# ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

**(AUTONOMOUS)**

(Anjugramam-Kanyakumari Main Road, Palkulam,Variyoor P.O.-629 401, K.K.Dist.)

**Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai**

**Accredited with A+ Grade by NAAC**

# Department of Mechanical Engineering

## (M.E Thermal Engineering)

## Curriculum & Syllabus

## (*2024-2025 Admitted Students Onwards*)

**Vision Statement of RCET**

To be an academic institute of continuous excellence towards education and research in rural regime and provide service to nation in terms of nurturing potentially higher social, ethical and engineering companion graduands.

**Mission Statement of RCET**

To foster and promote technically competent graduands by imparting the state of art engineering education in rural regime.

To enunciate research assisted scientific learning by dissemination of knowledge towards science, agriculture, industry and national security.

**Vision of the Department**

To inculcate competence in the field of mechanical engineering for the students by providing quality education and learning opportunities to become ethically strong engineers for the development of society.

**Mission of the Department**

To provide fundamentals and technical skills in Mechanical Engineering through effective teaching-learning methodologies.

To provide an ambience for research through collaborations with industry and academia.

To inculcate the students' leadership quality through employability skills with ethical values.

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

| | |
|---|---|
| PEO1 | Graduates will apply the knowledge of Mechanical Engineering concepts and innovative methods to solve real-world engineering problems. |
| PEO2 | Graduates will have the required qualities for a successful carrier in Mechanical Engineering and related fields. |
| PEO3 | Graduates will exhibit professional skills with ethical values and teamwork. |

## PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

| | |
|---|---|
| **PO1** | An ability to independently carry out research /investigation and development work to solve practical problems. |
| **PO2** | An ability to write and present a substantial technical report/document. |
| **PO3** | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the Thermal Engineering. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |

| CREDIT INFO | | |
|---|---|---|
| **Sl.No** | **Category** | **Credits** |
| 1 | Fundamental Courses (FC) | 8 |
| 2 | Research Methodology Courses (RMC) | 2 |
| 3 | Audit Courses (AC) | - |
| 4 | Professional Core Courses (PCC) | 24 |
| 5 | Professional Electives (PEC) | 18 |
| 6 | Open Electives (OEC) | 3 |
| 7 | Employability Enhancement Courses (EEC) | 20 |
| Total Credits | | **75** |

| Fundamental Courses (FC) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1 | 24TE101 | Advanced Numerical Methods | FC | 4 | 0 | 0 | 4 |
| 2 | 24TE102 | Advanced Heat Transfer | FC | 4 | 0 | 0 | 4 |
| **Research Methodology Courses (RMC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1 | 24RM101 | Research Methodology and IPR | RMC | 2 | 0 | 0 | 2 |
| **Audit Courses (AC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24AC201 | English for Research Paper Writing | 2 | 0 | 0 | 0 | - |
| 2. | 24AC202 | Disaster Management | 2 | 0 | 0 | 0 | - |
| 3. | 24AC203 | Constitution of India | 2 | 0 | 0 | 0 | - |
| **Professional Core Courses (PCC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24TE103 | Advanced Thermodynamics | PCC | 3 | 1 | 0 | 4 |
| 2. | 24TE104 | Advanced Fluid Mechanics | PCC | 3 | 0 | 0 | 3 |
| 3. | 24TE131 | Thermal Engineering Laboratory | PCC | 0 | 0 | 4 | 2 |
| 4. | 24TE201 | Instrumentation for Thermal Engineering | PCC | 3 | 0 | 0 | 3 |
| 5. | 24TE202 | Internal Combustion Engine Design | PCC | 3 | 0 | 0 | 3 |
| 6. | 24TE203 | Fuels, Combustion and Emission Control | PCC | 4 | 0 | 0 | 4 |
| 7. | 24TE231 | Thermal Systems Simulation Laboratory | PCC | 0 | 0 | 4 | 2 |
| 8. | 24TE301 | Design and Optimization of Thermal Energy Systems | PCC | 3 | 0 | 0 | 3 |
| **Professional Electives Courses (PEC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24TE111 | Aircraft and Jet Propulsion | PEC | 3 | 0 | 0 | 3 |
| 2. | 24TE112 | Hydrogen and Fuel Cell Technologies | PEC | 3 | 0 | 0 | 3 |
| 3. | 24TE113 | Energy Resources | PEC | 3 | 0 | 0 | 3 |
| 4. | 24TE114 | Advanced Internal Combustion Engines | PEC | 3 | 0 | 0 | 3 |
| 5. | 24TE115 | Cryogenic Engineering | PEC | 3 | 0 | 0 | 3 |
| 6. | 24TE116 | Refrigeration Systems | PEC | 3 | 0 | 0 | 3 |
| 7. | 24TE117 | Electronic Engine Management Systems | PEC | 3 | 0 | 0 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8. | 24TE118 | Cogeneration and Waste Heat Recovery Systems | PEC | 3 | 0 | 0 | 3 |
| **Open Electives Courses (OEC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24CI341 | Integrated Water Resources Management | OEC | 3 | 0 | 0 | 3 |
| 2. | 24CI342 | Water, Sanitation and Health | OEC | 3 | 0 | 0 | 3 |
| 3. | 24CI343 | Principles of Sustainable Development | OEC | 3 | 0 | 0 | 3 |
| 4. | 24CI344 | Environmental Impact Assessment | OEC | 3 | 0 | 0 | 3 |
| 5. | 24CP311 | Block-chain Technologies | OEC | 3 | 0 | 0 | 3 |
| 6. | 24CP310 | Deep Learning | OEC | 3 | 0 | 0 | 3 |
| 7. | 24CI345 | Sustainable Management | OEC | 3 | 0 | 0 | 3 |
| 8. | 24IS 341 | Micro and Small Business Management | OEC | 3 | 0 | 0 | 3 |
| 9. | 24IS 343 | Intellectual Property Rights | OEC | 3 | 0 | 0 | 3 |
| 10. | 24IS 344 | Ethical Management | OEC | 3 | 0 | 0 | 3 |
| 11. | 24EM341 | IoT for Smart Systems | OEC | 3 | 0 | 0 | 3 |
| 12. | 24EM342 | Machine Learning and Deep Learning | OEC | 3 | 0 | 0 | 3 |
| 13. | 24CP 301 | Renewable Energy Technology | OEC | 3 | 0 | 0 | 3 |
| 14. | 24CP 206 | Smart Grid | OEC | 3 | 0 | 0 | 3 |
| 15. | 24TE 344 | Security Practices | OEC | 3 | 0 | 0 | 3 |
| 16. | 24CP 341 | Cloud Computing Technologies | OEC | 3 | 0 | 0 | 3 |
| 17. | 24CP 342 | Design Thinking | OEC | 3 | 0 | 0 | 3 |
| 18. | 24CM341 | Principles of Multimedia | OEC | 3 | 0 | 0 | 3 |
| 19. | 24EM343 | Big Data Analytics | OEC | 3 | 0 | 0 | 3 |
| 20. | 24CI 346 | Internet of Things and Cloud | OEC | 3 | 0 | 0 | 3 |
| 21. | 24TE 345 | Medical Robotics | OEC | 3 | 0 | 0 | 3 |
| 22. | 24TE 346 | Embedded Automation | OEC | 3 | 0 | 0 | 3 |
| 23. | 24CI 346 | Environmental Sustainability | OEC | 3 | 0 | 0 | 3 |
| 24. | 24CI 342 | Textile Reinforced Composites | OEC | 3 | 0 | 0 | 3 |
| 25. | 24CI 343 | Nano-composite Materials | OEC | 3 | 0 | 0 | 3 |
| **Employability Enhancement Courses (EEC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24TE251 | Technical Seminar – I | EEC | 0 | 0 | 2 | 1 |
| 2. | 24TE351 | Technical Seminar – II | EEC | 0 | 0 | 2 | 1 |
| 3. | 24TE352 | Project Work - I | EEC | 0 | 0 | 12 | 6 |
| 4. | 24TE451 | Project Work - II | EEC | 0 | 0 | 24 | 12 |

Recommended Courses for I SEMESTER

| S. No. | Course Code | Course Title | Course Category | L | T | P | C |
|---|---|---|---|---|---|---|---|
| **FUNDAMENTAL COURSES** | | | | | | | |
| 1. | 24TE101 | Advanced Numerical Methods | FC | 4 | 0 | 0 | 4 |
| 2. | 24TE102 | Advanced Heat Transfer | FC | 4 | 0 | 0 | 4 |
| **PROFESSIONAL CORE COURSES** | | | | | | | |
| 3. | 24TE103 | Advanced Thermodynamics | PCC | 3 | 1 | 0 | 4 |
| 4. | 24TE104 | Advanced Fluid Mechanics | PCC | 3 | 0 | 0 | 3 |
| **RESEARCH METHODOLOGY AND IPR COURSES** | | | | | | | |
| 5. | 24RM101 | Research Methodology and IPR | RMC | 2 | 0 | 0 | 2 |
| **PROFESSIONAL ELECTIVE COURSES** | | | | | | | |
| 6. | 24TE11X | Professional Elective - I | PEC | 3 | 0 | 0 | 3 |
| 7. | 24TE11X | Professional Elective - II | PEC | 3 | 0 | 0 | 3 |
| **AUDIT COURSES** | | | | | | | |
| 8. | 24AC2XX | Audit Course I* | AC | 2 | 0 | 0 | 0 |
| **PROFESSIONAL CORE COURSES** | | | | | | | |
| 9. | 24TE131 | Thermal Engineering Laboratory | PCC | 0 | 0 | 4 | 2 |
| | | TOTAL | | 24 | 1 | 4 | 25 |

Recommended Courses for II SEMESTER

| S. No. | Course Code | Course Title | Course Category | L | T | P | C |
|---|---|---|---|---|---|---|---|
| **PROFESSIONAL CORE COURSES** | | | | | | | |
| 1. | 24TE201 | Instrumentation for Thermal Engineering | PCC | 3 | 0 | 0 | 3 |
| 2. | 24TE202 | Internal Combustion Engine Design | PCC | 3 | 0 | 0 | 3 |
| 3. | 24TE203 | Fuels, Combustion and Emission | PCC | 4 | 0 | 0 | 4 |
| **PROFESSIONAL ELECTIVE COURSES** | | | | | | | |
| 4. | 24TE21X | Professional Elective - III | PEC | 3 | 0 | 0 | 3 |
| 5. | 24TE21X | Professional Elective – IV | PEC | 3 | 0 | 0 | 3 |
| 6. | 24TE21X | Professional Elective - V | PEC | 3 | 0 | 0 | 3 |
| **AUDIT COURSES** | | | | | | | |
| 7. | 24AC2XX | Audit Course II* | AC | 2 | 0 | 0 | 0 |
| **PROFESSIONAL CORE COURSES** | | | | | | | |
| 8. | 24TE231 | Thermal Systems Simulation Laboratory | PCC | 0 | 0 | 4 | 2 |
| **EMPLOYABILITY ENHANCEMENT COURSES** | | | | | | | |
| 9. | 24TE251 | Technical Seminar – I | EEC | 0 | 0 | 2 | 1 |
| | | TOTAL | | 21 | 0 | 6 | 22 |

| Course Code: | 24TE101 | Course Title: | Advanced Numerical Methods |
|---|---|---|---|
| Credits: | 4 | L – T – P | 4-0-0 |

**Course objectives:**

To impart knowledge on the

- To study various numerical techniques to solve linear and non-linear algebraic and transcendental equations.
- To compare ordinary differential equations by finite difference and collocation methods.
- To establish finite difference methods to solve Parabolic and hyperbolic equations.
- To establish finite difference method to solve elliptic partial differential equations.
- To provide basic knowledge in finite elements method in solving partial differential equations.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – Algebraic Equations | [12 hours] |
|---|---|

Systems of linear equations : Gauss elimination method – Pivoting techniques – Thomas algorithm for tri diagonal system – Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence - Systems of nonlinear equations : Fixed point iterations, Newton's method, Eigenvalue problems : Power method and Given’s method.

| UNIT II – Ordinary Differential Equations | [12 hours] |
|---|---|

Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method, Shooting method, BVP: Finite difference method, Collocation method and orthogonal collocation method.

| **UNIT III – Finite Difference Method for Time Dependent Partial Differential Equations** | **[12 hours]** |
|---|---|
| Parabolic equations: Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – ADI method: First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation: Explicit scheme – Stability. | |
| **UNIT IV – Finite Difference Methods for Elliptic Equations** | **[12 hours]** |
| Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet's and Neumann conditions – Laplace equation in polar coordinates: Finite difference schemes – Approximation of derivatives near a curved boundary while using a square mesh. | |
| **UNIT V – Finite Element Method** | **[12 hours]** |
| Basics of finite element method: Weak formulation, Weighted residual method – Shape functions for linear and triangular element – Finite element method for two point boundary value problems, Laplace and Poisson equations. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method. | **K3** |
| **CO2** | Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods. | **K3** |
| **CO3** | Solving parabolic and hyperbolic partial differential equations by finite difference methods. | **K3** |
| **CO4** | Compute solution of elliptic partial differential equations by finite difference methods. | **K3** |
| **CO5** | Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved, accuracy requirements and available computational resources. | **K3** |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 3 | 2 | 1 |
| **CO2** | 3 | 3 | 2 |
| **CO3** | 3 | 2 | 1 |
| **CO4** | 3 | 3 | 2 |
| **CO5** | 3 | 2 | 1 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9th Edition, Cengage Learning, New Delhi, 2016.
2. Gupta S.K., "Numerical Methods for Engineers",4th Edition, New Age Publishers, 2019.
3. Jain M. K., Iyengar S. R., Kanchi M. B., Jain, "Computational Methods for Partial Differential Equations", New Age Publishers ,1993.
4. Sastry, S.S., "Introductory Methods of Numerical Analysis", 5th Edition, PHI Learning, 2015.
5. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
6. Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.

**Web Links and Video Lectures (E-Resources):**

1. Runge - Kutta methods for system of IVPs: https://onlinecourses.nptel.ac.in/noc21_ge26/preview
2. Weighted average approximation: https://onlinecourses.nptel.ac.in/noc24_cs97/preview
3. Two dimensional parabolic equations: https://onlinecourses.nptel.ac.in/noc22_ma72/preview
4. Dirichlet's and Neumann conditions: https://onlinecourses.nptel.ac.in/noc20_ee04/preview

**Suggested Skill Activities:**

1. List some common methods for tridiagonal systems.
2. Problem solving in computational fluid dynamics for one dimension.
3. Problem solving in computational fluid dynamics for two dimension.
4. Solving heat transfer problems using finite element method.

| Course Code: | 24TE102 | Course Title: | Advanced Heat Transfer |
|---|---|---|---|
| Credits: | 4 | L – T – P | 4-0-0 |

**Course objectives:**

To impart knowledge on the

- To impart knowledge on conduction heat transfer associated with radiation.
- To impart knowledge on the turbulent forced convective heat transfer.
- To impart knowledge on the significance of Phase Change Heat Transfer and Mass
- Transfer.
- To teach the heat exchanger design aspects including compact heat exchangers.
- To impart knowledge on Mass transfer as an engineering phenomenon.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – Conduction and Radiation Heat Transfer | [12 hours] |
|---|---|

One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer- various pin profiles- pin optimization - transient conduction-- conduction with moving boundaries - radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection

| UNIT II – Turbulent Forced Convective Heat Transfer | [12 hours] |
|---|---|

Momentum and energy equations - turbulent boundary layer heat transfer - mixing length concept - turbulence model – k Є model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows.

| UNIT III – Phase Change Heat Transfer and Heat Exchanger | [12 hours] |
|---|---|
| Condensation on bank of tubes - boiling – pool and flow boiling - heat Transfer Enhancement Techniques. | |
| **UNIT IV – Heat Exchangers** | **[12 hours]** |
| Heat Exchanger – Є- NTU approach and design procedure – compact heat exchangers – Plate heat exchangers– Mini and Micro Channel heat exchangers, Heat transfer correlations for specific cases. | |
| **UNIT V – Mass Transfer** | **[12 hours]** |
| Mass transfer - vaporization of droplets - combined heat and mass transfers applications – Cooling Towers, Evaporative condensers, solar pond, Cooling and dehumidification systems – porous media heat transfer | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Apply the problems on heat transfer associated with conduction and convection and radiation through vapours and gases. | **K3** |
| **CO2** | Solve the problems on turbulent heat transfer and also solve high speed flow problems. | **K3** |
| **CO3** | Apply the problems on phase change heat transfer. | **K3** |
| **CO4** | Estimate the performance of compact heat exchangers and also understand the use of correlations to predict heat transfer from specific devices | **K2** |
| **CO5** | Illustrate and predict the mass transfer associated with heat transfer in engineering systems | **K3** |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 2 | 1 | 3 |
| **CO2** | 2 | 2 | 3 |
| **CO3** | 2 | 1 | 3 |
| **CO4** | 2 | 2 | 3 |
| **CO5** | 2 | 2 | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004.
2. Holman.J.P., Heat Transfer, Tata Mc Graw Hill, 2002.
3. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
4. Nag.P.K., Heat Transfer, Tata McGraw-Hill, 2002.
5. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985.
6. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.
7. Yunus A.Cengal., Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.

**Web Links and Video Lectures (E-Resources):**

1. Conduction and Radiation Heat Transfer: https://onlinecourses.nptel.ac.in/noc20_ch12/preview
2. Turbulent Forced Convective Heat Transfer: https://onlinecourses.nptel.ac.in/noc20_ch12/preview
3. Phase Change Heat Transfer and Heat Exchanger: https://onlinecourses.nptel.ac.in/noc20_ch12/preview
4. Heat Exchangers: https://onlinecourses.nptel.ac.in/noc20_ch12/preview
5. Mass Transfer: https://onlinecourses.nptel.ac.in/noc20_ch12/preview

**Suggested Skill Activities:**

1. Analyzing Multi-dimensional Transient heat conduction problems using a software.
2. Analyzing One-dimensional Transient heat conduction problems using a software.
3. Analysis of fin heat conduction problems.
4. Compare between shell and tube heat exchanger and parallel flow heat exchanger.

| Course Code: | 24TE103 | Course Title: | Advanced Thermodynamics |
|---|---|---|---|
| Credits: | 4 | L – T – P | 3-1-0 |

**Course objectives:**

To impart knowledge on the

- To achieve an understanding of basic principle and scope of thermodynamics.
- To predict the availability and irreversibility associated with the thermodynamic processes.
- To analyse the properties of ideal and real gas mixtures and to understand the basic concepts of thermal systems

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – Thermodynamic Property Relations | [12 hours] |
|---|---|

Thermodynamic Potentials, Maxwell relations, Generalised relations for changes in Entropy, Internal Energy and Enthalpy, Generalised Relations for Cp and Cv, Clausius Clapeyron Equation, Joule Thomson Coefficient, Bridgeman Tables for Thermodynamic Relations.

| UNIT II – Real Gas Behavior and Multi-Component Systems | [12 hours] |
|---|---|

Equations of State (mention three equations), Fugacity, Compressibility, Principle of Corresponding States, and use of generalised charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kesler generalised three parameter tables. Fundamental property relations for systems of variable composition, partial molar properties, Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi-phase systems, Gibb's phase rule for non-reactive components.

| UNIT III – Availability Analysis | [12 hours] |
|---|---|
| Introduction, Reversible work, Availability, Irreversibility and Second - Law Efficiency for a closed System and Steady-State Control Volume. Availability Analysis of Simple Cycles. Chemical availability of closed and control volume. Fuel Chemical availability, Evaluation of the availability of hydrocarbon fuels. | |
| **UNIT IV – Fuel - Air Cycles and Their Analysis** | **[12 hours]** |
| Ideal Models of Engine Processes, Fuel–Air Cycle Analysis – SI Engine Cycle Simulation, CI Engine Cycle Simulation, Results of Cycle Calculations, Availability Analysis of Engine Processes – Availability Relationships – Entropy changes in Ideal Cycles – Availability Analysis of Ideal Cycles. | |
| **UNIT V – Thermo Chemistry** | **[12 hours]** |
| Ideal gas laws and properties of Mixtures, Combustion Stoichiometry, Application of First Law of Thermodynamics – Heat of Reaction – Enthalpy of Formation – Adiabatic flame temperature. Second law of Thermodynamics applied to combustion – entropy, maximum work and efficiency Chemical equilibrium: - Equilibrium constant evaluation Kp & Kf, Equilibrium composition evaluation of ideal gas and real gas mixtures. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Apply the law of thermodynamics to thermal systems. | **K3** |
| **CO2** | Solve the actual thermodynamic cycles | **K3** |
| **CO3** | Develop a multi component thermodynamic system | **K3** |
| **CO4** | Apply the thermodynamics concepts in automotive systems | **K3** |
| **CO5** | Illustrate and analyse the combustion of different fuels | **K3** |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 2 | - | 3 |
| **CO2** | 2 | 1 | 3 |
| **CO3** | 2 | - | 3 |
| **CO4** | 2 | 1 | 3 |
| **CO5** | 2 | 1 | 3 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Kenneth Wark., J.R, Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.
2. K.Annamalai, I.K.Puri, M.A.Jog, Advanced Thermodynamics Engineering, Second Edition, CRC Press, 2011.
3. Advanced Thermodynamics, S.S. Thipse, Narosa Publishing Home Pvt. Ltd., 2013
4. Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006.
5. B.P. Pundir, I.C. engine combustion and emissions. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
6. Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.

**Web Links and Video Lectures (E-Resources):**

1. Thermodynamic Property Relations: https://onlinecourses.nptel.ac.in/noc22_me113/preview
2. Real Gas Behavior and Multi-Component Systems: https://onlinecourses.nptel.ac.in/noc22_me113/preview
3. Availability Analysis: https://onlinecourses.nptel.ac.in/noc22_me113/preview
4. Fuel - Air Cycles and Their Analysis: https://onlinecourses.nptel.ac.in/noc22_me113/preview
5. Thermo Chemistry: https://onlinecourses.nptel.ac.in/noc22_me113/preview

**Suggested Skill Activities:**

1. Describe the correlation between various properties of a thermodynamic system, such as temperature, pressure, volume, internal energy, enthalpy and entropy.
2. Application of modified ideal gas equation to real gas.
3. Energy based optimization for various thermodynamical systems.
4. Experimental investigation of engines performance for modified fueled engines.

| Course Code: | 24TE104 | Course Title: | Advanced Fluid Mechanics |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To understand the laws of fluid flow for ideal and viscous fluids.
- To represent the real solid shapes by suitable flow patterns and to analyze the same for aerodynamics performances.
- To understand the changes in properties in compressible flow and shock expansion.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – Basic Equations of Flow | [9 hours] |
|---|---|

Three dimensional continuity equation - differential and integral forms – equations of motion momentum and energy - Reynolds transport theorem – Navier – Stokes equation – Engineering Applications

| UNIT II – Potential Flow Theory | [9 hours] |
|---|---|

Rotational and irrorational flows - circulation – vorticity - stream and potential functions for standard flows and combined flows – representation of solid bodies by flow patterns. Pressure distribution over stationery and rotating cylinders in a uniform flow - Magnus effect - Kutta –Zhukov sky theorem. Complex potential functions. Conformal transformation to analyze the flow over flat plate, cylinder, oval body and airfoils. Thin airfoil theory – generalized airfoil theory for cambered and flapped airfoils.

| UNIT III – Viscous Flow Theory | [9 hours] |
|---|---|

Laminar and turbulent flow - laminar flow between parallel plates - Poiseuille's equation for flow through circular pipes. Turbulent flow - Darcy Weisbach equation for flow through

| | |
|---|---|
| circular pipe - friction factor - smooth and rough pipes - Moody diagram – losses during flow through pipes. Pipes in series and parallel – transmission of power through pipes. | |
| **UNIT IV – Boundary Layer Concept** | **[9 hours]** |
| Boundary Layer - displacement and momentum thickness - laminar and turbulent boundary layers in flat plates - velocity distribution in turbulent flows in smooth and rough boundaries - laminar sub layer. | |
| **UNIT V – Compressible Fluid Flow** | **[9 hours]** |
| One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – fundamentals of supersonics – normal and oblique shock waves and calculation of flow and fluid properties over solid bodies (like flat plate, wedge, diamond) using gas tables | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Illustrate the basic equations of flow. | **K3** |
| **CO2** | Identify the flow over flat plate, cylinder, oval body and airfoils. | **K3** |
| **CO3** | Classify the various losses during flow through pipes. | **K3** |
| **CO4** | Illustrate the boundary layer concept in flat plate. | **K3** |
| **CO5** | Interpretation of flow and fluid properties of compressed gases. | **K3** |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 3 | - | 3 |
| **CO2** | 3 | - | 3 |
| **CO3** | 2 | - | 3 |
| **CO4** | 3 | - | 2 |
| **CO5** | 2 | - | 3 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Anderson J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.
2. Bansal R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.
3. Houghten E.L. and Carruthers N.B., Aerodynamics for Engineering Students, Arnold Publishers, 1993.

4. Kumar K.L., Engineering Fluid Mechanics, Eurasia Publishing House, New Delhi, 2002.
5. Munson B.R., Young D.F. and Okiisi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc., NewYork, 1990.
6. Schlichting H., Boundary layer theory, Mc Graw Hill Book Company, 1979
7. Shames, Mechanics of Fluids, Mc Graw Hill Book Company, 1962.
8. Streeter V.L., Wylie E.B. and Bedford K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.

**Web Links and Video Lectures (E-Resources):**

1. Basic Equations of Flow: https://onlinecourses.nptel.ac.in/noc22_me102/preview
2. Potential Flow Theory: https://onlinecourses.nptel.ac.in/noc22_me102/preview
3. Viscous Flow Theory: https://onlinecourses.nptel.ac.in/noc22_me102/preview
4. Boundary Layer Concept: https://onlinecourses.nptel.ac.in/noc22_me102/preview
5. Compressible Fluid Flow: https://onlinecourses.nptel.ac.in/noc22_me102/preview

**Suggested Skill Activities:**

1. Surface pressure distribution on a two-dimensional symmetric airfoil at different angles of incidence at low speeds.
2. Smoke flow visualization studies on a two dimensional multi-element airfoil with flaps and slats at different angles of incidence at low speeds.
3. Energy losses in pipe fittings

| Course Code: | 24RM101 | Course Title: | Research Methodology And IPR |
|---|---|---|---|
| Credits: | 2 | L – T – P | 2-0-0 |

**Course objectives:**

To impart knowledge on the

- To study various research process and design
- To prepare and explore various data collection methods and sources
- To study about various research data analyzing techniques and reporting formats
- To study the various practices involved in Intellectual Property Rights
- To study about the registration of Patent

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. NPTEL and Other Videos
3. Smart Class Room
4. Flipped Class
5. Technical Seminar
6. Poster Presentation

| UNIT I – Research Design | [6 hours] |
|---|---|
| Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. | |
| **UNIT II – Data Collection and Sources** | **[6 hours]** |
| Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods.<br>Data - Preparing, Exploring, examining and displaying | |
| **UNIT III – Data Analysis and Reporting** | **[6 hours]** |
| Overview of Multivariate analysis, Hypotheses testing and Measures of Association.<br>Presenting Insights and findings using written reports and oral presentation. | |

| UNIT IV – Intellectual Property Rights | [6 hours] |
|---|---|
| Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance. | |

| UNIT V – Patents | [6 hours] |
|---|---|
| Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Formulate research problem | **K6** |
| **CO2** | Analyze literature review and find research gaps to finalize research objectives | **K4** |
| **CO3** | Identify the need of ethics in research | **K3** |
| **CO4** | Identify the need of IPR of research projects for economic growth and social benefits | **K3** |
| **CO5** | Apply their research work for patent through IPR | **K3** |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **-** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **2** | **2** | **-** |
| **CO4** | **3** | 1 | **-** |
| **CO5** | **3** | **2** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 60 | 100 | 40 |
| | CIE – II | 100 | | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 10 | 10 | 10 |
| **Understand** | 20 | 30 | 20 |
| **Apply** | 30 | 40 | 40 |
| **Analyze** | 10 | 10 | 10 |
| **Evaluate** | 10 | 10 | 10 |
| **Create** | 20 | - | 10 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007
3. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

**Web Links and Video Lectures (E-Resources):**

1. https://onlinecourses.nptel.ac.in/noc23_ge36/preview

**Suggested Skill Activities:**

1. Developing a Research Plan
2. Data Collection Analysis for a defined problem
3. Poster preparation
4. Thesis Report Writing
5. Case studies using patent database

| Course Code: | 24TE131 | Course Title: | Thermal Engineering Laboratory |
|---|---|---|---|
| Credits: | 2 | L – T – P | 0-0-4 |

**Course objectives:**

To impart knowledge on the

- To conduct experiments on various Thermal Engineering devices to study the performance and its applications.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Experimental Learning

| List of Experiments | [60 hours] |
|---|---|

1. Performance and emission characteristics of multi cylinder Spark Ignition and Compression Ignition engines using alternate fuels.
2. Thermal performance of variable compression ratio engines.
3. Thermal analysis of natural / forced draught cooling towers.
4. Thermal analysis of heat pumps systems.
5. Experimental studies on vapour compression refrigeration systems using natural refrigerants
6. Overall performance of solar water heating system.
7. Physical, Chemical and thermal Properties of any liquid and gas fuels.
8. Experimental analysis of a Boiler.
9. Calibration of Temperature sensors (RTD / any thermocouple)
10. Calibration of Pressure sensors
11. Experimental studies on axial / centrifugal fan characteristics

| List of Equipment | Quantity |
|---|---|
| Single cylinder / multi cylinder Automotive Engine with data acquisition system | 1 |
| Flue gas analyzer | 1 |
| Smoke meter | 1 |
| Single cylinder variable Compression ratio petrol engine | 1 |
| Single cylinder variable Compression ratio Diesel engine | 1 |
| Cooling tower test rig | 1 |
| Refrigeration cum Heat Pump test rig | 1 |
| 100 LPD Solar flat plate water heater test rig | 1 |
| Pyranometer | 1 |
| Redwood / Saybolt viscometer | 1 |
| Bomb calorimeter apparatus | 1 |
| Gas calorimeter | 1 |
| Cloud & Pour point apparatus | 1 |
| IBR / Non-IBR Boiler test rig | 1 |
| Fan test rig | 1 |
| Pressure Calibrator | 1 |
| Temperature Calibrator | 1 |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Know the various alternate fuels are available for IC engines | K1 |
| **CO2** | Demonstrate with the thermodynamic relations for thermal engineering devices. | K2 |
| **CO3** | Apply the working principle of different renewable energy sources for energy applications. | K3 |
| **CO4** | Select the properties of different fuels | K3 |
| **CO5** | Experiment with refrigeration and air conditioning system | K3 |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 3 | - | 2 |
| **CO2** | 3 | - | 2 |
| **CO3** | 2 | - | 2 |
| **CO4** | 2 | - | 3 |
| **CO5** | 2 | - | 3 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | Continuous Assessment | 75 | 75 | 100 | 60 |
| | Model Lab Exam | 25 | 25 | | |
| End Semester Examination (ESE) | Lab Exam | 100 | 40 | 40 | 40 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

| Course Code: | 24TE201 | Course Title: | Instrumentation for Thermal Engineering |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

- To impart knowledge on the
- To classify various measuring instruments.
- To categories temperature sensors and their applications in measurement.
- To outline the advancements in pressure and volume measurements.
- To explore the various measurement techniques for thermos physical properties.
- To compare the different data acquisition systems.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – Measurement Characteristics | [9 hours] |
|---|---|

Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments

| UNIT II – Temperature Measurement | [9 hours] |
|---|---|

Temperature, Types, materials, Accuracy - Selection of Temperature sensors - Effect of length of sensor on temperature measurements- calibration of thermocouple, RTD's & Thermistors- Standards for temperature measurement - Cryogenic & High Temperature measurement techniques.

| UNIT III – Pressure Flow & Volume Measurements | [9 hours] |
|---|---|

Pressure Sensors: Types & materials - piezoelectric transducers- calibration of pressure sensors-selection of pipes & fittings for pressure sensors. Volume sensors: Standard

| | |
|---|---|
| volumetric flask- Types, Density measurement instruments for liquids & gases. Flow Sensors: Caroli's mass flow measurements - flow measurements for water, gases, other oils & other chemicals. | |
| **UNIT IV – Measurement of Thermo Physical Properties** | **[9 hours]** |
| Thermal Conductivity measurement of solids - liquids & gases- Sensors & calibration methods- Thermal conductivity of microbar nano composites - Specific heat of liquids, solids through DSC Analysis - viscosity measurement of Newtonian & non-Newtonian fluids through rheological analysis | |
| **UNIT V – Data Acquisition System** | **[9 hours]** |
| Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries - SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA/HMI Systems Various SCADA architectures. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Infer the role of uncertainty analysis in measuring instruments. | K2 |
| **CO2** | Select the appropriate temperature sensors based on specific applications. | K3 |
| **CO3** | Identify the suitable sensors for pressure and volume measurements. | K3 |
| **CO4** | Interpret the thermos physical properties of media. | K2 |
| **CO5** | Utilize the data acquisition systems in Thermal Systems. | K3 |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | 1 | - |
| **CO2** | 2 | - | 2 |
| **CO3** | 2 | - | 2 |
| **CO4** | 2 | - | 2 |
| **CO5** | 2 | - | 1 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**


1. Holman J.P., Experimental methods for engineers, McGraw-Hill, 2012.
2. Barnery, Intelligent Instrumentation, Prentice Hall of India, 2010.
3. Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.
4. John G Webster, The measurement, Instrumentation and sensors Handbook, CRC and IEE Press, 2014.
5. Morris A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 2004.
6. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, New Delhi, 2nd Edition 2003.
7. T.G.Beekwith R.D., Marangoni and J.H. Lienhard, Mechanical Measurements, Pearson Education, 2001


**Web Links and Video Lectures (E-Resources):**

1. Measurement Characteristics: https://onlinecourses.nptel.ac.in/noc23_ee105/preview
2. Temperature Measurement: https://onlinecourses.nptel.ac.in/noc23_ee105/preview
3. Pressure Flow & Volume Measurements: https://onlinecourses.nptel.ac.in/noc23_ee105/preview
4. Measurement of Thermo Physical Properties: https://onlinecourses.nptel.ac.in/noc23_ee105/preview
5. Data Acquisition System: https://onlinecourses.nptel.ac.in/noc23_ee105/preview

**Suggested Skill Activities:**

1. Monitoring the sensors in electronic injection system in an engine.
2. Monitoring the sensors in electronic ignition system in an engine.
3. Monitoring the sensors in engine lubrication system.
4. Monitoring the sensors in engine cooling system.

| Course Code: | 24TE202 | Course Title: | Internal Combustion Engine Design |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

- To provide the basic grounding on the piston engine design philosophy

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – Generalia | [5 hours] |
|---|---|
| Principle of similitude, Choice of material, Stress, Fatigue and Noise, Vibration and Harshness considerations (NVH) | |
| **UNIT II – Design of Major Components** | **[12 hours]** |
| Piston system, Power cylinder system, Connecting rod assembly, Crankshaft system, Valve Gearing, Stress analyses. | |
| **UNIT III – Design of Other Components / Subsystems** | **[12 hours]** |
| Inlet and exhaust manifolds, cylinder block, cylinder-head, crankcase. Design aspects of engine mountings, gaskets, bearings. Basics of ignition, lubrication and cooling system design. Introduction to design of catalytic converters, particulate traps and EGR systems. | |
| **UNIT IV – Design Specifics of Two-Stroke Engine Systems** | **[10 hours]** |
| Thermal Conductivity measurement of solids - liquids & gases- Sensors & calibration methods- Thermal conductivity of microbar nano composites - Specific heat of liquids, solids through DSC Analysis - viscosity measurement of Newtonian & non-Newtonian fluids through rheological analysis | |
| **UNIT V – Concepts of Computer Aided Design** | **[6 hours]** |
| Preparation of working drawings of designed components using CAD system. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Illustrate the principle of similitude, Choice of material, Stress, Fatigue and Noise, Vibration and Harshness considerations. | K2 |
| **CO2** | Summarize major components like Piston system, Power cylinder system, Connecting rod assembly, Crankshaft system, Valve Gearing, Stress analyses. | K2 |
| **CO3** | Develop the subsystems of engine components for ignition, lubrication and cooling system. | K3 |
| **CO4** | Demonstrate the specific parts of two-stroke engine system. | K2 |
| **CO5** | Apply the concept of CAD in IC engine components. | K3 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | 1 | - |
| **CO2** | 2 | - | 2 |
| **CO3** | 2 | - | 2 |
| **CO4** | 2 | - | 2 |
| **CO5** | 2 | - | 1 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| **Component** | **Type of assessment** | **Max Marks** | **Reduced Marks** | **Total** | **Final marks** |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**


1. An Introduction to Engine Testing and Development, Richard D. Atkids, SAE International, USA, 2009.
2. Design and Simulation of Four-Stroke Engines, Gordon P. Blair, Society of Automotive Engineers, Inc., USA, 1999.
3. Diesel Engine Reference Book, Second Edition, Rodica Baranescu and Bernard Challen (Editors), Society of Automotive Engineers, Inc., USA, 1999.
4. Engineering Design, A Systematic Approach, G. Pahl, W. Beltz J. Fieldhusen and K.H. Grote, Springer
5. Engineering Fundamentals of the Internal Combustion Engine, Willard W. Pulkrabek, Second Edition, Prentice – Hall of India Pvt. Ltd., New Delhi, 2006.
6. Internal Combustion Engine Design, A. Kolchin and V. Demidov, MIR Publishers, Moscow, 1984.
7. Internal Combustion Engine Fundamentals, John B. Heywood, McGraw – Hill Book Company, 1988.
8. Internal Combustion Engine Handbook: Basics, Components, Systems and Perpectives, Richard Van Basshuysen and Fred Schafer (Editors) SAE International USA and Siemes VDO Automotive, Germany, 2002.
9. Introduction to Engine Valve trains, Yushu Wang, SAE International, USA, 2007.
10. 1Introduction to Internal Combustion Engines, Richard Stone, Fourth Edition SAE International, USA and Macmillan Press, 2012.

11. Modern Engine Technology from A to Z, Richard Van Basshuysen and Fred Schafer, SAE International, USA and Siemens VDO, Germany, 2007.
12. Springer – Verlag, Wien, Austria, 2006.
13. Vehicular Engine Design, Kevin L. Hoag, SAE International USA.

**Web Links and Video Lectures (E-Resources):**

1. Internal Combustion Engine Design:
   https://onlinecourses.nptel.ac.in/noc22_me65/preview

**Suggested Skill Activities:**

1. Design major components like Piston system, Power cylinder system.
2. Design major components like Connecting rod assembly, Crankshaft system, Valve Gearing, Stress analyses.
3. Design subsystems of engine components.
4. Design of ignition, lubrication and cooling system.

| Course Code: | 24TE203 | Course Title: | Fuels, Combustion And Emission Control |
|---|---|---|---|
| Credits: | 4 | L – T – P | 4-0-0 |

**Course objectives:**

- To understand the types of fuels.
- To compare the fuels in specific point.
- To understand the principles of combustion and combustion equipment's.
- To understand the thermodynamic process behind the combustion.
- To identify the level of emission standards.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – Solid Fuels | [9 hours] |
|---|---|

Solid Fuel Types - Coal Family - Properties - Calorific Value - ROM, DMMF, DAF and Bone Dry Basis - Ranking - Bulk & Apparent Density - Storage - Washability - Coking & Caking Coals – Renewable Solid Fuels - Biomass - Wood Waste - Agro Fuels - Manufactured Solid Fuels.

| UNIT II – Liquid and Gaseous Fuels | [9 hours] |
|---|---|

Liquid Fuel Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc., - Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels. Gaseous Fuel Classification - Composition & Properties - Estimation of Calorific Value - Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas - Stripped NG -

| |
|---|
| Foul & Sweet NG - LPG - LNG - CNG - Methane - Producer Gas - Gasifiers - Water Gas - Town Gas - Coal Gasification - Gasification Efficiency - Non - Thermal Route - Biogas - Digesters - Reactions - Viability - Economics. |
| **UNIT III – Combustion: Stoichiometry & Kinetics** **[9 hours]** |
| Stoichiometry – Mass Basis & Volume Basis – Excess Air Calculation – Fuel & Flue Gas Compositions - Calculations – Rapid Methods – Combustion Processes – Stationary Flame – Surface or Flameless Combustion – Submerged Combustion – Pulsating & Slow Combustion Explosive Combustion. Mechanism of Combustion – Ignition & Ignition Energy – Spontaneous Combustion – Flame Propagation – Solid, Liquid & Gaseous Fuels Combustion – Flame Temperature – Theoretical, Adiabatic & Actual – Ignition Limits – Limits of Inflammability. Thermo Chemistry - Equilibrium combustion products. Low temperature combustion products – High temperature combustion products. |
| **UNIT IV – Combustion Equipments** **[9 hours]** |
| Coal Burning Equipments – Types – Pulverized Coal Firing – Fluidized Bed Firing – Fixed Bed & Recycled Bed – Cyclone Firing – Spreader Stokers – Vibrating Grate Stokers – Sprinkler Stokers, Traveling Grate Stokers. Oil Burners – Vaporizing Burners, Atomizing Burners – Design of Burners. Gas Burners – Atmospheric Gas Burners – Air Aspiration Gas Burners – Burners Classification according to Flame Structures – Factors Affecting Burners & Combustion. |
| **UNIT V – Emission Control Methods** **[9 hours]** |
| Emissions - Emission index - Corrected concentrations - Control of emissions for premixed and non-prefixed combustion. Flue gas Desulphurization, Coal Beneficiation, Coal Blending, Efficiency Improvement Methods (CO2 reduction) – Super critical boilers, Integrated Gasification Combined Cycle Power Plant, Carbon Capture & Storage (CCS) |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Identify to enable the fuels used for different purposes. | K3 |
| **CO2** | Select the fuels at different conditions. | K3 |
| **CO3** | Summarize the fuels and its combustion levels. | K2 |
| **CO4** | Select the correct Equipment's on combustion techniques. | K2 |
| **CO5** | Illustrate the emission control at a standard rate. | K2 |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 3 | - | 2 |
| **CO2** | 3 | - | 2 |
| **CO3** | 3 | - | 2 |
| **CO4** | - | - | 2 |
| **CO5** | 3 | - | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. B.I. Bhatt and S.M. Vora, Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 2010.
2. Blokh A.G., Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.
3. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966.
4. Holman J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.
5. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990.
6. Sharma SP., Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984.
7. Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006.

**Web Links and Video Lectures (E-Resources):**

1. Solid Fuels: https://onlinecourses.nptel.ac.in/noc24_ae09/preview
2. Liquid and Gaseous Fuels: https://archive.nptel.ac.in/courses/103/105/103105110/
3. Combustion: Stoichiometry & Kinetics: https://onlinecourses.nptel.ac.in/noc23_me27/preview
4. Combustion Equipments: https://onlinecourses.nptel.ac.in/noc23_me27/preview
5. Emission Control Methods: https://onlinecourses.nptel.ac.in/noc23_ce14/preview

**Suggested Skill Activities:**

1. Analyze various emission control equipments for solid fuels.
2. Analyze various emission control equipments for fossil fuels.
3. Analyze various emission control methods on automobiles.

| Course Code: | 24TE231 | Course Title: | Thermal Systems Simulation Laboratory |
|---|---|---|---|
| Credits: | 2 | L – T – P | 0-0-4 |

**Course objectives:**

To impart knowledge on the

- To learn the modeling and simulation analysis of various thermal engineering application using analysis software.
- To educate the students about calibration and its essentiality in thermal systems.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Experimental Learning

**DYNAMIC LINKING OF MAT LAB AND REF PROP SOFTWARE SIMPLE CFD PROBLEMS FOR PRACTICE**

**NOTE:** The above exercises are only guidelines to maintain the standard for teaching and conduct of examination.

| List of Experiments | [60 hours] |
|---|---|
| 1. Heat exchanger analysis – NTU method<br>2. Heat exchanger analysis – LMTD method<br>3. Convection heat transfer analysis – Velocity boundary layer.<br>4. Convection heat transfer analysis – Internal flow<br>5. Radiation heat transfer analysis – Emissivity<br>6. Critical radius of insulation<br>7. Lumped heat transfer analysis<br>8. Conduction heat transfer analysis<br>9. Condensation heat transfer analysis | |

| List of Equipment |
|---|
| Software - Modeling software like ProE, Gambit, Ansys, etc Analysis software like Ansys, fluent, CFX, etc. |
| Equation solving software like Matlab, Engg equation solver. |
| Every students in a batch must be provided with a terminal. |
| Hardwares are compatible with the requirement of the above software. |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain the basic concepts of ANSYS Software | K2 |
| **CO2** | Develop the thermal behavior of heat exchangers using ANSYS Software | K3 |
| **CO3** | Summarize the thermal deformation for conduction and convection heat transfer applications | K2 |
| **CO4** | Develop the thermal deformation for conduction and condensation heat transfer applications | K3 |
| **CO5** | Summarize the thermal deformation for lumped heat transfer applications | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 3 | 2 | 2 |
| **CO2** | 3 | 2 | 2 |
| **CO3** | 3 | 2 | 2 |
| **CO4** | 3 | 2 | 2 |
| **CO5** | 3 | 2 | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| **Component** | **Type of assessment** | **Max Marks** | **Reduced Marks** | **Total** | **Final marks** |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | Continuous Assessment | 75 | 75 | 100 | 60 |
| | Model Lab Exam | 25 | 25 | | |
| End Semester Examination (ESE) | Lab Exam | 100 | 40 | 40 | 40 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

PROFESSIONAL ELECTIVES SEMESTER I, (ELECTIVE I & II)

| S. No. | Course Code | Course Title | Course Category | L | T | P | C |
|---|---|---|---|---|---|---|---|
| **PROFESSIONAL ELECTIVE COURSES** | | | | | | | |
| 1. | 24TE111 | Aircraft and Jet Propulsion | PEC | 3 | 0 | 0 | 3 |
| 2. | 24TE112 | Hydrogen and Fuel Cell Technologies | PEC | 3 | 0 | 0 | 3 |
| 3. | 24TE113 | Energy Resources | PEC | 3 | 0 | 0 | 3 |
| 4. | 24TE114 | Advanced Internal Combustion Engines | PEC | 3 | 0 | 0 | 3 |
| 5. | 24TE115 | Cryogenic Engineering | PEC | 3 | 0 | 0 | 3 |
| 6. | 24TE116 | Refrigeration Systems | PEC | 3 | 0 | 0 | 3 |
| 7. | 24TE117 | Electronic Engine Management Systems | PEC | 3 | 0 | 0 | 3 |
| 8. | 24TE118 | Cogeneration and Waste Heat Recovery Systems | PEC | 3 | 0 | 0 | 3 |

| Course Code: | 24TE111 | Course Title: | Aircraft and Jet Propulsion |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To gain insight on the working principle of rocket engines, different feed systems, propellants and their properties and dynamics of rockets

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – GAS DYNAMICS | [8hours] |
|---|---|
| Wave motion - Compressible fluid flow through variable area devices – Stagnation state Mach Number and its influence and properties, Isentropic Flow, Rayleigh and Fanno Flow. Deflagration and Detonation – Normal shock and oblique shock waves | |
| **UNIT II – THERMODYNAMICS OF AIRCRAFT ENGINES** | **[9 hours]** |
| Theory of Aircraft propulsion – Thrust – Various efficiencies – Different propulsion systems – Turboprop – Ram Jet – Turbojet, Turbojet with after burner, Turbo fan and Turbo shaft. Variable thrust- nozzles – vector control. | |
| **UNIT III – PERFORMANCE CHARACTERISTICS OF AIRCRAFT ENGINES** | **[9 hours]** |
| Engine - Aircraft matching – Design of inlets and nozzles – Performance characteristics of Ramjet, Turbojet, Scramjet and Turbofan engines. | |

| UNIT IV – ROCKET PROPULSION | [9 hours] |
|---|---|
| Theory of rocket propulsion – Rocket equations – Escape and Orbital velocity – Multi-staging of Rockets – Space missions – Performance characteristics – Losses and efficiencies. | |
| **UNIT V – ROCKET THRUST CHAMBER** | **[10hours]** |
| Combustion in solid and liquid propellant classification – rockets of propellants and Propellant Injection systems – Non-equilibrium expansion and supersonic combustion – Propellant feed systems – Reaction Control Systems - Rocket heat transfer. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain the basics of Compressible fluid flow | K2 |
| **CO2** | Interpret the working principle of aircraft system | K2 |
| **CO3** | Solve the performance characteristics of air craft engines like Ramjet, Turbojet, Scramjet and Turbofan engines | K3 |
| **CO4** | Interpret the working principle of rocket propulsion systems | K2 |
| **CO5** | Explain the various propellant and combustion system used in rockets | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **-** | 2 |
| **CO2** | **2** | **-** | 2 |
| **CO3** | **2** | **-** | 2 |
| **CO4** | **2** | **-** | 2 |
| **CO5** | **2** | **-** | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped,
Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Bonney E.A., Zucrow N.J,. Principles of Guided Missile Design, Van Nostranc Co.,

1956.

2. Khajuria P.R. and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
3. Mattingly J.D., Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition, 1997.

**Reference Books:**

1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
2. S.M.Yahya, Fundamentals of Compressible Flow, Third edition, New Age International Pvt. Ltd, 2003.
3. Zucrow N.J., Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons, New York, 1970.
4. Zucrow N.J., Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc, New York, 1975.

**Web Links and Video Lectures (E-Resources):**

1. Compressible fluid flow through variable area devices:https://archive.nptel.ac.in/courses/101/108/101108086/
2. Aircraft propulsion: https://onlinecourses.nptel.ac.in/noc21_me95/preview
3. Aircraft Performance : https://archive.nptel.ac.in/courses/101/104/101104061/
4. Rocket propulsion: https://archive.nptel.ac.in/courses/101/106/101106082/
5. Fundamentals of supersonic and hyper sonic flow: https://onlinecourses.nptel.ac.in/noc24_ae12/preview

**Suggested Skill Activities:**

1. What type of gas flow occurs when the flow velocity is less than the speed of sound and disturbances propagate upstream?
2. What is the purpose of the dual ignition system on an aircraft?

| Course Code: | 24TE112 | Course Title: | HYDROGEN AND FUEL CELL TECHNOLOGIES |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To study in detail on the hydrogen production methodologies, possible applications and various storage options.
- To understand the working principle of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics.
- To study the cost effectiveness and eco-friendliness of Fuel Cells.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – HYDROGEN – BASICS AND PRODUCTION TECHNIQUES | [9hours] |
|---|---|
| Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water. | |
| **UNIT II – HYDROGEN STORAGE AND APPLICATIONS** | **[9 hours]** |
| Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Safety and management of hydrogen. Applications of Hydrogen | |
| **UNIT III FUEL CELLS** | **[9 hours]** |
| History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell. | |
| **UNIT IV – FUEL CELL – TYPES** | **[9 hours]** |

| |
|---|
| Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits. |

| UNIT V–APPLICATION OF FUEL CELL AND ECONOMICS | [9hours] |
|---|---|
| Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Classify the basics of fuel cells | K2 |
| **CO2** | Explain the working principles of Hydrogen storage technologies | K2 |
| **CO3** | Infer the working principles of fuel cells | K2 |
| **CO4** | Interpret the merits and demerits of various types of fuel cells | K2 |
| **CO5** | Illustrate the application of fuel cells and its economics | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | - |
| **CO2** | **2** | **1** | - |
| **CO3** | **2** | **1** | - |
| **CO4** | **2** | **1** | - |
| **CO5** | **2** | **1** | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.
2. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
3. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005.

**Reference Books:**

1. Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
2. Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989.
3. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.
4. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.

**Web Links and Video Lectures (E-Resources):**

1. Introduction about hydrogen energy :

   https://archive.nptel.ac.in/courses/103/101/103101215/

2. Hydrogen Energy: Production, Storage

   :https://onlinecourses.nptel.ac.in/noc22_ch66/

3. Introduction about fuel cell https://www.youtube.com/watch?v=L2VSOccUrSk
4. Fuel cell technology https://archive.nptel.ac.in/courses/103/102/103102015/
5. Fuel cell application https://www.youtube.com/watch?v=62363H_I_Qk

**Suggested Skill Activities:**

1. What are two common ways to produce hydrogen today?
2. How do fuel cells generate electricity from hydrogen?
3. How do you boost the amount of electricity a fuel cell system produces?
4. When hydrogen is used in a fuel cell to create electricity, what is emitted?

| Course Code: | 24TE113 | Course Title: | ENERGY RESOURCES |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To explain concept of various forms of Non-renewable and renewable energy.
- To outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
- To study the environmental and cost economics of using renewable energy sources compared to fossil fuels.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – COMMERCIAL ENERGY | [9hours] |
|---|---|

Coal, Oil, Natural gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India

| UNIT II – SOLAR ENERGY | [9 hours] |
|---|---|

Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells – Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

| UNIT III – WIND ENERGY | [9 hours] |
|---|---|
| Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection – wind energy conversion devices - classification, characteristics, applications – offshore wind energy - Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept | |
| **UNIT IV – BIO-ENERGY** | **[9 hours]** |
| Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction – biochemical conversion - anaerobic digestion - types of biogas Plant - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India. | |
| **UNIT V – OTHER TYPES OF ENERGY** | **[9hours]** |
| Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plant - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plant – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Outline the commercial energy and renewable energy sources. | K2 |
| **CO2** | Explain the working principle of Solar energy systems | K2 |
| **CO3** | Explain the working principle of Wind energy systems | K2 |
| **CO4** | Explain the working principle of Bio energy systems | K2 |
| **CO5** | Explain the working principle of other energy systems | K2 |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **-** | 2 |
| **CO2** | **2** | **-** | 2 |
| **CO3** | **2** | **-** | 2 |
| **CO4** | **2** | **-** | 2 |
| **CO5** | **2** | **-** | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**


1. Sukhatme S.P., "Solar Energy", Tata McGraw Hill, 1984.
2. Twidell J.W. and Weir A., "Renewable Energy Sources", EFN Spon Ltd., 1986.
3. Kishore V.V.N., "Renewable Energy Engineering and Technology", Teri Press, New Delhi, 2012
4. Peter Gevorkian, "Sustainable Energy Systems Engineering," McGraw Hill, 2007.
5. Kreith F. and Kreider J.F., "Principles of Solar Engineering", McGraw-Hill, 1978.


**Reference Books:**


1. Godfrey Boyle, "Renewable Energy Power for a Sustainable Future", Oxford University Press, U.K, 1996.
2. Veziroglu T.N., Alternative Energy Sources", Vol 5 and 6, McGraw-Hill, 1990.
3. Anthony San Pietro, "Biochemical and Photosynthetic aspects of Energy Production", Academic Press, 1980.
4. Bridgurater A.V., "Thermochemical processing of Biomass", Academic Press, 1981.
5. Bent Sorensen, "Renewable Energy", Elsevier, Academic Press, 2011.


**Web Links and Video Lectures (E-Resources):**

1. **COMMERCIAL ENERGY** https://archive.nptel.ac.in/courses/103/107/103107157/
2. Solar energyhttps://onlinecourses.nptel.ac.in/noc20_ph14/
3. Wind energy https://archive.nptel.ac.in/courses/103/103/103103206/
4. Bio energy https://onlinecourses.nptel.ac.in/noc19_bt16/preview
5. Ocean and other thermal energy https://www.youtube.com/watch?v=DD0Y6Snxpdk

**Suggested Skill Activities:**

1. What happens during the process nuclear fission?
2. Why is nuclear energy nonrenewable?
3. What can solar cells be used in?
4. What are the Advantages of Fossil Fuels

| Course Code: | 24TE114 | Course Title: | ADVANCED INTERNAL COMBUSTION ENGINES |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To gain insight on the working principle of spark ignition engines and compression ignition engines.
- To study the pollutant formation and its control in IC engines.
- To study the recent technologies adopted in IC engine applications

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – SPARK IGNITION ENGINES | [9hours] |
|---|---|

Spark ignition Engine mixture requirements – Fuel – Injection systems – Mono point, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – factors affecting knock – Combustion chambers.

| UNIT II – COMPRESSION IGNITION ENGINES | [9 hours] |
|---|---|

States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behavior – spray structure, spray penetration and evaporation – air motion – Introduction to Turbo charging.

| UNIT III – POLLUTANT FORMATION AND CONTROL | [9 hours] |
|---|---|

Pollutant – Sources – Formation of carbon monoxide, Unburnt hydrocarbon, NOx, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters and Particulate Traps – Methods of measurements and Introduction to emission norms and Driving cycles

| UNIT IV – ALTERNATIVE FUELS | [9 hours] |
|---|---|
| Alcohol, Hydrogen, Natural Gas and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications. | |
| **UNIT V – RECENT TRENDS** | **[9hours]** |
| Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – laser Doppler, Anemometry. Use of nano technology in IC Engines. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Summarize the various methods of combustion and injection systems on a spark ignition engine | K2 |
| **CO2** | Demonstrate the various methods of combustion, spray behavior and injection systems on a Compressed Ignition engine | K2 |
| **CO3** | Contrast the emission and control in SI & CI Engines | K2 |
| **CO4** | Illustrate the properties merits and demerits of various alternative fuels | K2 |
| **CO5** | Explain the recent trends of advanced combustion and measurement techniques. | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | | 2 |
| **CO2** | **2** | | |
| **CO3** | **2** | | 2 |
| **CO4** | **2** | | 2 |
| **CO5** | **2** | | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Duffy Smith, Auto fuel Systems, The Good Heart Willox Company, Inc., 1989.
2. Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988.
3. K.K. Ramalingam, Internal Combustion Engine fundamentals, Scitech Publications, 2002.

**Reference Books:**

1. Kirpal Singh, Automobile Engineering Vol - I, Standard Publishers, Delhi 2013.
2. R.B. Mathur and R.P.Sharma, Internal Combustion Engines, Dhanapat Rai Publications, 1993.
3. V. Ganesan, Internal Combustion Engines, II Edition, Tata McGraw-Hill Education, 2002.
4. Willard W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, Prentice Hall, 1997.

**Web Links and Video Lectures (E-Resources):**

1. Ignition systems http://acl.digimat.in/nptel/courses/video/112103262/L14.html
2. Alternatives fuels https://archive.nptel.ac.in/courses/103/105/103105110/
3. IC engine pollution control https://www.youtube.com/watch?v=aI8GcsTiL30
4. Combustion engine https://archive.nptel.ac.in/courses/112/103/112103262/

**Suggested Skill Activities:**

1. What is the stoichiometric ratio of the Air + Gasoline mixture?
2. What is the compression ratio of a typical spark-ignition (SI) engine?
3. What is Compression ratio/Expansion ratio/Clearance ratio?
4. How does knocking occur in a Petrol/Diesel engine
5. How does a Turbocharger / Supercharger work?

| Course Code: | 24TE115 | Course Title: | CRYOGENIC ENGINEERING |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To give introductory knowledge of cryogenic Engineering.
- To impart knowledge in liquefaction, separation of cryogenics gases and working of cryocoolers.
- To embark on a research career in Cryogenic Engineering.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|
| Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo Metallurgy, Medical applications. | |
| **UNIT II – LIQUEFACTION CYCLES** | **[9 hours]** |
| Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve – Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho-Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems. | |
| **UNIT III – SEPARATION OF CRYOGENEIC GASES** | **[9 hours]** |
| Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis- McCabe Thiele Method. Adsorption Systems for purification. | |

| UNIT IV – CRYOGENIC REFRIGERATORS | [9 hours] |
|---|---|
| J. T. Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators. | |
| **UNIT V – HANDLING OF CRYOGENS** | **[9hours]** |
| Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain the Concepts of Cryogenics | K2 |
| **CO2** | Solve the various cycles during liquefaction. | K3 |
| **CO3** | Explain the various methods adopted in the separation of cryogenic gases. | K2 |
| **CO4** | Explain the working principle of cryogenic refrigerator. | K2 |
| **CO5** | Explain the concepts in handling of cryogens. | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **-** | **-** |
| **CO2** | **2** | **-** | **-** |
| **CO3** | **2** | **-** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **-** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, PlenumPress,New York, 1989.
2. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
3. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.

**Reference Books:**

1. .Herald Weinstock, Cryogenic Technology, Boston Technical Publishers, inc., 1969.

2. Robert W. Vance, Cryogenic Technology, John wiley & Sons, Inc., New York, London.

3. G.Venkatarathnam, Cryogenic Mixed Refrigerant Processes, Springer Publication, 2010.

4. J.G.Weisend, Hand Book of Cryogenic Engineering —II, Taylor and Francis, 1998.

**Web Links and Video Lectures (E-Resources):**

1. Cryogenic engine https://www.youtube.com/watch?v=4gGMBNEzeuc
2. Introduction https://www.youtube.com/watch?v=4gGMBNEzeuc&t=10s
3. LIQUEFACTION CYCLES https://youtu.be/UOi9JXlicXA
4. Safety of crogenic https://nptel.ac.in/courses/112101004

**Suggested Skill Activities:**

1. What is the meaning of negative exergy destruction in a cryogenic system?
2. What is cryogenic machining used for?
3. How does cryogenic machining work?
4. What are the benefits of cryogenic machining?
5. What types of tools are used in cryogenic machining
6. What safety precautions are needed for cryogenic machining?

| Course Code: | 24TE116 | Course Title: | REFRIGERATION SYSTEMS |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To study the cycle analysis pertaining to Refrigeration systems.
- To study the performance of system components and their balancing in cycles.
- To study the significance of Refrigerants and their impact on the environment

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION AND REFRIG ERANTS | [9hours] |
|---|---|

Applications, Unit of refrigeration – Ideal cycles - Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact-Montreal / Kyoto protocols-Eco Friendly Refrigerants, alternatives to HCFCS, Secondary Refrigerants.

| UNIT II – REFRIGERATION CYCLES – ANALYSIS | [9 hours] |
|---|---|

Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle-conditions for high COP-deviations from ideal vapor compression cycle, Multipressure System, Cascade Systems-Analysis. Vapor Absorption Systems-Aqua Ammonia & Li-Br Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles, Heat pumps.

| UNIT III – REFRIGERATION SYSTEM COMPONENTS | [9 hours] |
|---|---|

Compressor- Types, performance, Characteristics, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behaviour with fluctuating load, cycling controls, other components such as Accumulators, Receivers, Oil Separators, Strainers, Driers,

| | |
|---|---|
| Check Valves, Solenoid Valves Defrost Controllers, etc. | |
| **UNIT IV – SYSTEM BALANCING** | **[9 hours]** |
| Balance points and system simulation - compressor, condenser, evaporator and expansion devices performance – Complete system performance; graphical and mathematical analysis – sensitivity analysis. | |
| **UNIT V – ELECTRICAL DRIVES & CONTROLS** | **[9hours]** |
| Electric circuits in Refrigeration systems, Refrigerant control devices, Types of Motors, Starters, Relays, Thermostats, Microprocessor based control systems, Pressure controls and other controls, Acoustics and noise controls. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Summarize the various refrigerants used in Refrigeration system | K2 |
| **CO2** | Make use of the various cycles of Refrigeration | K3 |
| **CO3** | Explain the working Principle of components of refrigerated system | K2 |
| **CO4** | Utilize the performance of refrigeration devices | K3 |
| **CO5** | Explain the working principle of drives and control devices used in refrigerated systems | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **2** | **-** |
| **CO2** | **2** | **2** | **-** |
| **CO3** | **2** | **2** | **-** |
| **CO4** | **2** | **2** | **-** |
| **CO5** | **2** | **2** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Arora C.P., Refrigeration and Air conditioning, McGraw Hill, 3rd Ed., 2010.
2. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001.
3. Jordan and Priester, Refrigeration and Air conditioning 1985.

**Reference Books:**

1. Kuehn T.H., Ramsey J.W. and Threlkeld J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998.
2. Langley Billy C., 'Solid state electronic controls for HVACR, Prentice-Hall 1986.
3. Rex Milter, Mark R.Miller., Air conditioning and Refrigeration, McGraw Hill, 2006.

Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill BookCompany,1989

**Web Links and Video Lectures (E-Resources):**

1. **Introduction about refrigeration**
   **https://www.youtube.com/watch?v=nlsNmhiID74**
2. **Application of refrigeration system**
   **https://archive.nptel.ac.in/courses/112/105/112105129/**
3. **Refrigeration cycle https://www.youtube.com/watch?v=kC-VswG3W8s**
4. **Fundamental of electrical drives**
   **https://www.youtube.com/watch?v=1AT1yuQ9awM&list=PLFW6lRTa1g83sIfVY1p1xGqPGYUmXyahx**

**Suggested Skill Activities:**

1. What does a vapour absorption refrigerator use in the form of a refrigerant?
2. one ton of refrigeration in the S.J. unit is:
3. At a domestic refrigerator's back, the bank of tubes is known as:
4. Which refrigerants is highly flammable and toxic?

| Course Code: | 24TE117 | Course Title: | ELECTRONIC ENGINE MANAGEMENT SYSTEMS |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To provide basic grounding on electronics
- To learn the various sensors used in engine management systems
- Give an overview of different types of ignition systems
- To understand the significance of gasoline injection systems
- To know the latest advancements in Diesel injection systems

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS | [9hours] |
|---|---|

Components for Electronic Engine Management System- Open and Closed Loop Control Strategies- PID Control- Look Up Tables- Introduction to Modern Control Strategies Like Fuzzy Logic and Adaptive Control. Switches- Active Resistors- Transistors- Current Mirrors/Amplifiers- Voltage and Current References- Comparator- Multiplier. Amplifier- Filters- A/D and D/A Converters.

| UNIT II – SENSORS AND ACTUATORS | [9 hours] |
|---|---|

Inductive- Hall Effect- Thermistor- Piezo Electric- Piezoresistive- Based Sensors. Throttle Position- Mass Air Flow- Crank Shaft Position- Cam Position- Engine Speed Sensor- Exhaust Oxygen Level (Two Step- Linear Lambda and Wideband)- Knock- Manifold Temperature and Pressure Sensors. Solenoid- Relay (Four and Five Pin)- Stepper Motor

| UNIT III – SI ENGINE MANAGEMENT | [9 hours] |
|---|---|
| Layout and Working of SI Engine Management Systems. Group and Sequential Injection Techniques. MPFI- GDI- Advantages of Electronic Ignition Systems. Types of Solid State Ignition Systems and Their Principle of Operation- Contactless (BREAKERLESS) Electronic Ignition System- Electronic Spark Timing Control | |
| **UNIT IV – CI ENGINE MANAGEMENT** | **[9 hours]** |
| Fuel Injection System Parameters Affecting Combustion- Noise and Emissions in CI Engines. Electronically Controlled Unit Injection System. Common Rail Fuel Injection System. Working of Components Like Fuel Injector- Fuel Pump- Rail Pressure Limiter- Flow Limiter- EGR Valve. | |
| **UNIT V – DIGITAL ENGINE CONTROL SYSTEM** | **[9hours]** |
| Cold Start and Warm Up Phases- Idle Speed Control- Acceleration and Full Load Enrichment- Deceleration Fuel Cut-off. Fuel Control Maps- Open Loop and Closed Loop Control – Integrated Engine Control System- Electromagnetic Compatibility – EMI Suppression Techniques – Electronic Dash Board Instruments – Onboard Diagnosis System. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain the basic electronic components and controls used in Sensors | K2 |
| **CO2** | Explain the different types of sensors used in an automobile engine | K2 |
| **CO3** | Explain the ignition and injection methods used in an SI engine | K2 |
| **CO4** | Illustrate the fuel injection systems in a diesel engine and the emission control systems | K2 |
| **CO5** | Explain the electronic systems used in the fuel control system and the dash board unit. | K2 |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | | 2 |
| **CO2** | **2** | | 2 |
| **CO3** | **1** | **1** | |
| **CO4** | **2** | | 1 |
| **CO5** | **2** | | |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| **Component** | **Type of assessment** | **Max Marks** | **Reduced Marks** | **Total** | **Final marks** |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Understanding Automotive Electronics William B Ribbens, SAE 1998
2. Automobile Electronics by Eric Chowanietz SAE

**Reference Books:**

1. Diesel Engine Management by Robert Bosch, SAE Publications, 3rd Edition, 2004
2. Gasoline Engine Management by Robert Bosch, SAE Publications, 2nd Edition, 2004

**Web Links and Video Lectures (E-Resources):**

1. **Fundamental of automotive systems**

   **https://archive.nptel.ac.in/courses/107/106/107106088/**
2. **Digital engine control system**

   **https://archive.nptel.ac.in/courses/108/105/108105186/**
3. fuel system http://acl.digimat.in/nptel/courses/video/112106299/L26.html
4. **senor and actuars https://onlinecourses.nptel.ac.in/noc21_ee32/preview**

**Suggested Skill Activities:**

1. What are the important parameters in a gasoline engine that can be controlled?
2. Hall effect pickup use
3. LVDT is used to measure
4. Thermistors are desirable because of their
5. Seebeck effect is used in?
6. Catalytic converters use lambda sensors to keep?

| Course Code: | 24TE118 | Course Title: | COGENERATION AND WASTE HEAT RECOVERY SYSTEMS |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|

Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle-organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri and quad generation

| UNIT II – COGENERATION TECHNOLOGIES | [9 hours] |
|---|---|

Configuration and thermodynamic performance – steam turbine congeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc

| UNIT III – ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES | [9 hours] |
|---|---|

Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector –

| | |
|---|---|
| building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment. | |
| **UNIT IV – WASTE HEAT RECOVERY SYSTEMS** | **[9 hours]** |
| Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems. | |
| **UNIT V – ECONOMIC ANALYSIS** | **[9hours]** |
| Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain the basic concepts of waste heat recovery systems. | K2 |
| **CO2** | Illustrate the technologies in cogeneration systems. | K2 |
| **CO3** | Explain the issues and applications of cogeneration technologies. | K2 |
| **CO4** | Explain the working of various waste heat recovery systems. | K2 |
| **CO5** | Explain the concepts of economic analysis of waste heat recovery systems. | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. De Nevers, Noel, Air Pollution Control Engineering, McGraw Hill, New York,1995.
3. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001.

**Reference Books:**

1. Energy Cogeneration Hand book, George Polimveros, Industrial Press Inc, New York 1982.
2. Horlock JH., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.

**Web Links and Video Lectures (E-Resources):**

1. **Co-generation system https://onlinecourses.nptel.ac.in/noc23_ge47/preview**
2. **Thermodynamics basic https://onlinecourses.nptel.ac.in/noc22_me88/preview**
3. **Energy conservation https://archive.nptel.ac.in/courses/112/105/112105221/**
4. **Economic analysis https://www.youtube.com/watch?v=rey19R8ng0A**

**Suggested Skill Activities:**

1. Having two separate units for process heat and power is?
2. A plant producing both, electrical power & process heat simultaneously is?
3. The waste heat source with the highest potential to recover quality waste heat is
4. Cogeneration is the simultaneous generation of
5. The Ranking Cycle is related to

PROFESSIONAL ELECTIVES SEMESTER II, (ELECTIVE III, IV & V)

| S. No. | Course Code | Course Title | Course Category | L | T | P | C |
|---|---|---|---|---|---|---|---|
| **PROFESSIONAL ELECTIVE COURSES** | | | | | | | |
| 1. | 24TE211 | Design of Turbo Machines | PEC | 3 | 0 | 0 | 3 |
| 2. | 24TE212 | Electronics Cooling and Packaging | PEC | 3 | 0 | 0 | 3 |
| 3. | 24TE213 | Air Conditioning Systems | PEC | 3 | 0 | 0 | 3 |
| 4. | 24TE214 | Alternate Fuels for IC Engines | PEC | 3 | 0 | 0 | 3 |
| 5. | 24TE215 | Design of Heat Exchangers | PEC | 3 | 0 | 0 | 3 |
| 6. | 24TE216 | Battery Thermal Management System | PEC | 3 | 0 | 0 | 3 |
| 7. | 24TE217 | Advanced Energy Storage Technologies | PEC | 3 | 0 | 0 | 3 |
| 8. | 24TE218 | Hybrid and Electric Vehicles | PEC | 3 | 0 | 0 | 3 |
| 9. | 24TE219 | Advanced Power Plant Engineering | PEC | 3 | 0 | 0 | 3 |

| Course Code: | 24TE211 | Course Title: | DESIGN OF TURBO MACHINES |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|

Energy transfer between fluid and rotor velocity triangles for a generalised turbo machines – velocity triangle. Euler's equation for turbo machines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic – fan laws – Dimensionless parameters – Specific speed – Cordier Diagram

| UNIT II – CENTRIFUGAL BLOWERS | [9 hours] |
|---|---|

Centrifugal Blowers: Theoretical characteristic curves, velocity triangles, losses and hydraulic efficiency, flow through impeller casing, inlet, nozzle, volute, diffusers. Leakage losses, mechanical losses, multi-vane impellers, cross flow fans. Selection of Centrifugal blower for duct flow.

| UNIT III – AXIAL FLOW FANS | [9 hours] |
|---|---|

| | |
|---|---|
| Rotor design using airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist, stage design, surge and stall, stator and casing, mixed flow impellers. Selection of axial fans / blower for duct flow. | |
| **UNIT IV – COMPRESSORS** | **[9 hours]** |
| Reciprocating compressors, Construction Type – open, hermetic and semi sealed, effect of cylinder cooling, heating and friction. Dynamic compressor - centrifugal compressor, velocity triangles, performance characteristics, part load operation, Capacity control. Selection of compressor for different applications. | |
| **UNIT V – DESIGN AND APPLICATIONS** | **[9hours]** |
| Special design and applications of blowers / compressors for air conditioning plants, cooling towers, ventilation systems, booster systems - turbocharger. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Apply the fundamentals of Turbo machinery and solve the problems on Energy Transfer | K3 |
| **CO2** | Apply the Centrifugal Blowers and Fans for various applications. | K3 |
| **CO3** | Summarize the different types of axial fan design and performance. | K2 |
| **CO4** | Interpret the various compressors based on its performance. | K2 |
| **CO5** | Choose the fans / blowers /compressors for the given applications | K3 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 2017
2. Dixon, Fluid Mechanics, Thermodynamics of turbo machinery Pergamon Press, 1984.

**Reference Books:**

1. Fans & Ventilation A practical guide (Bill) cory WTW, Elsevier, 2005.
2. Jay Matley., Fluid Movers: Pumps, Compressors, Fans and Blowers, McGraw-Hill Publications, 1990.
3. Royce N. Brown, Compressors: Selection and Sizing, Elsevier, 2005.
4. Tony Giampaolo, Compressor Hand Book Principles and Practice, The Fairmont Press, 2010.
5. Yahya S. M., Turbines compressors and fans(4th Edition), Tata McGraw-Hill, 2010.
6. Forsthoffer's rotating equipment handbooks Volume 3: Compressors, Elsevier Advanced Technolgy, UK, 2005

**Web Links and Video Lectures (E-Resources):**

1. Introduction to Turbomachinery

   https://archive.nptel.ac.in/courses/112/104/112104305/
2. Centrifugal blowers: https://www.youtube.com/watch?v=b1dyUVA19kQ
3. Axial flow fans: https://archive.nptel.ac.in/courses/101/105/101105089/
4. Compressors: https://www.youtube.com/watch?v=NakOoD-G0IY
5. Design and Applications: https://www.youtube.com/watch?v=vRx8UH9cqB0

| Course Code: | 24TE212 | Course Title: | ELECTRONICS COOLING AND PACKAGING |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|

Electronic Equipment, Components of Electronic Systems, Thermal management in electronic devices - Packaging Trends. Electronic packaging and interconnection technology. Conduction in Electronic Equipment: Thermal Conductivity, Thermal Resistances, Conductivity in Solids, Conductivity in Fluids, Conduction—Steady State, Conduction in Simple Geometries, Conduction through a Plane Wall, Conduction through Cylinders and Spheres.

| UNIT II – ELECTRONICS ASSISTED IN THERMAL COMPONENTS | [9 hours] |
|---|---|

Conduction—Transient, Lumped Capacitance Method, Conduction in Extended Surfaces. Fin Efficiency, Fin Optimization, Fin Surface Efficiency, Thermal Contact Resistance in Electronic Equipment, Discrete Heat Sources and Thermal Spreading. Fluid Dynamics for Electronic Equipment- Boundary Layer Theory, Turbulent Flow, Loss Coefficients and Dynamic Drag, Fans and Pumps, Electronic Chassis Flow.

| UNIT III – IMPACT OF RADIATION ON SURFACE | [9 hours] |
|---|---|

| | |
|---|---|
| Radiation Heat Transfer in Electronic Equipment, The Electromagnetic Spectrum, Radiation Equations, Stefan-Boltzmann Law, Surface Characteristics, Emittance, Emittance Factor, Emittance from Extended Surface, Absorptance, Reflectance, Specular Reflectance, Heat Transfer with Phase Change. Combined Modes of Heat Transfer for Electronic Equipment, Radiation and Convection in Parallel | |
| **UNIT IV – ANALYSIS OF ELECTRONIC EQUIPMENT** | **[9 hours]** |
| Introduction to Thermal Design of Electronic Equipment. Analysis of Thermal Failure of Electronic Components. Analysis of Thermal Stresses and Strain, Effect of PCB Bending Stiffness on Wire Stresses, Vibration Fatigue in Lead Wires and Solder Joints. Electronics Cooling Methods in Industry. Heat Sinks, Heat Pipes, Heat Pipes in Electronics Cooling, Thermoelectric Cooling, Immersion Cooling, Cooling Techniques for High Density Electronics. | |
| **UNIT V – COOLING SYSTEMS FOR ELECTRONIC PACKAGES** | **[9hours]** |
| Cooling systems for electronics packages – heat sinks, heat spreaders, heat pipes, microchannels, actuators, fans, cold plates; Thermo-mechanical issues in electronic packages Effects of Vibration – vibrating systems, vibration of axially loaded components, circuit boards, Theorem of Castigliano; Reliability Metrology and Analysis, Environmental Stress Screening | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Identify the basic knowledge about the packaging of electronics | K3 |
| **CO2** | Utilize the ability of electronic cooling system. | K3 |
| **CO3** | Relate the radiation through multi electronic devices | K2 |
| **CO4** | Summarize the performance calculation of Electronics Equipment. | K2 |
| **CO5** | Applying cooling systems for different thermal sourcing agents | K3 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |

| | | | |
|---|---|---|---|
| **CO4** | **2** | **-** | - |
| **CO5** | **2** | **1** | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Rao R. Tummala : Fundamentals of Microsystem Packaging, McGraw Hill, 2001.
2. Richard K. Ulrich &William D. Brown Advanced Electronic Packaging - 2nd Edition: IEEE Press,2006.

**Reference Books:**

1. Yunus A. Cengel : Heat Transfer – A Practical Approach, McGraw Hill, 2003.
2. The Electronic Packaging Handbook- Glenn R. Blackwell, 1st Edition, 2000 Royce N. Brown, Compressors: Selection and Sizing, Elsevier, 2005.

**Web Links and Video Lectures (E-Resources):**

1. Introduction of Electronic Equipment : https://nptel.ac.in/courses/113105025
2. Electronics Assisted In Thermal Components : https://archive.nptel.ac.in/courses/108/108/108108110/
3. Impact Of Radiation On Surface : https://archive.nptel.ac.in/courses/112/107/112107256/
4. Analysis Of Electronic Equipment : https://archive.nptel.ac.in/courses/108/101/108101167/
5. cooling systems for electronic packages : https://archive.nptel.ac.in/courses/112/105/112105267/

| Course Code: | 24TE213 | Course Title: | AIR CONDITIONING SYSTEMS |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – PSYCHROMETRY AND AIR CONDITIONING PROCESSES | [9hours] |
|---|---|
| Moist Air properties, use of Psychrometric Chart, Various Psychrometric processes, Air Washer, Adiabatic Saturation. Summer and winter Air conditioning, Enthalpy potential and its insights. | |
| **UNIT II – LOAD ESTIMATION** | **[9 hours]** |
| Thermal comfort – Design conditions – Solar Radiation-Heat Gain through envelopes – Infiltration and ventilation loads – Internal loads – Procedure for heating and cooling load estimation. | |
| **UNIT III – AIR CONDITIONING SYSTEMS** | **[9 hours]** |
| Thermal distribution systems – Single, multi zone systems, terminal reheat systems, Dual duct systems, variable air volume systems, water systems and Unitary type systems. | |
| **UNIT IV – AIR DISTRIBUTION AND CONTROL** | **[9 hours]** |

| | |
|---|---|
| Flow through Ducts , Static & Dynamic Losses , Diffusers , Duct Design–Equal Friction Method, System Balancing , Fans & Duct System Characteristics , Fan Arrangement Variable Air Volume systems, Air Handling Units and Fan Coil units – Control of temperature, humidity, air flow and quality. | |
| **UNIT V – HVAC SYSTEM IN AUTOMOBILES** | **[9hours]** |
| Automotive System layout and Components- Commonly used Refrigerants- Safety devices – Climate control – Fuel efficiency aspects. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Demonstrate the psychometrically the Air conditioning processes. | K3 |
| **CO2** | Experiment with the heat load for summer and winter Air conditioning applications. | K3 |
| **CO3** | Understand and appreciate the utility of different Air conditioning systems for different applications. | K2 |
| **CO4** | Develop a fan-duct system for Air conditioning application. | K3 |
| **CO5** | Understand and appreciate the individual components of an automobile Air conditioning system. Various HVAC system components for various applications in the building requirements. | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. ALI VEDAVARZ, SUNIL KUMAR, Mohammed Iqbal, Hussain Handbook of Heating**,** Ventilation and Air conditioning for Design Implementation, Industrial press Inc, 2007.
2. Arora C.P., Refrigeration and Air Conditioning, Tata McGraw Hill Pub. Company, 2010.

**Reference Books:**


1. ASHRAE , Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2005.
2. Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design, McGraw Hill, 1985.
3. Jones, Air Conditioning Engineering, Edward Amold pub. 2001.
4. Kuehn T.H., Ramsey, J.W. and Threlkeld, J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998
5. Langley, Billy C. ,Refrigeration and Air Conditioning Ed. 3, Engie wood Cliffs (N.J) Prentice Hall 1986.


**Web Links and Video Lectures (E-Resources):**

1. PSYCHROMETRY AND AIR CONDITIONING PROCESSES:
   https://archive.nptel.ac.in/courses/112/107/112107208/
2. LOAD ESTIMATION:
   https://archive.nptel.ac.in/courses/112/105/112105129/
3. AIR CONDITIONING SYSTEMS:
   https://www.youtube.com/watch?v=nvUhiXD63Eg
4. AIR DISTRIBUTION AND CONTROL:
   https://www.youtube.com/watch?v=URazpNDS-u0
5. HVAC SYSTEM IN AUTOMOBILES:
   https://archive.nptel.ac.in/courses/107/106/107106088/

| Course Code: | 24TE214 | Course Title: | ALTERNATE FUELS FOR IC ENGINES |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|
| Availability, Suitability, Properties, Merits and Demerits of Potential Alternative Fuels – Alcohols, Biodiesel, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Biogas, Fuel standards – ASTM & EN. | |
| **UNIT II – SPECIAL AND SYNTHETIC FUELS** | **[9 hours]** |
| Different synthetic fuels, Merits, and demerits, Dual, Bi-fuel and Pilot injected fuel systems, Fuel additives – types and their effect on performance and emission characteristics of engines, Flexi-fuel systems, Ethers - as fuel and fuel additives, properties and characteristics. | |
| **UNIT III – ALCOHOL FUELS** | **[9 hours]** |
| Alcohols – Properties, Production methods and usage in engines. Blending, dual fuel operation, surface ignition, spark ignition and oxygenated additives. Performance, combustion and emission Characteristics in engines. Issues & limitation in alcohols | |

| UNIT IV – BIO-DIESEL FUELS | [9 hours] |
|---|---|
| Vegetable oils and their important properties. Fuel properties characterization. Methods of using vegetable oils – Blending, preheating, Transesterification and emulsification – Performance, combustion and emission characteristics in diesel engines. Third generation biofuels, Ternary and Quaternary fuels, Issues & limitation of using vegetable oils in IC engines | |
| **UNIT V – GASEOUS FUELS** | **[9hours]** |
| Biogas, Natural gas, LPG, Hydrogen – Properties, problems, storage and safety aspects. Methods of utilisation in engines. Performance, combustion and emission characteristics in engines. Issues & limitation in Gaseous fuels | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Identify the potential alternate fuels and their characteristics | **K3** |
| **CO2** | Make use of appropriate synthetic fuels and fuel additives for better combustion characteristics | **K3** |
| **CO3** | Illustrate the alcohol fuels effectively for lower emissions | **K2** |
| **CO4** | Summarize the utilization of Bio-Diesel and its types as a suitable fuel in CI engines | **K2** |
| **CO5** | Utilize the different gaseous fuels and predict their performance and combustion characteristics | **K3** |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications, 1990.
2. Pundir B.P, I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.

**Reference Books:**

1. Pundir B.P , Engine Combustion and Emission, 2011, Narosa Publishing House Keith

2. Richard L. Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997

**Web Links and Video Lectures (E-Resources):**

1. INTRODUCTION: https://archive.nptel.ac.in/courses/112/103/112103262/
2. SPECIAL AND SYNTHETIC FUELS: https://nptel.ac.in/courses/112104033
3. ALCOHOL FUELS: https://www.youtube.com/watch?v=RUYU279222M
4. BIO-DIESEL FUELS: https://www.youtube.com/watch?v=VnGH2EScMDE
5. GASEOUS FUELS : https://archive.nptel.ac.in/courses/103/105/103105110/

| Course Code: | 24TE215 | Course Title: | DESIGN OF HEAT EXCHANGERS |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – FUNDAMENTALS OF HEAT EXCHANGER | [9hours] |
|---|---|
| Temperature distribution and its implications types–shell and tube heat exchangers– regenerators and recuperators – analysis of heat exchangers–LMTD and effectiveness method. | |
| **UNIT II – STRESS ANALYSIS** | **[9 hours]** |
| Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses –types of failures. | |
| **UNIT III – DESIGN ASPECTS** | **[9 hours]** |
| Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe – finned tube – shell and tube heat exchangers – simulation of heat exchangers. | |
| **UNIT IV – COMPACT AND PLATE HEAT EXCHANGERS** | **[9 hours]** |
| Types–merits and demerits–design of compact heat exchangers, plate heat exchangers– performance influencing parameters– limitations. | |

| UNIT V – CONDENSERS AND COOLING TOWERS | [9hours] |
|---|---|
| Design of surface and evaporative condensers–cooling tower –performance characteristics | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Identify the heat exchangers and illustrate the applications of various types of heat exchangers | K3 |
| **CO2** | Interpret the significance of stress analysis of heat exchangers | K2 |
| **CO3** | Apply the design of tubular heat exchangers for various applications | K3 |
| **CO4** | Apply the design of compact heat exchangers for industrial requirements | K3 |
| **CO5** | Solve the performance calculation of condensers and cooling towers | K3 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| **Component** | **Type of assessment** | **Max Marks** | **Reduced Marks** | **Total** | **Final marks** |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |

| | | | | | |
|---|---|---|---|---|---|
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. SadikKakac, Hongtan Liu, Anchasa Pramuanjaroenkij, "Heat Exchangers Selection, Rating and Thermal Design", CRC Press,Third Edition,2012.
2. Ramesh K.Shah, Dušan P.Sekulić, "Fundamentals of heat exchanger design", John Wiley & Sons, 2003.

**Reference Books:**

1. Robert W. Serth, "Process heat transfer principles and applications", Academic press, Elesevier, 2010.
2. T. Kuppan, "Heat exchanger design hand book",New York: Marcel Dekker,2009.
3. Arthur.P Frass, "Heat Exchanger Design", John Wiley & Sons,1989.

**Web Links and Video Lectures (E-Resources):**

1. FUNDAMENTALS OF HEAT EXCHANGER: https://archive.nptel.ac.in/courses/112/105/112105248/
2. STRESS ANALYSIS : https://nptel.ac.in/courses/112105248
3. DESIGN ASPECTS: https://onlinecourses.nptel.ac.in/noc23_me121/preview

4. COMPACT AND PLATE HEAT EXCHANGERS:
   https://www.youtube.com/watch?v=Kj0ebo-vVAg
5. CONDENSERS AND COOLING TOWERS :
   https://www.youtube.com/watch?v=XFwm3SJhJMk

| Course Code: | 24TE216 | Course Title: | BATTERY THERMAL MANAGEMENT SYSTEM |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|

Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithiumion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging.

| UNIT II – BATTERY MANAGEMENT SYSTEM REQUIREMENT | [9 hours] |
|---|---|

Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of- charge estimation, Cell total energy and cell total power.

| UNIT III – BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION, CELL BALANCING | [9 hours] |
|---|---|

| | |
|---|---|
| Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Lithium-ion aging: Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing. | |
| **UNIT IV – MODELLING AND SIMULATION** | **[9 hours]** |
| Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, simulating an electric vehicle, Vehicle range calculations, simulating constant power and voltage, Simulating battery packs, | |
| **UNIT V – DESIGN OF BATTERY BMS** | **[9hours]** |
| Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Interpret the role of battery management system | K2 |
| **CO2** | Explain the requirements of Battery Management System | K2 |
| **CO3** | Interpret the concept associated with battery charging / discharging process | K2 |
| **CO4** | Identify the various parameters of battery and battery pack | K3 |
| **CO5** | Make use of the model of battery pack | K3 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
2. Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods, Artech House, 2015.

**Reference Books:**

1. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design

by Modelling" Philips Research Book Series 2002.
2. Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
3. Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery powered applications. Vol. 9. Springer Science & Business Media, 2008.

**Web Links and Video Lectures (E-Resources):**

1. INTRODUCTION: https://www.youtube.com/watch?v=KMVoci_xJ2E
2. SPECIAL AND SYNTHETIC FUELS:

http://acl.digimat.in/nptel/courses/video/103108162/L32.html

3. ALCOHOL FUELS : https://www.youtube.com/watch?v=Y5NOQWTqJIo
4. BIO-DIESEL FUELS : https://nptel.ac.in/courses/113105102
5. GASEOUS FUELS : https://www.youtube.com/watch?v=qgMll02dP1w

| Course Code: | 24TE217 | Course Title: | ADVANCED ENERGY STORAGE TECHNOLOGIES |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|
| Necessity of energy storage–types of energy storage–comparison of energy storage technologies– Applications. | |
| **UNIT II – THERMAL STORAGE SYSTEM** | **[9 hours]** |
| Thermal storage–Types–Modelling of thermal storage units–Simple water and rock bed storage system–pressurized water storage system–Modelling of phase change storage system –Simple units, packed bed storage units – Modelling using porous medium approach, Use of TRNSYS. | |
| **UNIT III – ELECTRICAL ENERGY STORAGE** | **[9 hours]** |
| Fundamental concept of batteries–measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel–Cadmium, Zinc Manganese di oxide and modern batteries for example(i)zinc-Air(ii)Nickel Hydride,(iii)Lithium Battery. | |

| UNIT IV – HYDROGEN AND BIOGAS STORAGE | [9 hours] |
|---|---|
| Hydrogen storage options–compressed gas–liquid hydrogen–Metal Hydrides, chemical Storage, Biogas storage-comparisons. Safety and management of hydrogen and Biogas storage-Applications. | |
| **UNIT V – ALTERNATE ENERGY STORAGE TECHNOLOGIES** | **[9hours]** |
| Flywheel, Super capacitors, Principles & Methods–Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Identify the energy storage technologies for suitable applications. | K3 |
| **CO2** | Interpret the energy storage systems using TRNSYS. | K2 |
| **CO3** | Summarize the concepts and types of batteries. | K2 |
| **CO4** | Examine the principle of operation of Hydrogen and Biogas storage systems. | K3 |
| **CO5** | Explain the working of super capacitor, Flywheel and compressed energy storage systems | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2010.
2. Viswanathan, Fuel cell principle and applications university press,2006.

**Reference Books:**

1. Luisa F.Cabeza, Advances in Thermal Energy Storage Sy stems: Methods and Applications, Elsevier Wood head Publishing, 2015
2. Robert Huggins, Energy Storage: Fundamentals, Materials and Applications ,2nd

edition, Springer,2015.
3. Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion,,Wileypublications,2012.
4. National Energy Technology Laboratory, U.S. Department of Energy, Fuel Cell Handbook (Seventh Edition).

**Web Links and Video Lectures (E-Resources):**

1. INTRODUCTION: https://archive.nptel.ac.in/courses/113/105/113105102/
2. THERMAL STORAGE SYSTEM: https://www.youtube.com/watch?v=0FSEKHc-COA
3. ELECTRICAL ENERGY STORAGE: https://www.youtube.com/watch?v=yar51GJVqgg
4. HYDROGEN AND BIOGAS STORAGE: https://onlinecourses.nptel.ac.in/noc22_ch66/preview
5. ALTERNATE ENERGY STORAGE TECHNOLOGIES: https://www.youtube.com/watch?v=yar51GJVqgg

| Course Code: | 24TE218 | Course Title: | HYBRID AND ELECTRIC VEHICLES |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|
| Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. | |
| **UNIT II – HYBRID ELECTRIC DRIVE TRAINS** | **[9 hours]** |
| Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.<br>Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. | |
| **UNIT III – CONTROL OF AC & DC DRIVES** | **[9 hours]** |
| Introduction to electric components used in hybrid and electric vehicles, Configuration and control - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency. | |

| UNIT IV – ENERGY STORAGE | [9 hours] |
|---|---|
| Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis - Battery based, Fuel Cell based, and Super Capacitor based, Hybridization of different energy storage devices. | |
| **UNIT V – DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES** | **[9hours]** |
| Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification and comparison of energy management strategies, implementation issues. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Interpret the Characterize and configure hybrid drivetrains requirement for a vehicle | K2 |
| **CO2** | Summarize the appropriate hybrid and electric drive trains in a vehicle | K2 |
| **CO3** | Classify the suitable AC and DC drives for electric vehicles. | K2 |
| **CO4** | Relate the suitable energy storage system for a hybrid / electric vehicle | K2 |
| **CO5** | Illustrate the energy management strategies to ensure better economy and efficiency | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

**Reference Books:**

1. MehrdadEhsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley &

Sons, 1998

**Web Links and Video Lectures (E-Resources):**

1. INTRODUCTION: https://archive.nptel.ac.in/courses/108/103/108103009/
2. HYBRID ELECTRIC DRIVE TRAINS : https://nptel.ac.in/courses/108106170
3. CONTROL OF AC & DC DRIVES: https://onlinecourses.nptel.ac.in/noc23_ee01/preview
4. ENERGY STORAGE: https://archive.nptel.ac.in/courses/108/106/108106182/
5. DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES : https://www.youtube.com/watch?v=3E1SXG7VkQk

| Course Code: | 24TE219 | Course Title: | ADVANCED POWER PLANT ENGINEERING |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION | [9hours] |
|---|---|
| Energy scenario: India Vs. World – Load curves and–thermodynamic analysis of Conventional Power Plants (Coal, Gas Turbine and Diesel)-Advanced Power Cycles-Kalina Cycle, IGCC. | |
| **UNIT II – COAL BASED THERMAL POWER PLANTS** | **[9 hours]** |
| Basics of typical power plant utilities – Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system – steam rate and heat rate – mean temperature of heat addition-Rankine cycle improvements–Superheat, Reheat, Regeneration, Supercritical, AFBC/PFBC – computation of per unit cost of power generation from coal/biomass | |
| **UNIT III – GAS TURBINE AND DIESEL POWER PLANTS** | **[9 hours]** |
| Brayton cycle – Open and Closed – Improvements – Intercooler, Reheating and Regeneration. Diesel power plant – Layout – Performance analysis and improvement – Techniques for starting, cooling and lubrication of diesel engines-computation of per unit cost of power generation . | |

| UNIT IV – CHP AND MHD POWER PLANTS | [9 hours] |
|---|---|
| Cogeneration systems–types-heat to power ratio-Thermodynamic performance of steam turbine gas turbine and IC engine-based cogeneration systems–Poly Generation-Binary Cycle-Combined cycle. MHD –Open cycle and closed cycle-Hybrid MHD & steam power plants | |
| **UNIT V – HYDRO ELECTRIC & NUCLEAR POWER PLANTS** | **[9hours]** |
| Hydroelectric Power plants – classifications – essential elements – pumped storage systems – micro and mini hydel power plants. General aspects of Nuclear Engineering – Components of nuclear power plants – Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor-nuclear safety–Environmental Issues-Computation of per Unit cost of power generation. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Classify the appropriate power generation technologies for mitigating the energy gap | K2 |
| **CO2** | Interpret the steam rate, heat rate and cost for generating electricity from coal based thermal power plants | K2 |
| **CO3** | Choose the measures for improving the performance of gas turbine and diesel power plants | K3 |
| **CO4** | Explain the applicability and performance of a cogeneration system | K2 |
| **CO5** | Infer the suitable type of hydroelectric/nuclear power plant commensurate with the prevailing conditions | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Nag, P.K., Power Plant Engineering, Tata McGraw Hill Publishing Co Ltd, New Delhi,1998.
2. Haywood, R.W., Analysis of Engineering Cycles,4th Edition, Pergamon Press,Oxford,1991.

**Reference Books:**

1. Wood, A.J., Wollen berg, B.F., Power Generation, operation and control, John Wiley, New York,1984.
2. Gill, A.B., Power Plant Performance, Butter worths,1984.
3. Lamarsh, J.R., Introduction to Nuclear Engg. 2nd edition, Addison-Wesley, 1983.

**Web Links and Video Lectures (E-Resources):**

1. INTRODUCTION : https://archive.nptel.ac.in/courses/112/107/112107291/
2. COAL BASED THERMAL POWER PLANTS : http://www.digimat.in/nptel/courses/video/112107291/L31.html
3. GAS TURBINE AND DIESEL POWER PLANTS : https://archive.nptel.ac.in/courses/112/103/112103262/
4. CHP AND MHD POWER PLANTS : https://archive.nptel.ac.in/courses/112/107/112107291/
5. HYDRO ELECTRIC & NUCLEAR POWER PLANTS : https://archive.nptel.ac.in/courses/112/103/112103243/

AUDIT COURSES SEMESTER I & II,

| S. No. | Course Code | Course Title | Course Category | L | T | P | C |
|---|---|---|---|---|---|---|---|
| **AUDIT COURSES** | | | | | | | |
| 1. | 24AC201 | English for Research Paper Writing | PEC | 2 | 0 | 0 | 0 |
| 2. | 24AC202 | Disaster Management | PEC | 2 | 0 | 0 | 0 |
| 3. | 24AC203 | Constitution of India | PEC | 2 | 0 | 0 | 0 |

| Course Code: | 24AC201 | Course Title: | ENGLISH FOR RESEARCH PAPER WRITING |
|---|---|---|---|
| Credits: | 0 | L – T – P | 2-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION TO RESEARCH PAPER WRITING | [6 hours] |
|---|---|
| Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness. | |
| **UNIT II – PRESENTATION SKILLS** | **[6 hours]** |
| Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction | |
| **UNIT III – TITLE WRITING SKILLS** | **[6 hours]** |
| Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check | |
| **UNIT IV - RESULT WRITING SKILLS** | **[6 hours]** |

| | |
|---|---|
| Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions. | |
| **UNIT V – VERIFICATION SKILLS** | **[6 hours]** |
| Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Understand that how to improve your writing skills and level of readability | K2 |
| **CO2** | Infer about what to write in each section | K2 |
| **CO3** | Understand the skills needed when writing a Title | K2 |
| **CO4** | Understand the skills needed when writing the Conclusion | K2 |
| **CO5** | Interpret the good quality of paper at very first-time submission | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | **-** |
| **CO2** | **2** | **1** | **-** |
| **CO3** | **-** | **1** | **-** |
| **CO4** | **2** | **-** | **-** |
| **CO5** | **2** | **1** | **-** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| **Component** | **Type of assessment** | **Max Marks** | **Reduced Marks** | **Total** | **Final marks** |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |

| | | | | | |
|---|---|---|---|---|---|
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **Terminal Examination** |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006

**Reference Books:**

1. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
2. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

| Course Code: | 24AC202 | Course Title: | DISASTER MANAGEMENT |
|---|---|---|---|
| Credits: | 0 | L – T – P | 2-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – INTRODUCTION TO RESEARCH PAPER WRITING | [6 hours] |
|---|---|
| Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. | |
| **UNIT II – REPERCUSSIONS OF DISASTERS AND HAZARDS** | **[6 hours]** |
| Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts. | |
| **UNIT III – DISASTER PRONE AREAS IN INDIA** | **[6 hours]** |
| Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics | |
| **UNIT IV - DISASTER PREPAREDNESS AND MANAGEMENT** | **[6 hours]** |

| | |
|---|---|
| Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness. | |
| **UNIT V – RISK ASSESSMENT** | **[6 hours]** |
| Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Summarize the basics of disaster | K2 |
| **CO2** | Explain the critical understanding of key concepts in disaster risk reduction and humanitarian response. | K2 |
| **CO3** | Illustrate the disaster risk reduction and humanitarian response policy and practice from multiple perspectives. | K2 |
| **CO4** | Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. | K2 |
| **CO5** | Relate the strengths and weaknesses of disaster management approaches | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | - |
| **CO2** | **2** | **1** | - |
| **CO3** | **-** | **1** | - |
| **CO4** | **2** | **-** | - |
| **CO5** | **2** | **1** | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi,2009.

**Reference Books:**

1. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007.
2. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi, 2001.

| Course Code: | 24AC203 | Course Title: | CONSTITUTION OF INDIA |
|---|---|---|---|
| Credits: | 0 | L – T – P | 2-0-0 |

**Course objectives:**

To impart knowledge on the

- To analyze the basic energy generation cycles.
- To detail about the concept of cogeneration, its types and probable areas of applications.
- To study the significance of waste heat recovery systems and carry out its economic analysis.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – HISTORY OF MAKING OF THE INDIAN CONSTITUTION | [3 hours] |
|---|---|
| History, Drafting Committee, (Composition & Working) | |
| **UNIT II – PHILOSOPHY OF THE INDIAN CONSTITUTION** | **[3 hours]** |
| Preamble, Salient Features | |
| **UNIT III – CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES** | **[6 hours]** |
| Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties. | |
| **UNIT IV - ORGANS OF GOVERNANCE** | **[6 hours]** |
| Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions. | |

| UNIT V – LOCAL ADMINISTRATION | [6 hours] |
|---|---|
| District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Summarize the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics | K2 |
| **CO2** | Explain the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India. | K2 |
| **CO3** | Illustrate the circumstances surrounding the foundation of the Congress Socialist Party under the leadership of Jawaharlal Nehru | K2 |
| **CO4** | Interpret the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution. | K2 |
| **CO5** | Contrast the passage of the Hindu Code Bill of 1956. | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **2** | **1** | - |
| **CO2** | **2** | **1** | - |
| **CO3** | **-** | **1** | - |
| **CO4** | **2** | **-** | - |
| **CO5** | **2** | **1** | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Text Books:**

1. The Constitution of India,1950(Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.

**Reference Books:**

1. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
2. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

| Professional Core Courses (PCC) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24TE301 | Design and Optimization of Thermal Energy Systems | PCC | 3 | 0 | 0 | 3 |
| **Professional Electives Courses (PEC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24TE311 | Boundary Layer Theory and Turbulence | PEC | 3 | 0 | 0 | 3 |
| 2. | 24TE312 | Steam Generator Technology | PEC | 3 | 0 | 0 | 3 |
| 3. | 24TE313 | Fluidized Bed Systems | PEC | 3 | 0 | 0 | 3 |
| 4. | 24TE314 | Energy Efficient Buildings | PEC | 3 | 0 | 0 | 3 |
| 5. | 24TE315 | Engine Pollution and Control | PEC | 3 | 0 | 0 | 3 |
| 6. | 24TE316 | Solar Thermal Technologies | PEC | 3 | 0 | 0 | 3 |
| **Open Electives Courses (OEC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24TE 344 | Design Thinking | OEC | 3 | 0 | 0 | 3 |
| 2. | 24TE 345 | Textile Reinforced Composites | OEC | 3 | 0 | 0 | 3 |
| 3. | 24TE 346 | Nanocomposite Materials | OEC | 3 | 0 | 0 | 3 |
| **Employability Enhancement Courses (EEC)** | | | | | | | |
| **Sl.No** | **Course Code** | **Course Title** | **Course Type** | **L** | **T** | **P** | **Credit** |
| 1. | 24TE351 | Technical Seminar – II | EEC | 0 | 0 | 2 | 1 |
| 2. | 24TE352 | Project Work - I | EEC | 0 | 0 | 12 | 6 |
| 3. | 24TE451 | Project Work - II | EEC | 0 | 0 | 24 | 12 |

Recommended Courses for III SEMESTER

| S. No. | Course Code | Course Title | Course Category | L | T | P | C |
|---|---|---|---|---|---|---|---|
| **PROFESSIONAL CORE COURSES** | | | | | | | |
| 1. | 24TE301 | Design and Optimization of Thermal Energy Systems | PCC | 3 | 0 | 0 | 3 |
| **PROFESSIONAL ELECTIVE COURSES** | | | | | | | |
| 2. | 24TE31X | Professional Elective - IV | PEC | 3 | 0 | 0 | 3 |
| **OPEN ELECTIVE COURSES** | | | | | | | |
| 3. | 24XXXXX | Open Elective | OEC | 3 | 0 | 0 | 3 |
| **EMPLOYABILITY ENHANCEMENT COURSES** | | | | | | | |
| 4. | 24TE351 | Technical Seminar – I | EEC | 0 | 0 | 2 | 1 |
| 5. | 24TE352 | Project Work - I | EEC | 0 | 0 | 12 | 6 |
| | | TOTAL | | 9 | 0 | 14 | 16 |

Recommended Courses for IV SEMESTER

| S. No. | Course Code | Course Title | Course Category | L | T | P | C |
|---|---|---|---|---|---|---|---|
| **EMPLOYABILITY ENHANCEMENT COURSES** | | | | | | | |
| 1. | 24TE451 | Project Work - II | EEC | 0 | 0 | 24 | 12 |
| | | TOTAL | | 0 | 0 | 24 | 12 |

| Course Code: | 24TE301 | Course Title: | Design and Optimization of Thermal Energy Systems |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To learn basic principles underlying pumping, heat exchangers; modeling and optimization in design of thermal systems.
- To develop representational modes of real processes and systems.
- To optimization concerning design of thermal systems.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – DESIGN CONCEPTS | [9 hours] |
|---|---|
| Design Principles, Workable Systems, Optimal Systems, Matching of System Components, Economic Analysis, Depreciation, Gradient Present Worth factor, modelling overview – levels and steps in model development - Examples of models – curve fitting and regression analysis | |
| **UNIT II –MODELLING AND SYSTEMS SIMULATION** | **[10 hours]** |
| Modelling of thermal energy systems – heat exchanger - solar collectors – distillation - rectification turbo machinery components - refrigeration systems - information flow diagram -solution of set of nonlinear algebraic equations - successive substitution - Newton Raphson method- examples of thermal systems simulation | |
| **UNIT III – OPTIMIZATION** | **[10 hours]** |
| Objectives - constraints, problem formulation - unconstrained problems - necessary and | |

| | |
|---|---|
| Sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization techniques – examples. | |
| **UNIT IV – DYNAMIC BEHAVIOUR** | **[8 hours]** |
| Steady state Simulation, Laplace Transformation, Feedback Control Loops, Stability Analysis, Non-Linearities. | |
| **UNIT V – APPLICATIONS AND CASE STUDIES** | **[8 hours]** |
| Case studies of optimization in thermal systems problems- Dealing with uncertainty-probabilistic techniques – Trade-offs between capital and energy using Pinch analysis. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Apply the principles of the thermal energy systems and analysis the optimize level of pumps, heat exchangers. | **K3** |
| **CO2** | Solve the modelling thermal systems simulation | **K3** |
| **CO3** | Solving with optimization techniques in thermal energy systems | **K3** |
| **CO4** | Compute the solution of Laplace transformation and its linearity's | **K3** |
| **CO5** | Apply the uncertainty techniques with optimization case studies | **K3** |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | - | - |
| **CO2** | 1 | - | - |
| **CO3** | 1 | 1 | - |
| **CO4** | 1 | 1 | - |
| **CO5** | - | 2 | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. B.K.Hodge, Analysis and Design of Thermal Systems, Prentice Hall Inc., 1990.

2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization, Wiley ,1996.

3. D.J. Wide, Globally Optimal Design, Wiley- Interscience, 1978.

4. Kapur J. N., Mathematical Modelling, Wiley Eastern Ltd , New York , 1989.

5. Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.

6. Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.

7. YogeshJaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.

**Web Links and Video Lectures (E-Resources):**

1. Design Concepts : https://archive.nptel.ac.in/courses/112/106/112106064/
2. Modelling and Systems Simulation : http://www.digimat.in/nptel/courses/video/112107214/L01.html
3. Optimization : http://sdnbvc.digimat.in/nptel/courses/video/112106064/L17.html
4. Dynamic Behavior : http://kcl.digimat.in/nptel/courses/video/112103278/L36.html
5. Applications and Case Studies : http://acl.digimat.in/nptel/courses/video/112102248/L12.html

**Suggested Skill Activities:**

1. Thermodynamic Analysis and Simulation
2. Designing a Heat Exchanger
3. Renewable Thermal Energy Integration
4. Energy Management and Heat Recovery Systems
5. Energy Auditing and Optimization

| Course Code: | 24TE311 | Course Title: | Boundary Layer Theory and Turbulence |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To introduce the fundamental concepts of boundary layer in real flows.
- To distinguish between turbulent and laminar boundary layers.
- To model turbulent flows using various approaches.
- To analyze various flow parameters using statistical principles.
- To introduce the types, characteristics of wall shear flows from free shear flows.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – FUNDAMENTALS OF BOUNDARY LAYER THEORY | [9 hours] |
|---|---|
| Boundary Layer Concept, Laminar Boundary Layer on a Flat Plate at zero incidence, Turbulent Boundary Layer on a Flat plate at zero incidence, Fully Developed Turbulent Flow in a pipe, Boundary Layer on an airfoil, Boundary Layer separation. | |
| **UNIT II – TURBULENT BOUNDARY LAYERS** | **[9 hours]** |
| Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Laws of the wall– Friction law – Fully developed Internal flows – Channel Flow, Couette – Poiseuille flows, Pipe Flow | |
| **UNIT III – TURBULENCE AND TURBULENCE MODELS** | **[9 hours]** |
| Nature of turbulence – Averaging Procedures – Characteristics of Turbulent Flows – Types of Turbulent Flows – Scales of Turbulence, Prandtl's Mixing length, Two-Equation Models, Low – Reynolds Number Models, Large Eddy Simulation | |

| UNIT IV – STATISTICAL THEORY OF TURBULENCE | [9 hours] |
|---|---|
| Ensemble Average – Isotropic Turbulence and Homogeneous Turbulence – Kinematics of Isotropic Turbulence – Taylor's Hypothesis – Dynamics of Isotropic Turbulence – Grid Turbulence and decay – Turbulence in Stirred Tanks. | |
| **UNIT V – TURBULENT FLOWS** | **[9 hours]** |
| Wall Turbulent shear flows – Structure of wall flow – Turbulence characteristics of Boundary layer – Free Turbulence shear flows – Jets and wakes – Plane and axi-symmetric flows. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Analyze flow with the principles of boundary layer theory | **K3** |
| **CO2** | Choose the turbulent boundary layer for various types of flows | **K3** |
| **CO3** | Select and use various turbulence models for the appropriate applications | **K3** |
| **CO4** | Apply the statistical theory for averaging various flow parameters | **K3** |
| **CO5** | Identify the characteristics of wall shear and free shear flows. | **K3** |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 2 | 2 | 1 |
| **CO2** | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
2. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H, Gas Turbine Theory, Longman,1989
3. G.C. Oates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education Series, 1985.
4. S. M. Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd, 2003.

5. George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010.
6. Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010.
7. W.P.Gill, H.J.Smith& J.E. Ziurys, "Fundamentals of Internal Combustion Engines asapplied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980.

**Web Links and Video Lectures (E-Resources):**

1. Fundamentals of boundary layer theory : https://www.youtube.com/watch?v=dzsPmCLpqI4
2. Turbulent boundary layers : https://www.youtube.com/watch?v=Adasa4hLEw8
3. Turbulence and turbulence models : https://archive.nptel.ac.in/courses/115/104/115104112/
4. Statistical theory of turbulence : https://onlinecourses.nptel.ac.in/noc24_me110/preview
5. Turbulent flows : https://archive.nptel.ac.in/courses/101/106/101106060/

**Suggested Skill Activities:**

1. Boundary Layer Flow Visualization
2. Reynolds Number Calculation
3. Turbulence Simulation
4. Boundary Layer Thickness Measurement
5. Boundary Layer Separation and Reattachment

| Course Code: | 24TE312 | Course Title: | Steam Generator Technology |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To educate the students on the types of boilers with their constructional and functional significance.
- To understand the working and design of fuel preparation units and boilers.
- To introduce the concept of boiler design, emission aspects.
- To Classify the auxiliary Equipment's in design.
- To enumerate the technological design aspect in steam generator

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – BASICS | [9 hours] |
|---|---|
| Steam Cycle for Power Generation – Fuel Stoichiometry - Boiler Classification & Components – Specifications - Boiler Heat Balance – Efficiency Estimation (Direct & Indirect) – Sankey Diagram | |
| **UNIT II – FUELS AND BOILER TYPES** | **[9 hours]** |
| Solid Fuel: Coal Preparation – Pulverization – Fuel feeding arrangements, Fuel Oil: Design of oil firing system – components – Air regulators, Types of Boilers – Merits & Limitations – Specialty of Fluid Bed Boilers – Basic design principles (Stoker, Travelling Grate etc). | |
| **UNIT III – COMPONENTS DESIGN** | **[9 hours]** |
| Furnace– Water Wall – Steam Drum – Attemperator - Superheaters – Reheaters – Air Preheaters – Economisers - Steam Turbines: Design Aspects of all these. | |

| UNIT IV – AUXILIARY EQUIPMENTS – DESIGN & SIZING | [9 hours] |
|---|---|
| Forced Draft & Induced Draft Fans – PA / SA Fans – Water Pumps (Low Pressure & High Pressure) – Cooling Towers – Softener – DM Plant. | |
| **UNIT V – EMISSION ASPECTS** | **[9hours]** |
| Emission Control – Low NOx Burners– Boiler Blow Down - Control & Disposal: Feed Water Deaeration & Deoxygenation – Reverse Osmosis - Ash Handling Systems Design – Ash Disposal– Chimney Design to meet Pollution std – Cooling Water Treatment & Disposal. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Experiment with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation. | **K3** |
| **CO2** | Apply the solid fuels for energy generation technology | **K3** |
| **CO3** | Make use of Boiler cycles, components and in Design. | **K3** |
| **CO4** | Utilize the specialized knowledge in steam boiler performance evaluation. | **K3** |
| **CO5** | Identify the Emission related aspects in terms of CO2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society | **K3** |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | 2 | - |
| **CO2** | 2 | - | - |
| **CO3** | 1 | - | - |
| **CO4** | - | - | - |
| **CO5** | - | - | 1 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Blokh A.G.,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corporation, 2017
2. Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982.
3. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986.

4. Ganapathy V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003. 5. Howard J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983.
5. Mosoon Kwauk, Fluidization Idealized and Bubbleless, with Applications, Science Press, 1992.
6. PrabirBasu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer, 2000.

**Web Links and Video Lectures (E-Resources):**

1. Basics for Steam Generator Technology : https://archive.nptel.ac.in/courses/112/107/112107291/
2. Fuels and boiler types : https://www.youtube.com/watch?v=wtol--hku0M
3. Components design for generator technology : http://digimat.in/nptel/courses/video/112103421/L13.html
4. Auxiliary equipment's – design & sizing : https://archive.nptel.ac.in/courses/103/107/103107143/
5. Emission aspects in steam generator : https://archive.nptel.ac.in/courses/112/103/112103277/

**Suggested Skill Activities:**

1. Understanding and Analyzing Boiler Efficiency
2. Design and Selection of Boiler Materials
3. Heat Recovery and Regeneration Systems
4. Steam Generator Performance Testing
5. Control Systems in Steam Generators

| Course Code: | 24TE313 | Course Title: | Fluidized Bed Systems |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To understand the behavior of fluidized beds
- To learn about the heat transfer process.
- To differentiate the combustion and gasification, and appreciate the relative merits
- To design components of fluidized bed systems
- To understand the industrial applications of fluidized bed systems

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – FLUIDIZED BED BEHAVIOUR | [9 hours] |
|---|---|
| Characterization of bed particles–comparison of different methods of gas–solid contacts. Fluidization phenomena – regimes of fluidization – bed pressure drop curve. Two phase and well mixed theory of fluidization. Particle entrainment and elutriation – unique features of circulating fluidized beds. | |
| **UNIT II – HEAT TRANSFER** | **[9 hours]** |
| Different modes of heat transfer in fluidized bed– bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement external heat exchangers– heat transfer and part load operations. | |
| **UNIT III – COMBUSTION AND GASIFICATION** | **[9 hours]** |
| Fluidized bed combustion and gasification–stages of combustion of particles–performance–start –up methods. Pressurized fluidized beds. | |

| UNIT IV – DESIGN CONSIDERATIONS | [9 hours] |
|---|---|
| Design of distributors–stoichiometric calculations–heat and mass balance–furnace design–design of heating surfaces–gas solid separators. | |
| **UNIT V – INDUSTRIAL APPLICATIONS** | **[9 hours]** |
| Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing. Cracking and reforming of hydrocarbons, carbonization, combustion and gasification. Sulphur retention and oxides of nitrogen emission Control. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Apply the behavior of fluidized bed particles and explain the theory of fluidization. | **K3** |
| **CO2** | Identify the heat transfer process in fluidized beds | **K3** |
| **CO3** | Apply the concepts of combustion and gasification in fluidized beds | **K3** |
| **CO4** | Solve the design consideration for components of fluidized bed system. | **K3** |
| **CO5** | Select the fluidized bed systems for various industrial applications. | **K3** |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 3 | - | 2 |
| **CO2** | 3 | - | 3 |
| **CO3** | 3 | - | 2 |
| **CO4** | 3 | - | 3 |
| **CO5** | 3 | - | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**


1. Howard,J.R.,Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork,1983.
2. Geldart, D., Gas Fluidization Technology, John Willey and Sons, 1986.
3. Kunii,D and Levespiel,O., Fluidization Engineering, John Wiley and Son Inc, New York,1969.
4. 4. Howard,J.R.(Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
5. 5. Botteril,J.S.M., Fluid Bed Heat Transfer, Academic Press, London,1975.

**Web Links and Video Lectures (E-Resources):**

1. Fluidized bed behavior : https://archive.nptel.ac.in/courses/103/103/103103132/
2. Heat transfer : http://digimat.in/nptel/courses/video/103103132/L26.html
3. Combustion and gasification : https://archive.nptel.ac.in/courses/102/104/102104057/
4. Design considerations : https://onlinecourses.nptel.ac.in/noc24_ch57/preview
5. Industrial applications : http://digimat.in/nptel/courses/video/103103221/L19.html

**Suggested Skill Activities:**

1. Fluidized Bed Flow Visualization
2. Determine the Minimum Fluidization Velocity
3. Study of Bed Expansion and Pressure Drop
4. Study of Bed Stability and Flow Regimes
5. Analysis of Heat Transfer in Fluidized Beds

| Course Code: | 24TE314 | Course Title: | Energy Efficient Buildings |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To learn the green buildings concepts applicable to alternate design
- To be familiar with basic terminologies related to buildings
- To learn the building (air) conditioning techniques
- To know the methods to evaluate the performance of buildings
- To incorporate Renewable energy systems in buildings

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. NPTEL and Other Videos
3. Smart Class Room
4. Flipped Class
5. Technical Seminar
6. Poster Presentation

| UNIT I – INTRODUCTION | [9 hours] |
|---|---|
| Climate and Building, Historical perspective, Aspects of green building design – Sustainable Site, Water, Energy, Materials and IAQ, ECBC Standards | |
| **UNIT II – LANDSCAPE AND BUILDING ENVELOPES** | **[9 hours]** |
| Energy efficient Landscape design – Microclimate, Shading, Arbors, Windbreaks, Xeriscaping, Building envelope – Thermal comfort, Psychrometry, Comfort indices, Thermal Properties of Building Materials – Thermal Resistance, Thermal Time Constant (TTC), Diurnal Heat Capacity (DHC), Thermal Lag, Decrement Factor, Effect of Solar Radiation – Sol-air Temperature, Processes of heat exchange of building with environment, Insulation. | |

| UNIT III – PASSIVE HEATING AND COOLING | [9 hours] |
|---|---|
| HVAC introduction, Passive Heating – Solar radiation basics, Sun Path Diagram, Direct Heating, Indirect Heating and Isolated heating, Concept of Daylighting, Passive Cooling – Natural Ventilation (Stack and Wind), Evaporative Cooling and Radiative Cooling. | |
| **UNIT IV – THERMAL PERFORMANCE OF BUILDINGS** | **[9 hours]** |
| Heat transfer due to fenestration/infiltration, Calculation of Overall Thermal Transmittance, Estimation of building loads: Steady state method, network method, numerical method, correlations, Thermal Storage integration in buildings. | |

| UNIT V – RENEWABLE ENERGY IN BUILDINGS | [9 hours] |
|---|---|
| Introduction of renewable sources in buildings, BIPV, Solar water heating, small wind turbines, standalone PV systems, Hybrid system – Economics. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Interpret the climate responsive building design and basic concepts | **K2** |
| **CO2** | Explain the basic terminologies related to buildings | **K2** |
| **CO3** | Demonstrate the passive (air) conditioning techniques | **K2** |
| **CO4** | Infer to evaluate the performance of buildings | **K2** |
| **CO5** | Contrast the Renewable energy systems in buildings | **K2** |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | **3** | **2** | **1** |
| **CO2** | **-** | **1** | **1** |
| **CO3** | **-** | **-** | **2** |
| **CO4** | **-** | **-** | **2** |
| **CO5** | **1** | **-** | **2** |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 60 | 100 | 40 |
| | CIE – II | 100 | | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**


1. ASHRAE Handbook -2009 - Fundamentals.
2. Baruch Givoni: Climate considerations in building and Urban Design, John Wiley & Sons, 1998.
3. Baruch Givoni: Passive Low Energy Cooling of Buildings by, John Wiley & Sons, 15-Jul-1994.
4. JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition, John Wiley &Sons, 2006.
5. Jan F. Kreider, Peter S. Curtiss, Ari Rabl, Heating and cooling of buildings: Design for Efficiency, Revised Second Edition, CRC Press, 28-Dec-2009.

**Web Links and Video Lectures (E-Resources):**

1. Introduction : https://youtu.be/LulkblznV1Y
2. Landscape and building envelopes : https://www.youtube.com/watch?v=nTz588-yRJk
3. Passive heating and cooling : https://youtu.be/Rk1OF2qB5Ag
4. Thermal performance of buildings : https://onlinecourses.nptel.ac.in/noc20_ce08/preview
5. Renewable energy in buildings : https://archive.nptel.ac.in/courses/105/102/105102195/

**Suggested Skill Activities:**

1. Basic Level (Awareness & Fundamentals)
2. Intermediate Level (Hands-on & Application)
3. Advanced Level
4. Smart Building Technologies
5. Energy Simulation & Modeling

| Course Code: | 24TE315 | Course Title: | Engine Pollution and Control |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

- To provide an insight about effect of engine out emissions on human health and Environment.
- To impart the knowledge on various pollutant species formations in SI and CI engine.
- To divulge about various emission measurement techniques in engines and its significance
- To provide a discernment about various emission control methods
- To impart the knowledge about international and national driving cycles and emission standards

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – AIR POLLUTION – ENGINES | [9 hours] |
|---|---|
| Atmospheric pollution from automotive, stationary engines and gas turbines, Global warming – Greenhouse effect, Effects of engine pollution on human health and environment. | |
| **UNIT II – POLLUTANT FORMATION** | **[9 hours]** |
| Formation of Oxides of nitrogen, Carbon monoxide, Hydrocarbon, Aldehydes, Smoke and Particulate matter emissions. Effects of Engine design and operating variables on emission formation, Noise pollution. | |
| **UNIT III – EMISSION MEASUREMENT TECHNIQUES** | **[9 hours]** |
| CO, CO2 - Non dispersive infrared gas analyzer, NOx - Chemiluminescent analyzer, HC – Flame ionization detector, Smoke – Opacity and filter paper measurements, Particulate Matter – Full flow and Partial flow dilution tunnel, Gas chromatography, Noise measurement. | |

| UNIT IV – EMISSION CONTROL TECHNIQUES | [9 hours] |
|---|---|
| Engine design modifications, Fuel modification, Evaporative emission control, EGR, Air injection, Thermal reactors, Water injection, Common rail direct injection and Gasoline direct injection system, After treatment systems - Catalytic converters, Diesel oxidation catalyst, Particulate traps, De-NOx catalysts, SCR systems. Low temperature combustion concepts. | |
| **UNIT V – DRIVING CYCLES AND EMISSION STANDARDS** | **[9 hours]** |
| Transient dynamometer, Test cells, Driving cycles for emission measurement, chassis dynamometer, CVS system, National and International emission standards. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain about atmospheric pollution from engines and its impact on human health and environment. | K2 |
| **CO2** | Infer the formation of emissions in both SI and CI engines. | K2 |
| **CO3** | Interpret the various measurement techniques used globally for the measurement of automotive and stationary engine out emissions. | K2 |
| **CO4** | Illustrate the various control methods/techniques used in IC engine to control the engine out emissions | K2 |
| **CO5** | Summarize the transient and steady state driving cycles performed on automotive and stationary engines and emission standards that are followed in the national and international level. | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | 1 | - |
| **CO2** | 1 | - | - |
| **CO3** | 1 | - | - |
| **CO4** | 1 | - | - |
| **CO5** | 1 | - | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**


1. Crouse William, Automotive Emission Control, Gregg Division /McGraw-Hill,1980
2. Ernest, S., Starkman, Combustion Generated Air Pollutions, Plenum Press, 1980.
3. George Springer and Donald J Patterson, Engine emissions, Pollutant Formation and Measurement, Plenum press, 2013
4. Obert, E.F., Internal Combustion Engines and Air Pollution, Intext Educational Publishers,Third Edition, 1973.
5. Pundir B. P., "IC Engines Combustion and Emission" Narosa publishing house, 2010.

**Web Links and Video Lectures (E-Resources):**

1. Air pollution – engines : https://www.youtube.com/watch?v=aI8GcsTiL30
2. Pollutant formation : https://archive.nptel.ac.in/courses/105/104/105104099/
3. Emission measurement techniques : https://www.youtube.com/watch?v=QoruG4ma210
4. Emission control techniques : https://www.youtube.com/watch?v=BsJEBRdjGZw
5. Driving cycles and emission standards : https://archive.nptel.ac.in/courses/112/104/112104033/

**Suggested Skill Activities:**

1. Understanding Engine Emissions
2. Emission Sources & Effects
3. Emission Testing & Monitoring
4. Fuel & Combustion Efficiency
5. Advanced Engine Technologies for Pollution Control

| Course Code: | 24TE316 | Course Title: | Solar Thermal Technologies |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

- To clarify impression of various solar thermal energy collectors
- To delineate the other applications and the devices used to collect solar energy
- To study the various types and configurations of solar space conditioning system
- To learn the various solar applications.
- To summarize the basic economics of solar energy collection system.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – SOLAR COLLECTORS | [5 hours] |
|---|---|
| Collectors: Flat plate: Water, Air - Evacuated tube – Concentrated – Construction – Function - Suitability – Comparison – Design of Storage Tank - Solar Fluids. | |
| **UNIT II – SOLAR WATER HEATING SYSTEMS** | **[12 hours]** |
| Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools - Solar Heated Hot Tubs and Spas. | |
| **UNIT III – SOLAR SPACE CONDITIONING SYSTEMS** | **[12 hours]** |
| Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations – Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning. | |
| **UNIT IV – OTHER SOLAR APPLICATIONS** | **[10 hours]** |
| Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying – Solar Chimney. | |

| UNIT V – SOLAR ECONOMICS | [6 hours] |
|---|---|
| Application of economic methods to analyze the feasibility of solar systems to decide project / policy alternatives - Net energy analysis - and cost requirements for active and passive heating and cooling - for electric power generation - and for industrial process-heating. Economics – Fixed and variable cost - Payback period - Net Present Value - Internal Rate of Return - Carbon credit – Embodied energy analysis. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain the technical and physical principles of different solar collectors | K2 |
| **CO2** | Compare and evaluate different solar energy technologies through knowledge of the physical function of the devices | K2 |
| **CO3** | Interpret the technical and economic fundamentals of solar thermal energy conversion useful to society and industry | K2 |
| **CO4** | Demonstrate the spectrum of possible solar thermal technologies to assist industrial processing or power production | K2 |
| **CO5** | Contrast the technological and socio-economic issues around solar energy in a concise and an accessible way to a target group with basic technical skills. | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | - | 1 |
| **CO2** | 1 | 2 | - |
| **CO3** | - | - | - |
| **CO4** | - | - | - |
| **CO5** | - | - | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process - 4 th Edition (2013), John Wiley and Sons, New York, ISBN: 978-0-470-87366-3, Solar Energy Laboratory, University of Wisconsin-Madison, pp. 944.
2. H P Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, Springer, 2007.
3. Sukhatme S.P. J K Nayak, Solar Energy, Tata McGraw Hills P Co., ISBN: 9789352607112, 4th Edition, 2017, pp. 568.

4. Charles Christopher Newton - Concentrated Solar Thermal Energy- Published by VDM Verlag, 2008.
5. H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage Springer, 2005

**Web Links and Video Lectures (E-Resources):**

1. Solar collectors : https://www.youtube.com/watch?v=hGZva0QYN8A
2. Solar water heating systems : https://www.youtube.com/watch?v=yWi7sI0Jo6w
3. Solar space conditioning systems : https://archive.nptel.ac.in/courses/115/103/115103123/
4. Other solar applications : https://www.youtube.com/watch?v=iZyzvDj6Y3c
5. Solar economics : https://archive.nptel.ac.in/courses/112/105/112105051/

**Suggested Skill Activities:**

1. Understanding Solar Energy
2. Solar Water Heating Basics
3. Thermal Storage Experiment
4. Advanced Solar Thermal Systems
5. Thermal Storage & Heat Transfer

| Course Code: | 24TE344 | Course Title: | Design Thinking |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

- To provide a sound knowledge in UI & UX
- To understand the need for UI and UX
- Research Methods used in Design
- Tools used in UI & UX
- Creating a wireframe and prototype

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – UX LIFECYCLE TEMPLATE | [8 hours] |
|---|---|

Introduction. A UX process lifecycle template. Choosing a process instance for your project. The system complexity space. Meet the user interface team. Scope of UX presence within the team. More about UX lifecycles. Business Strategy. Value Innovation. Validated User Research. Killer UX Design. The Blockbuster Value Proposition. What Is a Value Proposition?.

| UNIT II – CONTEXTUAL INQUIRY | [10 hours] |
|---|---|

The system concept statement. User work activity data gathering. Look for emotional aspects of work practice. Abridged contextual inquiry process. Data-driven vs. model-driven inquiry. Organizing concepts: work roles and flow model. Creating and managing work

| | |
|---|---|
| activity notes. Constructing your work activity affinity diagram (WAAD). Abridged contextual analysis process. History of affinity diagrams. | |
| **UNIT III – SECURITY MANAGEMENT** | **[9 hours]** |
| Design-informing models: second span of the bridge. Some general "how to" suggestions. A New example domain: slideshow presentations. User models. Usage models. Work environment models. Barrier summaries. Model consolidation. Protecting your sources. Abridged methods for design-informing models extraction. Design paradigms. Design thinking. Design perspectives. User personas. Ideation. Sketching | |
| **UNIT IV – UX GOALS, METRICS, AND TARGETS** | **[8 hours]** |
| Introduction. UX goals. UX target tables. Work roles, user classes, and UX goals. UX measures. Measuring instruments. UX metrics. Baseline level. Target level. Setting levels. Observed results. Practical tips and cautions for creating UX targets. How UX targets help manage the user experience engineering process. | |
| **UNIT V – ANALYSING USER EXPERIENCE** | **[10 hours]** |
| Sharpening Your Thinking Tools. UX Research and Strength of Evidence. Agile Personas. How to Prioritize Usability Problems. Creating Insights, Hypotheses and Testable Design Ideas. How to Manage Design Projects with User Experience Metrics. Two Measures that Will Justify Any Design Change. Evangelizing UX Research. How to Create a User Journey Map. Generating Solutions to Usability Problems. Building UX Research Into the Design Studio Methodology. Dealing with Common objections to UX Research. The User Experience Debrief Meeting. Creating a User Experience Dashboard. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Summarize UI for user Applications | K2 |
| **CO2** | Interpret the UI Interaction behaviors and principles | K2 |
| **CO3** | Explain the UX design of any product or application | K2 |
| **CO4** | Demonstrate UX Skills in product development | K2 |
| **CO5** | Contrast the Sketching principles | K2 |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | - | 2 |
| **CO2** | 1 | - | 2 |
| **CO3** | 1 | - | 2 |
| **CO4** | 1 | - | 2 |
| **CO5** | 1 | - | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. UX for Developers: How to Integrate User-Centered Design Principles into Your Day-to- Day Development Work, Westley Knight. Apress, 2018.
2. The UX Book: Process and Guidelines for Ensuring a Quality User Experience, Rex Hartson, Pardha Pyla. Morgan Kaufmann, 2012.
3. UX Fundamentals for Non-UX Professionals: User Experience Principles for Managers,Writers, Designers, and Developers, Edward Stull. Apress, 2018.
4. Lean UX: Designing Great Products with Agile Teams, Gothelf, Jeff, Seiden, and Josh.O'Reilly Media, 2016
5. Designing UX: Prototyping: Because Modern Design is Never Static, Ben Coleman, and Dan Goodwin. SitePoint, 2017

**Web Links and Video Lectures (E-Resources):**

1. UX Lifecycle template : https://onlinecourses.nptel.ac.in/noc22_mg32/preview
2. Contextual inquiry : https://www.youtube.com/watch?v=t7l6EQjsBSY
3. Design thinking, ideation, and sketching : https://onlinecourses.nptel.ac.in/noc22_mg32/preview
4. UX Goals, metrics, and targets : https://archive.nptel.ac.in/courses/109/104/109104109/
5. Analyzing user experience : https://archive.nptel.ac.in/courses/112/105/112105316/

**Suggested Skill Activities:**

1. Hands on Design Thinking process for a product
2. Defining the Look and Feel of any new Project
3. Create a Sample Pattern Library for that product (Mood board, Fonts, Colors based on UI principles)
4. Identify a customer problem to solve.
5. Conduct end-to-end user research - User research, creating personas, Ideation process (User stories, Scenarios), Flow diagrams, Flow Mapping

| Course Code: | 24TE345 | Course Title: | Textile Reinforced Composites |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To Understanding Material Composition & Properties
- To exploring Manufacturing Techniques
- To enhancing Structural Performance & Durability
- To Simulate & Testing Methods

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – REINFORCEMENTS | [9 hours] |
|---|---|
| Introduction – composites –classification and application; reinforcements- fibres and its properties; preparation of reinforced materials and quality evaluation; preforms for various composites | |
| **UNIT II – MATRICES** | **[9 hours]** |
| Preparation, chemistry, properties and applications of thermoplastic and thermoset resins; mechanism of interaction of matrices and reinforcements; optimization of matrices | |
| **UNIT III – COMPOSITE MANUFACTURING** | **[9 hours]** |
| Classification; methods of composites manufacturing for both thermoplastics and thermosets- Hand layup, Filament Winding, Resin transfer moulding, prepregs and autoclave moulding, pultrusion, vacuum impregnation methods, compression moulding; post processing of composites and composite design requirements | |

| UNIT IV – TESTING | [9 hours] |
|---|---|
| Fibre volume and weight fraction, specific gravity of composites, tensile, flexural, impact, compression, inter laminar shear stress and fatigue properties of thermoset and thermoplastic Composites. | |
| **UNIT V – MECHANICS** | **[9 hours]** |
| Micro mechanics, macro mechanics of single layer, macro mechanics of laminate, classical lamination theory, failure theories and prediction of inter laminar stresses using at ware | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Explain the basics of concepts of reinforcements | K2 |
| **CO2** | Interpret the matrices of resins and optimizing techniques | K2 |
| **CO3** | Infer the thermoplastics and various methods in manufacturing | K2 |
| **CO4** | Illustrate the different testing process in composites | K2 |
| **CO5** | Demonstrate the mechanics and theories in manufacturing | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 2 | - | 2 |
| **CO2** | 2 | - | - |
| **CO3** | 2 | - | 2 |
| **CO4** | 2 | - | 1 |
| **CO5** | 2 | - | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped,
Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**


1. BorZ.Jang,"Advanced Polymer composites",ASM International,USA,1994.
2. Carlsson L.A. and Pipes R.B., "Experimental Characterization of advanced composite Materials",SecondEdition,CRCPress,NewJersey,1996.
3. George LubinandStanley T.Peters, "Handbook of Composites", Springer Publications,1998.
4. Mel. M. Schwartz, "Composite Materials", Vol. 1 &2, Prentice Hall PTR, New Jersey,1997.

5. Richard M.Christensen, “Mechanics of composite materials”, Dover Publications, 2005.
6. Sanjay K. Mazumdar, “Composites Manufacturing: Materials, Product, and Process Engineering”,CRC Press,2001

**Web Links and Video Lectures (E-Resources):**

1. Reinforcements : https://archive.nptel.ac.in/courses/116/102/116102057/
2. Matrices : http://acl.digimat.in/nptel/courses/video/116102057/L10.html
3. Composite Manufacturing : http://www.digimat.in/nptel/courses/video/112104221/L21.html
4. Testing : http://acl.digimat.in/nptel/courses/video/116102057/L04.html
5. Mechanics : http://www.digimat.in/nptel/courses/video/116102057/L09.html

**Suggested Skill Activities:**

1. Identify different textile reinforcement types (woven, knitted, braided, non-woven) through hands-on analysis.
2. Compare the mechanical properties of various textile fibers (glass, carbon, aramid, natural fibers).
3. Create a simple fiber-reinforced composite using fabric layers and resin.
4. Observe the effect of fiber orientation on composite strength.
5. Compare water absorption of textile-based composites with conventional materials.

| Course Code: | 24TE346 | Course Title: | Nano composite Materials |
|---|---|---|---|
| Credits: | 3 | L – T – P | 3-0-0 |

**Course objectives:**

To impart knowledge on the

- To Understanding Nanomaterials & Their Role in Composites.
- To Exploring Fabrication Techniques
- To Enhancing Mechanical & Functional Properties.
- To optimize processing parameters and material design.
- To investigate eco-friendly nanocomposites using bio-based or recycled nanomaterials.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Chalk and Talk
2. Lab experiment videos
3. Blended Mode of Learning
4. Project based Learning
5. Experiential Learning
6. NPTEL and Other Videos
7. Smart Class Room
8. Flipped Class

| UNIT I – BASICS OF NANOCOMPOSITES | [9hours] |
|---|---|
| Nomenclature, Properties, features and processing of nanocomposites. Sample Preparation and Characterization of Structure and Physical properties. Designing, stability and mechanical properties and applications of super hard nanocomposites. | |
| **UNIT II – METAL BASED NANOCOMPOSITES** | **[9 hours]** |
| Metal-metal nanocomposites, some simple preparation techniques and their properties. Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis. Core-Shell structured nanocomposites | |

| UNIT III POLYMER BASED NANOCOMPOSITES | [9 hours] |
|---|---|
| Preparation and characterization of diblock Copolymer based nanocomposites; Polymer Carbon Nano tubes based composites, their mechanical properties, and industrial possibilities. | |
| **UNIT IV – NANOCOMPOSITE FROM BIOMATERIALS** | **[9 hours]** |
| Natural nanocomposite systems - spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposites material; Use of synthetic nanocomposites for bone, teeth replacement. | |
| **UNIT V– NANOCOMPOSITE TECHNOLOGY** | **[9hours]** |
| Nanocomposite membrane structures- Preparation and applications. Nanotechnology in Textiles and Cosmetics-Nano-fillers embedded polypropylene fibers – Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes), Sun-screen dispersions for UV protection using titanium oxide – Colour cosmetics. Nanotechnology in Food Technology – Nano packaging for enhanced shelf life - Smart/Intelligent packaging. | |

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Classify the basics of nanocomposites | K2 |
| **CO2** | Explain the concepts of metal based nanocomposites | K2 |
| **CO3** | Infer the characterization of nanocomposites | K2 |
| **CO4** | Interpret the merits and demerits of nanocomposites | K2 |
| **CO5** | Illustrate the structure and membrane of nanocomposites | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 2 | - | - |
| **CO2** | 2 | 1 | 1 |
| **CO3** | 2 | 1 | 1 |
| **CO4** | 2 | - | 1 |
| **CO5** | 2 | 1 | 1 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) | CIE – I | 100 | 50 | 100 | 40 |
| | CIE – II | 100 | | | |
| | MCQ | 20 | 10 | | |
| | Skill Assessment - I | 40 | 40 | | |
| | Skill Assessment - II | 40 | | | |
| End Semester Examination (ESE) | Theory Exam | 100 | 60 | 60 | 60 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

**End semester Examination: (QP PATTERN)**

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

**Reference Books:**

1. Introduction to Nanocomposite Materials. Properties, Processing, Characterization- Thomas E. Twardowski. 2007. DEStech Publications. USA.
2. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V.Braun 2006.
3. Physical Properties of Carbon Nanotubes- R. Saito 1998.

4. Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
5. The search for novel, superhard materials- Stan Vepr¡ek (Review Article) JVST A,1999.
6. Nanometer versus micrometer-sized particles-Christian Brosseau, Jamal BeN Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003.
7. Diblock Copolymer, - Aviram (Review Article), Nature, 2002
8. Bikramjit Basu, Kantesh Balani Advanced Structural Ceramics, A John Wiley & Sons, Inc.,
9. P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006

**Web Links and Video Lectures (E-Resources):**

1. Basics of Nanocomposites : https://www.youtube.com/watch?v=t-pVi3IMdOk
2. Metal based Nanocomposites : https://www.youtube.com/watch?v=ScShTKcjEJ4
3. Polymer based Nanocomposites : http://www.digimat.in/nptel/courses/video/112104221/L28.html
4. Nanocomposite from biomaterials : https://archive.nptel.ac.in/courses/113/106/113106093/
5. Nanocomposite Technology : https://onlinecourses.nptel.ac.in/noc22_mm33/preview

**Suggested Skill Activities:**

1. Identify and compare different Nano fillers
2. Study how particle size and shape affect material properties.
3. Perform density and hardness tests on nanocomposites vs. conventional materials.
4. Observe nanoparticle dispersion in various solvents under a microscope.
5. Compare thermal and electrical conductivity of nanocomposite samples.

| Course Code: | 24TE351 | Course Title: | Technical Seminar - II |
|---|---|---|---|
| Credits: | 1 | L – T – P | 0-0-2 |

**Course objectives:**

To impart knowledge on the

- To enhance the reading ability required for identification of his/her field of interest.
- To develop skills regarding professional communication and technical report writing.
- To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
- To learn how to prepare and publish technical papers.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

Experiential Learning

**[30hours]**

1. The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues / technology.
2. The seminar shall be of 30 minutes' duration and give presentation to the Seminar Assessment Committee (SAC).
3. The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality.
4. A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
5. Each student has to submit a seminar report in the prescribed format given by the Institution.
6. In a session of three periods per week, 4 students are expected to present the seminar.
7. Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.
8. It is recommended that the report for Technical Seminar II may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Develop skills to read, write, comprehend and present research papers. | K3 |
| **CO2** | Demonstrate on recent areas of research in industrial safety engineering in two cycles. | K2 |
| **CO3** | Explain the Depth of understanding, coverage, quality of presentation material (PPT/OHP) | K2 |
| **CO4** | Develop the Communication skill. | K3 |
| **CO5** | Explain the advances in Industrial safety engineering/technology | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | - | 3 |
| **CO2** | 1 | - | - |
| **CO3** | 1 | - | - |
| **CO4** | 1 | - | 2 |
| **CO5** | - | - | 2 |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped,
Level 0- Not Mapped

**Scheme of Evaluation:**

| **Component** | **Type of assessment** | **Max Marks** | **Reduced Marks** | **Total** | **Final marks** |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) - Laboratory | Continuous Assessment | 75 | 75 | 100 | 60 |
| | Model Lab Exam | 25 | 25 | | |
| End Semester Examination (ESE) | Lab Exam | 100 | 15 | 40 | 40 |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

| Course Code: | 24TE352 | Course Title: | Project Work - I |
|---|---|---|---|
| Credits: | 6 | L – T – P | 0-0-12 |

**Course objectives:**

To impart knowledge on the

- To improve the skills in reading technical magazines, conference proceedings and journals.
- To develop the skill of identifying research problems/projects in the field of Thermal Engineering.
- To familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

Experiential Learning

Project based Learning

**[90hours]**

1. Each student has to identify the topic of project related to the field of Thermal Engineering.
2. 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.
3. The topic has to be approved by a review committee constituted by the department.
4. The work has to be presented periodically in front of the review committee.
5. The preparation of report consisting of a detailed problem statement and a literature review.
6. The preliminary results (if available) of the problem may also be discussed in the report.
7. The project report should be presented in standard format as provided by the Anna University.

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Develop skills to read, write, comprehend and present research papers. | K3 |
| **CO2** | Demonstrate on recent areas of research in industrial safety engineering in two cycles. | K2 |
| **CO3** | Explain the Depth of understanding, coverage, quality of presentation material (PPT/OHP) | K2 |
| **CO4** | Develop the Communication skill. | K3 |
| **CO5** | Explain the advances in Industrial safety engineering/technology | K2 |

**COs and POs Mapping:**

| COs | POs | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | - | - |
| **CO2** | 1 | - | - |
| **CO3** | 1 | - | - |
| **CO4** | 1 | - | - |
| **CO5** | 1 | - | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| Component | Type of assessment | Max Marks | Reduced Marks | Total | Final marks |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) - Laboratory | Review I | 20 | 20 | 20 | 20 |
| | Review II | 20 | 20 | | |
| | Review III | 20 | 20 | | |
| End Semester Examination (ESE) | Thesis | 100 | 100 | 80 | 80 |
| | Viva -Voce | | | | |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | **1** | **2** | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |

| Course Code: | 24TE451 | Course Title: | Project Work - II |
|---|---|---|---|
| Credits: | 12 | L – T – P | 0-0-24 |

**Course objectives:**

To impart knowledge on the

- To improve the skills in publishing technical papers in conference proceedings and journals.
- To produce factual results of their applied research idea in the Thermal engineering, from phase – I.

**Teaching-Learning Process:**

Suggested strategies that teachers may use to effectively achieve the course outcomes:

Experiential Learning

Project based Learning

**[90hours]**

1. Each student has to complete project (phase II) under the guidance of a faculty member, as specified in Phase I.
2. 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.
3. The topic has to be approved by a review committee constituted by the department.
4. The work has to be presented periodically in front of the review committee.
5. 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.
6. The report must bring out the conclusions of the work and future scope for the study.
7. The project report should be presented in standard format as provided by the Anna University.

**Course outcomes:**

On completion of the course, the student will have the ability to:

| | | |
|---|---|---|
| **CO1** | Develop skills to read, write, comprehend and present research papers. | K3 |
| **CO2** | Demonstrate on recent areas of research in industrial safety engineering in two cycles. | K2 |
| **CO3** | Explain the Depth of understanding, coverage, quality of presentation material (PPT/OHP) | K2 |
| **CO4** | Develop the Communication skill. | K3 |
| **CO5** | Explain the advances in Industrial safety engineering/technology | K2 |

**COs and POs Mapping:**

| **COs** | **POs** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| **CO1** | 1 | - | - |
| **CO2** | 1 | - | - |
| **CO3** | 1 | - | - |
| **CO4** | 1 | - | - |
| **CO5** | 1 | - | - |

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

**Scheme of Evaluation:**

| **Component** | **Type of assessment** | **Max Marks** | **Reduced Marks** | **Total** | **Final marks** |
|---|---|---|---|---|---|
| Continuous Internal Examination (CIE) - Laboratory | Review I | 20 | 20 | 20 | 20 |
| | Review II | 20 | 20 | | |
| | Review III | 20 | 20 | | |
| End Semester Examination (ESE) | Thesis | 100 | 100 | 80 | 80 |
| | Viva -Voce | | | | |
| | | | | Total | 100 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | Terminal Examination |
|---|---|---|---|
| | 1 | 2 | |
| **Remember** | 20 | 20 | 20 |
| **Understand** | 20 | 60 | 40 |
| **Apply** | 60 | 20 | 40 |
| **Analyze** | 0 | 0 | 0 |
| **Evaluate** | 0 | 0 | 0 |
| **Create** | 0 | 0 | 0 |