5 | Estimate the heat transfer rates in rocket nozzles and in aero-engine turbine components.   |
| CO6 | Design simple rocket propulsive system.   |

### Mapping of course outcomes with program outcomes

| POs →<br>COs | 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    |

### CourseContent

#### 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.

## **UNIT III**

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.

### **MTE11E1m/2m CONVECTIVE HEAT TRANSFER**

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE11E1m/2m            | Convective Heat Transfer          | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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:**

|     |   |
|-----|---|
| CO1 | Describe Applications of Convective Heat transfer in various thermal systems.   |
| CO2 | Formulate and solve Navier-Stokes equations and energy equations in for various flow patterns and systems.  |
| CO3 | Simulate and distinguish convective heat transfer through laminar and turbulent boundary layer by using computersoftware's e.g., MATLAB,CFD,EES etc., |
| CO4 | Analyze natural and combined convection for flows through various channel by using numerical techniques.  |
| CO5 | Categorize and illustrate flows through porous media with applying energy equation for fully developed flows.   |

#### **Mapping of course outcomes with program outcomes**

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

#### **Course Content**

##### **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-Stokes 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. Oosthuizen& David Naylor /McGraw Hill
2. Convective Heat & Mass Transfer /Kays & Crawford/TMH
- 3.Bejan ,Convective heat transfer

## MTE12E3n/4 Wind Energy Systems

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E3n/4n            | Wind Energy Systems               | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 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:

|     |   |
|-----|---|
| CO1 | Identify and describe history of wind energy and its scope in future.   |
| CO2 | survey and analyze through a literature review world distribution of wind, Weibull statistic, variation in wind energy etc.,                        |
| CO3 | Conduct an experiment to use various wind energy measurement indicators, anemometers, and apply it to analyze and check data obtained from surveys. |
| CO4 | Demonstrate and calculate performance parameters wind energy turbine.   |
| CO5 | Illustrate various electrical systems used in wind energy power plant.  |

Mapping of COs with POs:

| POs →<br>COs ↓ | 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   |     |     |     |     |     |     |     |      |      |      |

### 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

## MTE12E5a RESEARCH METHODOLOGY

|                        |                                   |                          |       |                    |
|------------------------|-----------------------------------|--------------------------|-------|--------------------|
| MTE12E5a               | Research Methodology              | PEC                      | 3-0-0 | 3 Credits          |
| <b>Exam Scheme</b>     |                                   |                          |       |                    |
| Class 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 the concept of research, paper writing, similarities, etc
2. To familiarize the students about the statistical methods, data interpretation , error analysis
3. To carry out analysis on the a published paper

**Course Outcomes:** At the end of the program 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

| POs →<br>COs ↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1            | 2   |     | 3   |     |     |     | 1   |     | 3   |      |      | 2    |
| CO2            | 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 I

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

#### Unit II

Research process – Criteria for good research – Problems in Indian context. Formulation of Research Task – Literature Review – Importance & Methods – Sources – Quantification of Cause Effect Relations – Discussions– Field Study – Critical Analysis of Facts Generated

#### Unit III

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

#### Unit IV

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 V**

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.

#### **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.

## MTE12E5b DESIGN OF EXPERIMENTS

|                        |                                   |                          |                    |           |
|------------------------|-----------------------------------|--------------------------|--------------------|-----------|
| MTE12E5b               | DESIGN OF EXPERIMENTS             | PEC                      | 3-0-0              | 3 Credits |
| <b>Exam Scheme</b>     |                                   |                          |                    |           |
| Class 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 the concept of design of experiments
2. To familiarize the students about the design of experiments techniques and their implementation
3. To design and analysis a real life problem using technique

**Course Outcomes:** At the end of the program 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

| POs<br>→<br>COs↓ | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1              | 1   | 1   |     | 1   | 1   | 1   | 1   | 1   |     | 1    |      | 1    |
| CO2              | 2   | 1   | 1   |     |     | 1   |     | 1   |     |      |      |      |
| CO3              |     | 2   | 1   |     |     | 1   |     |     | 1   |      |      |      |
| CO4              | 1   |     | 1   |     | 2   | 1   |     |     |     | 2    |      | 1    |
| CO5              |     |     | 1   | 2   | 3   | 2   | 2   |     | 1   | 2    |      | 1    |

### Course Contents:

#### Unit I

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 II

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 III**

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 IV**

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 V**

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 VI**

Computer Software for Experimental Design: Role of computer software in experimental design, summary 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<sup>th</sup> 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.

## MTE12E5c Environmental Pollution Control

|                        |                                   |                          |                    |           |
|------------------------|-----------------------------------|--------------------------|--------------------|-----------|
| MTE12E5c               | Environmental Pollution Control   | PEC                      | 3-0-0              | 3 Credits |
| <b>Exam Scheme</b>     |                                   |                          |                    |           |
| Class 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 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 power plant.             |
| CO4 | Do Case study on any industry and analyze carbon exertion rate, water pollution, soil pollution etc.                |
| CO5 | Design pollution control devices for vehicle, analyze and find out replacement CFC refrigerant with HC refrigerant. |

### Mapping of course outcomes with program outcomes

| POs →<br>COs ↓ | 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 Contents

#### 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 equipments - 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 organisms -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. Radio active 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

### **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.