# MECHANICAL ENGINEERING

## M.Tech
## Thermal Power Engineering

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI,620015
TAMIL NADU,INDIA

# M.Tech Degree
# In
# Thermal Power Engineering

Curriculum Structure

(for Students Admitted in 2024-25 onwards)


Department of Mechanical Engineering

National Institute of Technology

Tiruchirappalli

## VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

## MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

## VISION OF THE DEPARTMENT

To be a globally renowned Department in Mechanical Engineering where the best of teaching, learning and research synergize to fulfil the requirements of industry and society.

## MISSION OF THE DEPARTMENT

The Mechanical Engineering Department is committed to

- Prepare effective and responsible engineers for global requirements by providing quality education through graduate, post graduate and doctoral research programmes.
- Constantly strive to improve the teaching and learning processes by adopting innovative pedagogical methods.
- Respond effectively to the needs of the industry and society by offering sustainable and innovative solutions
- Conduct basic and interdisciplinary research to publish in reputed international journal and to generate intellectual property.
- Provide consultancy services and cultivate the spirit of entrepreneurship.

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

| | |
|---|---|
| **PEO1** | Graduates will be successful and socially responsible thermal engineers |
| **PEO2** | Graduates will possess the habit of continuous learning in the emerging thermal engineering technology and advanced field of study |
| **PEO3** | Graduates will work harmoniously in group with ethical and professional code of conduct. |

## PROGRAMME OUTCOMES (POs)

| | |
|---|---|
| **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 thermal power engineering. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |

## CURRICULUM

### SEMESTER I

| Code | Course of Study | Credit |
|---|---|---|
| ME601 | Mathematical Methods | 4 |
| ME602 | Advanced Fluid Mechanics | 4 |
| ME603 | Advanced Heat Transfer | 4 |
| | Programme Elective I | 4 |
| | Programme Elective II | 3 |
| | Programme Elective III / Online (NPTEL) | 3 |
| ME607 | Advanced Thermal Engineering Lab | 2 |
| | | **24** |

### SEMESTER II

| Code | Course of Study | Credit |
|---|---|---|
| ME604 | Fuels Combustion and Emission Control | 4 |
| ME605 | Heat Transfer Equipment Design | 4 |
| ME606 | Analysis and Design of Pressure Vessels | 4 |
| | Programme Elective IV | 4 |
| | Programme Elective V | 3 |
| | Programme Elective VI / Online (NPTEL) | 3 |
| ME608 | Advanced Engineering Simulation Lab | 2 |
| | | **24** |

### SUMMER TERM (evaluation in the III semester)

| Code | Course of Study | Credit |
|---|---|---|
| ME609 | Internship / Industrial Training / Academic Attachment (I/A) (6 weeks to 8 weeks) | 2 |

### SEMESTER III

| Code | Course of Study | Credit |
|---|---|---|
| ME747 | Project Work (Phase I) | 12 |

### SEMESTER IV

| Code | Course of Study | Credit |
|---|---|---|
| ME748 | Project Work (Phase II) | 12 |

## PROGRAMME ELECTIVES (PE)

### Program Elective Course with 4 credits

| Sl. No | Course Code | Course name | Credits |
|---|---|---|---|
| 1 | ME611 | Fluid Mechanics of Turbomachines | 4 |
| 2 | ME612 | Computational Fluid Dynamics | 4 |
| 3 | ME613 | Finite Element Method in Heat Transfer Analysis | 4 |
| 4 | ME614 | Mechanical Shock and vibration | 4 |
| 5 | ME615 | Thermal Piping Analysis and Design | 4 |

### Program Elective Course with 3 credits

| Sl. No | Course Code | Course name | Credits |
|---|---|---|---|
| 1 | ME621 | Energy Conservation, Management, and Audit | 3 |
| 2 | ME622 | Boiler Auxiliaries and Performance Evaluation | 3 |
| 3 | ME623 | Safety in Thermal and Nuclear Power Plants | 3 |
| 4 | ME624 | Boiler Production Technology | 3 |
| 5 | ME625 | Installation, Testing and Operation of Boilers | 3 |
| 6 | ME626 | Cogeneration and waste Heat Recovery Systems | 3 |
| 7 | ME627 | Advanced IC Engines | 3 |
| 8 | ME628 | Power Plant Instrumentation | 3 |
| 9 | ME629 | Refrigeration and Cryogenics | 3 |
| 10 | ME630 | Analysis of Thermal Power Cycles | 3 |
| 11 | ME631 | Design and Optimization of Thermal Energy Systems | 3 |
| 12 | ME632 | Hydrogen production, handling and storage | 3 |
| 13 | ME633 | Industrial ventilation and air-conditioning systems | 3 |

## OPEN ELECTIVES (OE)

| Sl. No. | Code | Course of Study | Credit |
|---|---|---|---|
| 1. | ME631 | Design and Optimization of Thermal Energy Systems | 3 |
| 2. | ME632 | Hydrogen production, handling and storage | 3 |
| 3. | ME633 | Industrial ventilation and air-conditioning systems | 3 |

## COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING

## PROGRAMME CORE (PC)

| Course Code | Course Title | CO | PO1 | PO2 | PO3 |
|---|---|---|---|---|---|
| ME601 | Mathematical Methods | CO1 | 3 | 2 | 1 |
| | | CO2 | 3 | 2 | 1 |
| | | CO3 | 3 | 1 | 1 |
| | | CO4 | 2 | 3 | 1 |
| | | CO5 | 3 | 1 | 1 |
| ME602 | Advanced Fluid Mechanics | CO1 | 3 | 1 | 3 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 3 | 1 | 3 |
| | | CO4 | 3 | 2 | 3 |
| | | CO5 | 2 | 1 | 3 |
| ME603 | Advanced Heat Transfer | CO1 | 3 | 1 | 3 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 3 | 1 | 3 |
| | | CO4 | 2 | 1 | 3 |
| | | CO5 | 3 | 1 | 3 |
| ME604 | Fuels Combustion and Emission Control | CO1 | 2 | 1 | 3 |
| | | CO2 | **2** | 1 | 3 |
| | | CO3 | 3 | 1 | 3 |
| | | CO4 | 2 | **1** | 3 |
| | | CO5 | 3 | **1** | 3 |
| ME605 | Heat Transfer Equipment Design | CO1 | 1 | 1 | 2 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 2 | 1 | 3 |
| | | CO4 | 2 | 1 | 3 |
| | | CO5 | 2 | 1 | 3 |
| ME606 | Analysis and Design of Pressure Vessels | CO1 | 2 | 1 | 3 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 2 | 1 | 2 |
| | | CO4 | 3 | 2 | 3 |
| | | CO5 | 2 | 3 | 2 |

## PROGRAMME ELECTIVES (PE)

| Course Code | Course Title | CO | PO1 | PO2 | PO3 |
|---|---|---|---|---|---|
| ME611 | Fluid Mechanics of Turbomachines | CO1 | 3 | 3 | 2 |
| | | CO2 | 3 | 3 | 2 |
| | | CO3 | 3 | 3 | 2 |
| | | CO4 | 3 | 3 | 3 |
| | | CO5 | 3 | 3 | 3 |
| ME612 | Computational Fluid Dynamics | CO1 | 3 | 2 | 3 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 3 | 2 | 3 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 3 | 2 | 3 |
| ME613 | Finite Element Method in Heat Transfer Analysis | CO1 | 3 | 2 | 3 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 3 | 1 | 3 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 2 | 2 | 3 |
| ME614 | Mechanical Shock and vibration | CO1 | 3 | 1 | 3 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 3 | 2 | 2 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 3 | 2 | 3 |
| ME615 | Thermal Piping Analysis and Design | CO1 | 3 | 1 | 3 |
| | | CO2 | 2 | 1 | 2 |
| | | CO3 | 1 | 2 | 3 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 2 | 1 | 2 |
| ME621 | Energy Conservation, Management, and Audit | CO1 | 2 | 3 | 3 |
| | | CO2 | 2 | 3 | 2 |
| | | CO3 | 2 | 3 | 2 |
| | | CO4 | 2 | 3 | 2 |
| | | CO5 | 1 | 3 | 2 |
| ME622 | Boiler Auxiliaries and Performance Evaluation | CO1 | 2 | 1 | 3 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 2 | 1 | 3 |
| | | CO4 | 2 | 1 | 3 |
| | | CO5 | 2 | 2 | 3 |
| ME623 | Safety in Thermal and Nuclear Power Plants | CO1 | 2 | 1 | 3 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 3 | 1 | 3 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 2 | 1 | 3 |
| ME624 | Boiler Production Technology | CO1 | 3 | 1 | 2 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 3 | 2 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| | | CO4 | 2 | 1 | 3 |
| | | CO5 | 2 | 1 | 3 |
| ME625 | Installation, Testing and Operation of Boilers | CO1 | 2 | 1 | 3 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 1 | 1 | 3 |
| | | CO4 | 3 | 2 | 3 |
| | | CO5 | 3 | 2 | 3 |
| ME626 | Cogeneration and waste Heat Recovery Systems | CO1 | 3 | 1 | 3 |
| | | CO2 | 2 | 3 | 2 |
| | | CO3 | 3 | 2 | 3 |
| | | CO4 | 2 | 1 | 2 |
| | | CO5 | 3 | 2 | 3 |
| ME627 | Advanced IC Engines | CO1 | 3 | 1 | 3 |
| | | CO2 | 3 | 2 | 2 |
| | | CO3 | 3 | 1 | 3 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 3 | 2 | 2 |
| ME628 | Power Plant Instrumentation | CO1 | 3 | 1 | 3 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 3 | 2 | 2 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 2 | 3 | 2 |
| ME629 | Refrigeration and Cryogenics | CO1 | 3 | 1 | 2 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 2 | 1 | 2 |
| | | CO4 | 3 | 1 | 2 |
| | | CO5 | 2 | 1 | 3 |
| ME630 | Analysis of Thermal Power Cycles | CO1 | 1 | 1 | 3 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 2 | 1 | 3 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 3 | 1 | 3 |
| ME631 | Design and Optimization of Thermal Energy Systems | CO1 | 2 | 2 | 2 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 3 | 1 | 3 |
| | | CO4 | 3 | 1 | 3 |
| | | CO5 | 3 | 1 | 3 |
| ME632 | Hydrogen production, handling and storage | CO1 | 2 | 1 | 3 |
| | | CO2 | 3 | 1 | 2 |
| | | CO3 | 3 | 2 | 3 |
| | | CO4 | 3 | 2 | 3 |
| | | CO5 | 3 | 2 | 3 |
| ME633 | Industrial ventilation and air-conditioning systems | CO1 | 3 | 1 | 3 |
| | | CO2 | 3 | 1 | 3 |
| | | CO3 | 3 | 2 | 3 |
| | | CO4 | 2 | 2 | 2 |
| | | CO5 | 3 | 1 | 3 |

## ESSENTIAL PROGRAMME LABORATORY REQUIREMENTS

| Course Code | Course Title | CO | PO1 | PO2 | PO3 |
|---|---|---|---|---|---|
| ME607 | Advanced Thermal Engineering Lab | CO1 | 3 | 1 | 2 |
| | | CO2 | 3 | 2 | 3 |
| | | CO3 | 3 | 3 | 2 |
| | | CO4 | 3 | 2 | 2 |
| | | CO5 | 3 | 2 | 2 |
| ME608 | Advanced Engineering Simulation Lab | CO1 | 3 | 2 | 3 |
| | | CO2 | 2 | 1 | 3 |
| | | CO3 | 3 | 2 | 3 |
| | | CO4 | 2 | 2 | 2 |
| | | CO5 | 3 | 2 | 3 |

**3 - High; 2 - Medium; 1 - Low**

# SYLLABUS

| | | |
|---|---|---|
| **Course Code** | **:** | ME601 |
| **Course Title** | **:** | Mathematical Methods |
| **Type of Course** | **:** | PC |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

## Course Learning Objectives (CLO)

| | |
|---|---|
| **CLO1** | To introduce the numerical methods for solving various equations in engineering field. |
| **CLO2** | To compute numerical methods for solving ODEs and PDEs |
| **CLO3** | To develop own code/scripts for the different numerical schemes |
| **CLO4** | To execute curve fitting and regression analysis |
| **CLO5** | To solve boundary and initial value problems |

## Course Content

Introduction: Numerical precision in digital computing and its effect on numerical calculations, Taylorseries and truncation, Rounding off errors, Introduction to programming

System of Equations and Eigen values: Review of solution methods to system of linear equations, Computation of Eigen values, solution of algebraic equations (univariate and multivariate non-linear equations, root finding and optimization), Well-conditioned and ill conditioned system, Matrix and vector norms

Interpolation, differentiation and integration: Interpolation (polynomial, Lagrange interpolation, error estimates, piecewise polynomial, Hermite, Spline, 2D (rectangle and triangle)), Curve Fitting/Regression, Numerical Differentiation, Numerical Integration (Simpson’s rule, Guass Quadrature)

Ordinary Differential Equations: Initial value problems (Euler Method, RK methods, Predictor corrector methods), Boundary Value Problems (Shooting method, FDM, FEM, Weighted residuals, FVM).

Partial Differential Equations - Introduction to PDEs, classification of PDEs, Numerical solutions methods, Laplace and Poisson Equations, Iterative methods (Jacobi, Guass-Seidal, steepest decentand conjugate gradient) Coding the iterative methods in MATLAB/C++/Fortran

## References


| | |
|---|---|
| 1. | S. P. Venkateshan, Prasanna Swaminathan, Computational Methods in Engineering, Ane Books |
| 2. | Steven C. Chapra, Numerical Methods for Engineering, Mc-Graw Hill Education |
| 3. | Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel. Dekker (2001) |
| 4. | Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Numerically compute solution of system of equations through programing. |
| **CO2** | Compute numerical solution for ODE and PDE using coding |
| **CO3** | Evaluate various iterative methods using computer programming |
| **CO4** | Perform curve fitting and regression analysis |
| **CO5** | Solve boundary value problem and initial value problem numerically |

| | | |
|---|---|---|
| **Course Code** | **:** | ME602 |
| **Course Title** | **:** | Advanced Fluid Mechanics |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To familiarize with the properties of fluids and the applications of fluid mechanics. |
| **CLO2** | To classify flows and to understand and apply the conservation principles for fluid flows. |
| **CLO3** | To formulate and analyze fluid problems related to calculation of drag and lift forces. |
| **CLO4** | To understand the principles of dimensional analysis. |
| **CLO5** | To develop a basic understanding of the characteristics of turbulent flows with their engineering applications. |

**Course Content**

Introduction to indicial notation of representing vectors and tensors – inner and outer products – directional derivatives – gradient, divergence and curl – Divergence & Stokes theorems.

Fluid Kinematics - Reynold's transport theorem - Physical conservation laws - Integral and differential formulations - Navier-Stokes and energy equations - Dimensionless forms and dimensionless numbers

Two-dimensional Potential flows - Different types of flow patterns, elementary complex potentials and their superpositions – uniform flow past cylinder – method of images – circle theorem - conformal mapping.

Exact Solution of Navier-Stokes equations – Couette flow - Poiseuille Flow – flow between rotating cylinders – Stokes first and second problems

Momentum integral approach - Boundary layer concept - Boundary layer thickness-Prandtl's equations - Blasius solution-skin friction coefficient.

Turbulent flows - Reynolds equation and closure problems, free and wall bounded shear flows- Prandtl and von Karman hypothesis- Universal velocity profile near a wall-flow through pipes.

**References**


| | |
|---|---|
| 1. | Currie, LG., *Fundamental Mechanics of Fluids, 3rd* ed., CRC Press, 2002. |
| 2. | White, P.M., *Viscous Fluid Flow, 2nd* ed., McGraw-Hill, 1991. |
| 3. | Ockendon, H. and Ockendon, J., *Viscous Flow,* Cambridge Uni. Press, 1995. |
| 4. | Tennekesse, H. and Lumley, JL., *A first course in turbulence*, MIT Press, 1971. |
| 5. | Kundu, P.K., Ira Cohen, M., Dowling, DR., *Fluid mechanics*, Elsevier, 1990. |
| 6. | Jog, C.S., *Fluid Mechanics - Foundation and Application of Mechanics (vol 2)*, Cambridge Uni. Press, 3rd ed., 2015 |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Understand the principles of continuity, momentum, and energy as applied to fluid flow |
| **CO2** | Recognize these principles written in form of mathematical equations. |
| **CO3** | Express any fluid-flow problem as a set of governing equations and identify appropriate boundary conditions |
| **CO4** | Solve simple fluid flow problems using appropriate mathematical techniques |
| **CO5** | Apply dimensional analysis to predict physical parameters that influence the flow in fluid |

| | | |
|---|---|---|
| **Course Code** | **:** | ME603 |
| **Course Title** | **:** | Advanced Heat Transfer |
| **Type of Course** | **:** | PC |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To understand steady state and transient heat conduction |
| **CLO2** | To compare, design and optimization of different fin profiles for engineering applications |
| **CLO3** | To understand boundary layers and to formulate convection correlations |
| **CLO4** | To understand the phase change heat transfer in engineering applications |
| **CLO5** | To discuss thermal radiation, view factor, gas radiation, radiation effect on temperature measurement. |

**Course Content**

Steady state heat conduction, Extended surfaces – Steady state analysis - Longitudinal fin of rectangular, triangular and spline profile radiating to free space – Radial fins, Transient heat conduction.

Thermal boundary layers – Momentum and energy equations (With Proof), Simplification of the Momentum Equations, Simplification of the Energy Equations, correlations for convection – Internal and external flows – Forced convection – turbulence in convection.

Heat transfer with phase change – Condensation and boiling heat transfer phenomena, Laminar Film Condensation on a Vertical Plate, Condensation on Outer Surface of a Horizontal Tube, Effect of non-condensable gases in condensing equipment – Relations for boiling heat transfer, heat pipe.

Thermal radiation – View factor - Radiation shields, Radiation energy Exchange – Gas radiation –Effect of Radiation in engineering applications.

**References**


| | |
|---|---|
| 1. | Ozisik, M.N., *Heat Transfer - A Basic Approach*, McGraw-Hill, 1987. |
| 2. | Incropera, P.P. and Dewitt, D.P., *Fundamentals of Heat and Mass Transfer*, 5th ed., John Wiley, 2002. |
| 3. | Bejan, A., *Heat Transfer*, John Wiley & Sons Inc., 1993. |
| 4. | Kakac, S. and Yener, Y., *Convective Heat Transfer*, CRC Press, 1995. |
| 5. | Kraus, A.D., Aziz, A., and Welty, J., *Extended Surface Heat Transfer*, John Wiley, 2001. |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Discuss and analyse about steady state and transient heat conduction. |
| **CO2** | Analyze and optimize various fins like rectangular, triangular and parabolic profiles for heat transfer applications. |

| | |
|---|---|
| **CO3** | Understand and solve thermal boundary layers, momentum and energy equations |
| **CO4** | Comprehend the heat transfer associated with phase changes in engineering applications. |
| **CO5** | Analyze thermal and gas radiation in heat transfer equipment. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME604 |
| **Course Title** | **:** | Fuels, Combustion and Emission Control |
| **Type of Course** | **:** | PC |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To study fuels production and processing methods and their properties |
| **CLO2** | To evaluate flame temperature, stoichiometric ratios and chemical reaction rate |
| **CLO3** | To apply simplified conservation equations for laminar and turbulent reacting flows |
| **CLO4** | To distinguish the factors influencing flame characteristics and emission formation |
| **CLO5** | To understand flame stabilization and ignition for designing combustor. |

**Course Content**

Types of fuels and their properties – fuel production and processing methods – Coal characterization – Propellants – Thermochemistry – Property Relations – Stoichiometry – Heat of reaction/formation – Adiabatic Flame Temperature – Equilibrium Products of Combustion – Mass transfer

Chemical kinetics – Reaction rates – Chemical Mechanisms – Steady state and Partial equilibrium approximations – Chain reactions and explosion limits – Coupling chemical & thermal analyses of reacting systems.

Simplified Conservation equations for reacting flows – Schvab Zeldovich Formulations – Laminar Premixed Flames – Simplified analysis – Factors influencing flame velocity and thickness – Flammability limits – Quenching – Ignition – Flame stabilization

Laminar diffusion flames – Droplet evaporation and burning – Turbulent Premixed & diffusion flames – Deflagration and detonation – Rankine-Hugoniot Relations – Detonation structure – Combustion of solid propellants – Combustion instabilities

Emission formation and reduction mechanism – nitrogen oxides – Sulphur oxides – soot – sooting tendencies – structure – influence of physical and chemical parameters – Emission legislation and control strategies

**References**


| | |
|---|---|
| 1. | Irvin Glassman, Nick G. Glumac and Richard A. Yetter, Combustion, 5$^{th}$ edition Academic Press, 2014. |
| 2. | Turns S.R., An Introduction to Combustion: Concepts and Applications, 4$^{th}$ Edition, McGraw Hill, 2021. |
| 3. | Kenneth K Kuo, Principles of Combustion, 2$^{nd}$ edition, John Wiley, 2012 |
| 4. | Williams F. A., Combustion Theory, 2$^{nd}$ edition, CRC Press. 2018 |
| 5. | Sharma, S.P. and Mohan, C., Fuels and Combustion, Tata McGraw-Hill, 1987. |
| 6. | Sarkar. S., Fuels and Combustion, 3$^{rd}$ edition Universities Press, 2009. |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Describe the fuel production or processing methods and their properties |
| **CO2** | Determine the flame temperature, stoichiometric ratios and chemical reaction rate |
| **CO3** | Apply simplified conservation equations for laminar and turbulent reacting flows. |
| **CO4** | Illustrate the factors influencing flame characteristics and emission formation. |
| **CO5** | Apply the different principles of flame stabilization and ignition to design combustor. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME605 |
| **Course Title** | **:** | Heat Transfer Equipment Design |
| **Type of Course** | **:** | PC |
| **Prerequisites** | **:** | ME 605 – Advanced Heat Transfer |
| **Contact Hours** | **:** | 04 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives**

| | |
|---|---|
| **CLO1** | To understand the types of heat transfer equipment and various flow patterns |
| **CLO2** | To study shell and tube heat exchanger and other types of heat exchangers for special services |
| **CLO3** | To understand the design procedure of air preheaters, economizers, superheaters, condensers and cooling towers for thermal power plants |
| **CLO4** | To design plate and compact heat exchangers for industries |
| **CLO5** | To select a suitable heat exchanger for any given application |

**Course Content**

Classification of heat transfer equipment, Heat transfer correlations, Overall heat transfer coefficient, Analysis of heat exchangers – LMTD and effectiveness methods – Fouling factors.

Design of shell and tube heat exchanger – Kern's method and Bell's method – Shell and tube condenser, Finned surface heat exchanger, Heat exchangers for special services, Fired heaters

Plate and spiral plate heat exchanger – Plate types – Flow Patterns – Plate heat exchanger for dairy industry, Heat pipes – Applications – Wick material – Construction – Performance calculations – Limitations.

Thermal design of heat exchange equipment such as Air preheater, Economizer and Superheater

Compact heat exchangers – Selection – Types of Cores – Heat transfer and pressure drop calculations, Cooling towers – Types – Performance characteristics – Design Procedure.

**References**


| | |
|---|---|
| 1. | Ozisik, M.N., Heat Transfer - A Basic Approach, McGraw-Hill, 1985 |
| 2. | Coulson and Richardson, Chemical Engineering Design, Vol.6, Elsevier Butterworth-Heinemann, 2005 |
| 3. | Ganapathy, V., Applied Heat Transfer, Pennwell Books, 1982 |
| 4. | Kays, W.M. and London, A.L., Compact Heat Exchangers, Mc Graw-Hill, 1998 |
| 5. | Kakac, S. and Liu, H., Heat Exchangers, CRC Press, 2002 |
| 6. | Shah, R.K and Sekulic, D.S., Fundamentals of Heat Exchanger Design, John Wiley & Sons, Inc., 2003 |
| 7. | Dunn, P. and Reay, D.A., Heat Pipes, Pergamon, 1994 |

**Course Outcomes**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Classify the various heat transfer equipment |
| **CO2** | Design shell and tube heat exchanger & condenser for power plants and process industries |
| **CO3** | Understand the heat transfer and pressure drop calculations in finned surface, plate and special purpose heat exchangers for thermal engineering industries |
| **CO4** | Analyze the performance of air preheaters, economizers and superheaters for power plants |
| **CO5** | Design compact heat exchangers and cooling towers |

| | | |
|---|---|---|
| **Course Code** | **:** | ME606 |
| **Course Title** | **:** | Analysis And Design Of Pressure Vessels |
| **Type of Course** | **:** | PC |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To impart basic knowledge of the design of pressure vessels and piping systems. |
| **CLO2** | To introduce the various standards used for the pressure vessel design. |
| **CLO3** | To understand the development of cracks, fracture mechanisms and corrosion |
| **CLO4** | To perform finite element analysis on high-pressure and temperature components |
| **CLO5** | To develop the ability to apply BIS codes through case studies and assignments related to pressure vessel design. |

**Course Content**

Establishment of design conditions – Fracture Mechanics – Heads, Basic shell thickness - Reinforcement of openings – Special components like flange, tube plate, supports.

Cylindrical shells – Thick cylinders- Lame's solution - Theories of breakdown of elastic action – Unrestrained solution – Lateral loading – General loading. Axisymmetric loading - Membrane solutions - Edge bending solutions - Flexibility matrix.

Application of general analysis – Flat closure plates –conical heads and reducers – hemispherical and torispherical, ellipsoidal heads.

Development of cracks - Fracture mechanics - Corrosion - Selection of working stress for ductile and brittle materials.

Finite element analysis for high-pressure and high-temperature components

Pressure vessel design case studies and assignments utilizing BIS codes.

**References**


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|---|---|
| 1. | Bickell, M.B. and Ruiz, c., Pressure Vessel Design and Analysis, MacMillan, London, 1967. |
| 2. | Den Hartog, J.P., Advanced Strength of Materials, McGraw-Hill, 1949. |
| 3. | Timoshenko, S., Strength of Materials, Van Nostrand, 1986. |
| 4. | Dennis Moss, Pressure vessel design manual, Gulf Professional Publishing, 2004. |
| 5. | John F. Harvey, Theory and Design of Pressure Vessels, Van Nostrand Reinhold Company, New Yark, 1985. |

**Course Outcomes (CO)**

At the end of the course, students will be able

| | |
|---|---|
| **CO1** | Analyze thin plates and shells for various types of stresses. |
| **CO2** | Design shells, end closures, and nozzles of pressure vessels using ASME codes. |
| **CO3** | Understand the fracture and corrosion mechanism |
| **CO4** | Analyze the FEM models on high-pressure and temperature components |
| **CO5** | Evaluate pressure vessel designs through case studies and assignments using BIS codes. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME607 |
| **Course Title** | **:** | Advanced Thermal Engineering Lab |
| **Type of Course** | **:** | ELR |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 2 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To study the performance and emission characteristics of IC engine |
| **CLO2** | To analyze the production, optimization, and characterization of alternate fuels. |
| **CLO3** | To determine the spray and flame characteristics of low carbon fuels. |
| **CLO4** | To measure thermal properties of liquids and study phase change materials. |
| **CLO5** | To study the modes of heat transfer and analyse HVAC systems and unsteady state heat transfer equipment. |

**List of Experiments**

1. Simulation of the combustion and emission formation process in IC engine
2. Combustion, Performance and emission characteristics of SI engines
3. Combustion, Performance and emission characteristics of CI engines
4. Production, optimization and characterization studies of alternate fuels
5. Thermal property estimation of liquids in various processes with ASPEN Plus
6. Determination of calorific value of solid and liquid fuels using a bomb calorimeter
7. Ammonia gas leak detection and quantification
8. Study on the performance and emission of gasifier
9. Spray characterization with optical diagnostic techniques
10. Study on the flame characteristics with micro-combustor
11. Conduct experiments on the charging and discharging behaviour of PCMs used in thermal energy storage
12. Unsteady state heat transfer equipment
13. Radiation errors in temperature measurement
14. Pool boiling heat transfer
15. Cooling Tower
16. AC Tutor
17. VCR Test Rig

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Analyze the performance and emission characteristics of IC engines. |
| **CO2** | Conduct production, optimization, and characterization studies of alternate fuels. |
| **CO3** | Measure thermal properties of liquids and study phase change materials. |
| **CO4** | Understand the mechanism of heat transfer and evaluate the unsteady state heat transfer. |
| **CO5** | Evaluate the performance of air-conditioning and refrigeration systems. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME608 |
| **Course Title** | **:** | Advanced Engineering Simulation Lab |
| **Type of Course** | **:** | ELR |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 2 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To learn the modeling of various thermal systems |
| **CLO2** | To provide basic knowledge on code development and commercial simulation software usage |
| **CLO3** | To understand the applications of different thermal systems |
| **CLO4** | To conduct fundamental combustion simulations |
| **CLO5** | To comprehend pre-processing and post-processing techniques for defined computational problems |

**List of experiments:**

Basics: Code development for 1D and 2D Diffusion equations using finite volume method / finite difference method by different adopting numerical schemes

Fluid flow Problems: Analyzing Flow over an airfoil, flow through pipes, boundary layer development and laminar and turbulent flow conditions using CFD package

Heat transfer Problems: Analyzing Heat transfer characteristics in heat exchangers, battery thermal management systems and jet impingement using CFD package

Combustion Problems: 0D and 1D analysis with chemical kinetic simulations and engine sector mesh simulations

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Develop basic codes by applying the proper discretization techniques and numerical method schemes. |
| **CO2** | Acquire knowledge in various fluid flow using computational fluid dynamics software |
| **CO3** | Simulate the steady and unsteady state heat transfer problems using computational fluid dynamics software |
| **CO4** | Execute the preprocessing and post-processing techniques for defined computational problems |
| **CO5** | Perform fundamental combustion simulations with detailed chemical species. |

| | | |
|---|---|---|
| **Course Code** | : | ME611 |
| **Course Title** | : | Fluid Mechanics of Turbomachines |
| **Type of Course** | : | PE |
| **Prerequisites** | : | Nil |
| **Contact Hours** | : | 4 |
| **Course Assessment Methods** | : | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To understand the basic concepts and flow equations of turbomachines and to learn concepts of velocity triangles of turbomachines and flow through cascades. |
| **CLO2** | To compare and choose machines for various operations of various of turbomachines. |
| **CLO3** | To understand the operating principles and fluid flow mechanisms of various types of turbomachines and |
| **CLO4** | To analyze the use of turbomachines for various engineering applications. |
| **CLO5** | To understand and formulate various design procedures and to optimum design of turbomachines |

**Course Content**

Introduction and cascades - Two-dimensional cascades - Analysis of cascade forces – Energy losses – Cascade correlation – Off design performance.

Power generating machine I - Axial flow turbines- Stage losses and efficiency – Soderberg"s correlation – Turbine flow characteristics

Power generating machine II - Radial flow turbines, Loss coefficients – off design operating condition – clearance and windage losses 90° IFR turbines.

Power absorbing machine I - Axial flow compressors, pumps, and fans – Three-dimensional flow in axial turbo machines – theory of radial equilibrium – actuator disc approach – Secondary flows

Power absorbing machine II - Centrifugal pumps, fans, and compressors – slip factor – optimum design of centrifugal compressor inlet choking in a compressor stage.

**References**


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|---|---|
| 1. | Dixon, S. L., *Fluid Mechanics and Thermodynamics of Turbomachinery, 5th* ed., Butterworths Heinemann, 2005. |
| 2. | William W, Peng, *Fundamentals of Turbomachinery*, John Wiley & Sons, 2007 |
| 3. | Lakshminarayana, B., *Fluid Dynamics and Heat Transfer of Turbomachinery*, Wiley, 1995. |
| 4. | Yahya, S.M., *Turbines, Compressor and Fans,* 3rd Edition, Tata McGraw Hill, 2005. |
| 5. | Earl Logan, *Turbomachinery – Basic Theory and Applications*, Marcel Dekker Inc. 1993. |
| 6. | Csanady, G.T., *Theory of Turbomachines,* McGraw Hill, 1964. |
| 7. | Cascade Aerodynamics, J. P. Gostelow, Pergamon Press, 1984. |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Explain basic concepts in terms of geometrical and fluid flow mechanism in support of flow equations of turbomachines. |
| **CO2** | Describe applications and limitations of various types of turbomachines and they will be in a position to select proper turbomachine with technical justification. |
| **CO3** | Discuss about the various design procedures of turbomachines and by which they can optimize the mechanical design of turbomachines in terms of various geometrical and dynamic parameters. |
| **CO4** | Design a complete experimentation in terms of design of turbomachines based on construction and operating principles of various fluid flow measuring instruments and their accessories. |
| **CO5** | Analyze the performance characteristics of turbomachines under off-design conditions and propose methods to improve efficiency and minimize energy losses. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME612 |
| **Course Title** | **:** | Computational Fluid Dynamics |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To introduce numerical modeling and its role in the field of heat transfer and fluid flow. |
| **CLO2** | To understand the various discretization methods for simplifying the differential equations |
| **CLO3** | To apply different numerical solution methods for the system of equations |
| **CLO4** | To numerically solve steady and unsteady state diffusion and convection diffusion problems |
| **CLO5** | To solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers |

**Course Content**

Computational Fluid Dynamics: What, When, and Why?, CFD Advantages and Applications, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. Approximate Solutions of Differential Equations: Error Minimization Principles, Functional involving higher order derivatives, Essential and natural boundary conditions,

Discretization methods - Finite Element Method and Finite difference methods: Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples and Some Conceptual Basics and Implementation of boundary conditions. Discretization of Unsteady State Problems: 1-D unsteady state diffusion problems: implicit, fully explicit and Crank- Nicholson scheme

Important Consequences of Discretization of Time Dependent Diffusion Type Problems: Consistency, Stability, Convergence, Grid independent and time independent study, Stability analysis of parabolic and hyperbolic equations. Finite Volume Discretization of 2-D unsteady State Diffusion type Problems: FVM for 2-D unsteady state diffusion problems

Solution of Systems of Linear Algebraic Equations: Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search methods with examples. Norm of a vector, Norm of a matrix, Some important properties of matrix norm, Error analysis of elimination methods.

Finite volume discretization of Convection-Diffusion Equations: Schemes. The concept of false diffusion, QUICK scheme. Discretization of Navier Stokes Equations: Discretization of the Momentum Equation, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm. What is there in implementing a CFD code: The basic structure of a CFD code: Pre-processor, Solver and Postprocessor, User-defined subroutines.

### References



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|---|---|
| 1. | Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997. |
| 2. | Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000. |
| 3. | Anderson J.D., Computational Fluid Dynamics – The basics with Applications, Mc Graw-Hill, 1995. |
| 4. | Versteeg, H.K. and Malalasekera, W., *An Introduction to Computational Fluid Dynamics – The finite volume method*, Longman Scientific & Technical, 1995. |
| 5. | Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980. |
| 6. | Date A.W., *Introduction to Computational Fluid Dynamics*, Cambridge University Press, 2005. |



### Course Outcomes (CO)

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Express numerical modeling and its role in the field of fluid flow and heat transfer. |
| **CO2** | Estimate the various errors and approximations associated with numerical techniques. |
| **CO3** | Apply the various discretization methods and solution procedures to solve flow and heat transfer problems. |
| **CO4** | Perform stability analysis for different numerical schemes |
| **CO5** | Evaluate the best method for a given thermo-fluids problem. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME613 |
| **Course Title** | **:** | Finite Element Method in Heat Transfer Analysis |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To Understand the concepts behind variational methods and weighted residual methods in FEM. |
| **CLO2** | To Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3-D element. |
| **CLO3** | To learn the theory and characteristics of finite elements that represent engineering structures. |
| **CLO4** | To apply Suitable boundary conditions to a global structural equation, and reduce it to a solvable form. |
| **CLO5** | To identify how the finite element method expands beyond the structural domain, for problems involving dynamics, heat transfer, and fluid flow. |

**Course Content**

Introduction, Weighted Residual Methods, Shape functions, Coordinate systems, Numerical Integration.

Modeling of Heat Conduction, Variational Formulation, Galerkin‟s Approach for one dimensional and two dimensional problems

One-dimensional Problem solved using a single element – Linear element, Quadratic element, the use of numerical integration. A one-dimensional problem solved using an assembly of elements.

Time stepping methods for Heat Transfer – Galerkin's approach in Non-linear transient heat conduction problems.

Basic Equations, Galerkin's Methods for steady Convection – Diffusion problems, Upwind Finite Elements in One Dimension, Heat Transfer in fluid flow between parallel planes, Convection on melting and solidification.

**References**


| | |
|---|---|
| 1. | Thomas, HR., Seetharamu, KN., Morgan, KR., and Lewis, W., *The Finite Element Method in Heat Transfer Analysis*, John Wiley & Sons Inc, 1996. |
| 2. | Lewis, RW., Nithiarasu P., and Seetharamu KN., *Fundamentals of the Finite Element Method for Heat and Fluid Flow*, Wiley; 1st edition, 2004. |
| 3. | Reddy, JN., and Gartling DK., *The Finite Element Method in Heat Transfer and Fluid Dynamics,* CRC Press; 2nd edition, 2000. |
| 4. | Taylor, C., and Hughes, JB., *Finite Element Programming of the Navier-Stokes Equation*, Pineridge Press Limited, U.K., 1981. |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Understand the concepts behind variational methods and weighted residual methods in FEM. |
| **CO2** | Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements, and 3-D element. |
| **CO3** | Develop element characteristic equation procedure and generation of global stiffness equation will be applied. |
| **CO4** | Apply Suitable boundary conditions to a global structural equation, and reduce it to a solvable form. |
| **CO5** | Identify how the finite element method expands beyond the structural domain, for problems involving dynamics, heat transfer, and fluid flow. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME614 |
| **Course Title** | **:** | Mechanical Shock and Vibration |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | Classify the characteristics of Vibration and shock and Estimate the natural frequency of structural and Continuous system. |
| **CLO2** | Introduce to various Instruments for vibration measurement and its measuring technique. |
| **CLO3** | Demonstrated with various frequency analysis of vibration and shock. |
| **CLO4** | Illustrate the need of vibration Isolation and control. |
| **CLO5** | Introduced to shock and vibration analysis using Finite element analysis |

**Course Content**

Characteristics of vibration & shock - Periodic vibration-Stationary random vibration-Transient phenomena and shocks-Non Stationary random vibrations, Response of mechanical system due to vibration - Response of linear and nonlinear system for vibrations-rotational & torsional vibrations- Response of mechanical system due to random vibration-Shock response & shock spectra-Vibration in structures- Shock and vibration analysis using FEA-Statistical energy analysis

Effects of vibration and shock on mechanical system - Damaging effects of vibration-Damaging effects of shock & transients, Effects of vibration and shock on man - Whole body vibration-Hand & arm vibration

Vibration measuring instrumentation and techniques - General measurement consideration-Selection of accelerometer-Selection of accelerometer pre amplifier-Calibration & system perfectness check- Force & impedance transducers - Mounting of accelerometers-Lab oriented instrumentation

Frequency analysis of vibration and shock - Introduction- Serial analysis of stationary signals-Real time analysis of transient and stationary signals-Analysis of non-stationary signals, Vibration measurement for machine health monitoring - Basic consideration- Force vibration relationships- Frequency range, dynamic range parameters-Use of vibration measurements for maintenance

Vibration and shock testing - Vibration testing-Shock testing, Fundamentals of shock and vibration control - Isolation of vibration and shock-Dynamic vibration control-Vibration damping.

**References**


| | |
|---|---|
| 1. | Broch, JT., *Mechanical Vibration and Shock Measurements*, Bruel & Kjaer, Denmark, 2nd Edison, 1984. |
| 2. | Dossing, O., *Structural Testing Part I & Part II*, Bruel &Kjaer, Denmark, 1988. |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Analyze and predict the response of mechanical systems to various vibration and shock excitations. |
| **CO2** | Understand the damaging effects of vibration and shock on mechanical systems, structures, and human beings. |
| **CO3** | Acquire practical skills in vibration and shock measurement, instrumentation, and data analysis techniques |
| **CO4** | Apply principles of vibration and shock control for the design and optimization of mechanical systems. |
| **CO5** | Utilize computational tools like FEA-SEA for the analysis and prediction of vibration and shock behaviour in complex systems |

| | | |
|---|---|---|
| **Course Code** | **:** | ME615 |
| **Course Title** | **:** | Thermal Piping Analysis and Design |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 4 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To understand the various stresses applied in pipes due to fluid pressure |
| **CLO2** | To learn the stable and unstable deformations |
| **CLO3** | To familiarize with code and standards |
| **CLO4** | To analyze the failure theories |
| **CLO5** | To understand the structural loading |

**Course Content**

Stresses in pipes due to fluid pressure – Collapsing pressure – Thin and thick walled cylinders – Code formulae for pipe wall thickness – Losses in piping systems – Effect of curvature on resistance of bends.

Stable and unstable deformations – Plastic deformation under uniaxial stress – Tri-axial stress – Yield condition – Plastic stress - strain relationship for tri-axial stress – Failure and Plastic Instability – Creep – Brittle and ductile fracture – Fatigue.

Codes and standards – Design considerations: Loadings – Design limits, Allowable stresses and Allowable stress ranges – Stress Evaluation – Combination of Stresses: Stress Intensification and Flexibility Factors – Evaluation of Deflections and Reactions.

Introduction – Failure theories: Maximum principal stress theory and Maximum shear stress theory – stress categories – stress limits – fatigue – Classification of loads – service limits – code requirements.

Structural loading: In-plane bending moment (closing and opening), Out of plane moment – Internal and External pressure – Combined loading – Occasional loads – Creep – Fatigue –Stress analysis – Shakedown –Limit analysis – Calculation of Collapse and Instability loads – Corrosion and Erosion Effects – Case studies using Finite Element Method.

**References**


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|---|---|
| 1. | The American Society of Mechanical Engineers, "*ASME Boiler and Pressure Vessel code*", New York, ASME, 2004. |
| 2. | King R.C., "*Piping Handbook*", 5th edition, McGraw Hill Book Company, 1973. |
| 3. | Nayyar, Mohinder L, "*Piping Handbook*",7th edition, McGraw Hill, 2000. |
| 4. | John F. Harvey, "*Theory and Design of Pressure Vessels*", CBS Publishers, 2001. |
| 5. | The M.W. Kellogg Company, *Design of Piping Systems*", 2nd edition, John Wiley & Sons, 1956. |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Understand the various stresses applied in pipes due to fluid pressure |
| **CO2** | Explain the stable and unstable deformations |
| **CO3** | Familiarize with code and standards |
| **CO4** | Analyze the failure theories |
| **CO5** | Describe the structural loading |

| | | |
|---|---|---|
| **Course Code** | **:** | ME621 |
| **Course Title** | **:** | Energy Conservation, Management, and Audit |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To provide a comprehensive understanding of energy fundamentals, energy sources, and their applications in addressing global energy demand and supply challenges. |
| **CLO2** | To equip students with the knowledge and skills to conduct both preliminary and detailed energy audits. |
| **CLO3** | To develop the ability to assess the efficiency of thermal and electrical utilities and implement appropriate energy conservation measures. |
| **CLO4** | To impart knowledge of economic and project planning techniques, including life cycle costing and financial management. |
| **CLO5** | To enhance awareness of global environmental concerns, resource conservation, and the integration of energy-efficient technologies in industrial and commercial systems. |

**Course Content**

Fundamentals of Energy and Energy Scenario – Grades of Energy - Non-Conventional and Renewable Energy - Energy demand and supply - Energy Management and Audit - Material and Energy Balance - Energy Action Planning - Financial Management - Project Management - Energy Monitoring and Targeting.

Energy Audit - preliminary and detailed energy audit methodology – technical and economic feasibility – understanding energy costs – benchmarking and energy performance – Energy audit instruments – Responsibilities of Energy Manager - Energy Conservation Act.

Thermal Energy Management - Energy Efficiency and Performance Assessment in Thermal Utilities - Fuels and Combustion - Boilers - Steam System - Furnaces - Insulation and Refractory - FBC Boilers - Cogeneration - Biomass Utilization - Waste heat recovery - Turbines (Gas, Steam).

Electrical Energy Management - Energy Efficiency and Performance Assessment in Electrical Systems - Electric Motors - Compressed Air System - HVAC and Refrigeration System - Fans and Blowers - Pumps and Pumping System - Cooling Tower - Lighting System - Diesel Power Plant - Energy Efficient Technologies in Electrical Systems.

Economic Analysis and Project Planning Techniques – Life Cycle Cost and Life Cycle Assessment - Waste Minimization and Resource Conservation - Global Environmental Concerns – Energy Conservation Measures – Goal Setting in Energy Management – Support and Commitment of Top Management – Formulation of an Action Plan – Case Studies.

**References**


| | |
|---|---|
| 1. | *Guide book for National Certification Examination for Energy Managers and Energy Auditors,* Bureau of energy efficiencies, 2005. |
| 2. | Eastop T.D & Croft D.R, *Energy Efficiency for Engineers and Technologists*, Logman Scientific & Technical, ISBN-0-582-03184, 1990. |
| 3. | Mehmet Kanoğlu, Yunus A. Çengel, *Energy Efficiency and Management for Engineers,* 1st Edition, McGraw-Hill Education, 2020. |
| 4. | Reay D.A, *Industrial Energy Conservation*, 1st edition, Pergamon Press, 1977. |
| 5. | Witte, LC., Schmidt, P.S., and Brown, DR., *Industrial Energy Management & Utilization*, United States, 1988. |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Analyze energy fundamentals, energy demand and supply, and the application of renewable and non-conventional energy sources to address global energy challenges. |
| **CO2** | Conduct preliminary and detailed energy audits using appropriate instruments and methodologies, and evaluate energy performance for benchmarking and optimization. |
| **CO3** | Assess the efficiency and performance of thermal utilities such as boilers, steam systems, furnaces, and waste heat recovery systems to recommend conservation strategies. |
| **CO4** | Evaluate electrical utilities, including motors, HVAC, lighting systems, and compressed air systems, to propose energy-efficient technologies and conservation measures. |
| **CO5** | Apply economic and project planning techniques, such as life cycle costing and financial management, to design and implement effective energy conservation and management strategies. |

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|---|---|---|
| **Course Code** | **:** | ME622 |
| **Course Title** | **:** | Boiler Auxiliaries and Performance Evaluation |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

### Course Learning Objectives (CLO)

| | |
|---|---|
| **CLO1** | To understand the concepts of boiler types, circulation system and desuperheaters |
| **CLO2** | To understand the types of fuel and ash handling equipment |
| **CLO3** | To learn feed pumps and air draft system |
| **CLO4** | To familiarize with the working principal of electrostatic precipitator |
| **CLO5** | To learn soot blowers selection, operation and maintenance |

### Course Content

Boiler types – Specification – Circulating systems - Efficiency calculation - Balance diagram – Drum Internals – Desuperheaters.

Fuel and Ash handling Equipment – Mills - Specification – Selection – Operation – Maintenance.

Feed pumps – Different types, Specifications, Operation and maintenance aspects - Fans, blowers – Applications – Performance requirements, Selection, Operation and maintenance.

Dust cleaning equipment – Selection criteria – Design, operation and maintenance of electro static precipitators, Bag filters.

Soot blowers – Various types and their constructional features – Specifications – Selection – Operation and Maintenance.

### References


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|---|---|
| 1. | *Modern Power Station Practice,* CEGB London, Pergamon Press, 1991. |
| 2. | Eck, B., *Fans,* Pergamon Press, 1973. |
| 3. | Shields, C.D., *Boilers, Types Characteristics and Functions,* McGraw-Hill, 1961. |


### Course Outcomes (CO)

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Understand the concepts of boiler types, circulation systems and desuperheaters |
| **CO2** | Understand the types of fuel and ash handling equipment |
| **CO3** | Describe the feed pumps and air draft system |
| **CO4** | Familiarize with the working principal of electrostatic precipitator |
| **CO5** | Explain soot blowers selection, operation and maintenance |

| | | |
|---|---|---|
| **Course Code** | **:** | ME623 |
| **Course Title** | **:** | Safety in Thermal and Nuclear Power Plants |
| **Type of Course** | **:** | PC / PE / OE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

### Course Learning Objectives (CLO)

| | |
|---|---|
| **CLO1** | To learn the general safety consideration in handling of materials in thermal power plant |
| **CLO2** | To identify the explosions and implosions of furnace |
| **CLO3** | To understand the chemical and fuel handling systems |
| **CLO4** | To understand the safety, operation, and maintenance of critical mechanical and electrical systems. |
| **CLO5** | To discuss safety in nuclear power plants, safety features and radioactive waste disposal atomic energy act. |

### Course Content

General safety considerations to be followed in material handling - Access requirements and welding. Safety in Commissioning of Thermal Power Plant Equipment - Steam blowing safety valve floating - Commissioning of rotary equipment.

Furnace explosions and implosions - Fire and other emergencies in boiler house - Mill bay - Air preheater bay - Cable racks and transformers - Pressure and nonpressure parts - Controls and protection logics.

Hydrogen plant - Cooling water system - Chemical handling - Fuel handling systems for coal, oil and gas - Electrostatic precipitator and H.V. rectifier.

Pressure parts - underground piping - Piping with a medium such as inflammable gas or vapour - Air pre-heaters and fans - Burner system - Closed vessels - Turbo generators - Switch-gears and transformers.

Safety in Nuclear Power Plants - Basic concepts - Radiation hazards and control practices - Reactor design safety features - Radioactive waste disposal Atomic Energy act - Radiation protection rules.

### References


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|---|---|
| 1. | Sterman, LS., *Thermal and Nuclear Power Stations*, MIR Publications, 1986. |
| 2. | El. Vakil, MM., *Nuclear Power Technology*, McGraw Hill, 1992. |
| 3. | Loffness, RL., *Nuclear Power Plant*, Van Nostrand, 1987. |
| 4. | Lish, KC., *Nuclear Power Plants Systems and Equipment*, Industrial Press, New York, 1972. |
| 5. | *Fossil Power Systems*, Combustion Engineering, 1990. |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Explain the general safety consideration in handling of materials |
| **CO2** | Identify the explosions and implosions of furnace |
| **CO3** | Understand the chemical and fuel handling systems |
| **CO4** | Understand the safety, operation, and maintenance of critical mechanical and electrical systems. |
| **CO5** | Understand the safety procedures to be followed in nuclear power plants |

| | | |
|---|---|---|
| **Course Code** | **:** | ME624 |
| **Course Title** | **:** | Boiler Production Technology |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To illustrate stresses in pipes due to fluid pressure and to review code formulae for pipe wall thickness and to compute losses in piping systems |
| **CLO2** | To distinguish stable and unstable deformations and to analyze failure and plastic instability |
| **CLO3** | To discuss loadings, design limits, allowable stresses, and evaluation of stresses |
| **CLO4** | To explain failure theories involved in piping |
| **CLO5** | To distinguish in-plane bending moment and out of plane moment and to discuss occasional loads, creep, fatigue and stress analysis |

**Course Content**

Mechanics of metal working, Effect of temperature, stain rate and metallurgical structure on metal working. Workability, Residual stresses. Casting of Valves components, coal compartment assembly. Forging - Open die forging and closed die forging, different types of dished ends, Cold bending - Explosive and hydrodynamic forming of dished ends.

Types of rolling - rolling of bars and shapes, forces and geometrical relationship in rolling, rolling defects. Edge preparation: Beveling of tubes for headers, drums, stubs. Tube Expanders.

Welding and allied processes an overview – SMAW – GTAW, GMAW, Resistance welding, Electron beam welding, ultrasonic welding, Laser welding, Friction welding, Plasma arc welding,

Welding metallurgy – Thermal effects – heat treatment associated with welding, testing and inspection – Destructive and Non-Destructive welding. Welding Joint design – location- symbol.

Manufacture of pressure vessel components – manufacture of boiler drums, headers, structures, water walls, super heaters, mills, fans. Manufacture of heat exchangers and nuclear components.

**References**


| | |
|---|---|
| 1. | *ASM Metals Handbook, Forming and Forging*, Vol.14, Metals Park, Ohio, USA, 1990. |
| 2. | Dieter, G.E., *Mechanical Metallurgy*, McGraw-Hill Co. 1995. |
| 3. | Lange, K., *Hand book of Metal Forming*, McGraw Hill Book Company, 1985. |
| 4. | *AWS Welding Hand Books*, Section 1 to VIII, American Welding Society, 1996. |
| 5. | Jeffus, LF., *Welding: principles and applications*, 5$^{th}$ edition, Delmer Publishers, 2004 |


**Course Outcomes (CO)**

At the end of the course student will be able

| | |
|---|---|
| **CO1** | To illustrate stresses in pipes due to fluid pressure and to review code formulae for pipe wall thickness and to compute losses in piping systems |
| **CO2** | To distinguish stable and unstable deformations and to analyze failure and plastic instability |
| **CO3** | To discuss loadings, design limits, allowable stresses, and evaluation of stresses. |
| **CO4** | To explain failure theories involved in piping |
| **CO5** | To distinguish in-plane bending moment and out of plane moment and to discuss occasional loads, creep, fatigue and stress analysis |

| | | |
|---|---|---|
| **Course Code** | **:** | ME625 |
| **Course Title** | **:** | Installation Testing and Operation Of Boilers |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To familiarize with the procedure and techniques of installing supporting structures |
| **CLO2** | To understand mounting installation, sealing, and erection of ESP, rotary APH, fans, ducts, dampers, and cold pull techniques. |
| **CLO3** | To choose modern boilers by using material characteristics |
| **CLO4** | To explain commissioning and pre-commissioning activities of boilers |
| **CLO5** | To predict life estimation for very old boilers and illustrate the thermal performance tests and capacity restoration |

**Course Content**

Methods and procedure of installation supporting structure - Civil foundations - sequence of Erection - HSFC Bolts. Pressure parts erection and alignment. - Provision for expansion.

Mountings - Seal boxes & seal welding, Erection of ESP, Rotary APH and fans - alignment and grouting of fans. Erection of ducks and dampers - „Cold Pull‟.

Lining and Insulation - Material characteristics and selection, Arrangements of refractory/insulation in modern boilers - methods of application.

Commissioning activities - Objectives - Pre commissioning checks - chemical cleaning Initial operation - Boiler turning and performance optimization.

Special commissioning checks - Preventive maintenance of boilers and auxiliaries, tube failures - causes and prevention - life estimation for very old boilers - Thermal performance tests and capacity restoration.

**References**


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|---|---|
| 1. | *Erection of Boilers and Auxiliary Equipment,* Manuals Prepared by B.H.E.L., Tiruchirappalli, 1990. |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Familiarize with the installation of supporting structures |
| **CO2** | Know Mountings, erection, alignment, grouting basics. |
| **CO3** | Know the boiler mountings, insulation and linings |
| **CO4** | Analyze the commissioning activities |
| **CO5** | Understand the thermal performance and capacity restoration |

| | | |
|---|---|---|
| **Course Code** | **:** | ME626 |
| **Course Title** | **:** | Cogeneration and Waste Heat Recovery Systems |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To learn the waste heat recovery and analyze the basic energy generation cycles. |
| **CLO2** | To detail about the concept of cogeneration, its types, and probable areas of applications. |
| **CLO3** | To study the significance of waste heat recovery systems and carry out its economic analysis. |
| **CLO4** | To understand the environmental considerations waste heat recovery and cogeneration |
| **CLO5** | To develop strategies for the implementation and optimization of cogeneration and waste heat recovery systems in various industrial applications. |

**Course Content**

Cogeneration - overview of historical development and the evolution of cogeneration technologies- Thermodynamic Principles Applied to Cogeneration, energy, entropy, and exergy consideration - Combined Cycles-Topping - Bottoming - Organic Rankine Cycles - Integration of Heat and Power Production, Advantages of Cogeneration Technology

Cogeneration Application. Sizing of waste heat boilers - Performance calculations, Part load characteristics - selection of Cogeneration Technologies, Matching Technology to Application Requirements – Financial considerations, Cost-Benefit Analysis, Economic Feasibility, Payback Period and Return on Investment (ROI).

Waste heat recovery - Importance and Potential of Waste Heat Recovery, Types and Sources of Waste Heat in Industrial Processes Second Law of Thermodynamics - Entropy, Exergy, and the Second Law of Thermodynamics, Maximizing Efficiency in Waste Heat Utilization. Integration of Waste Heat Recovery in Power Generation, Case Studies in Power Plant Waste Heat Recovery

Waste heat recovery systems - Design Considerations - fluidized bed heat exchangers - heat pipe exchangers - heat pumps -thermic fluid heaters - selection of waste heat recovery technologies – Lifecycle Thinking-Economic, Environmental, and Operational Factors

Environmental considerations for cogeneration and waste heat recovery - Emission Reduction through Cogeneration and Waste Heat Recovery, Environmental Regulations and Compliance Sustainability and Life Cycle Assessment of Cogeneration Systems.

**References**


| | |
|---|---|
| 1. | Butler, CH., *Cogeneration*, McGraw Hill Book Co., 1984. |
| 2. | Horlock JH., *Cogeneration - Heat and Power, Thermodynamics and Economics*, |

| | |
|---|---|
| | Oxford,1987. |
| 3. | Institute of Fuel, *Waste Heat Recovery*, Chapman & Hall Publishers, London, 1963. |
| 4. | Subrata, S., Lee, SS., *EDS, Waste Heat Utilization and Management*, Hemisphere, Washington, 1983. |
| 5. | Nevers, D., Noel, *Air Polllution Control Engineering*, McGrawHill, New York,1995. |
| 6. | Meera Sheriffa Begum K.M., Anand Ramanathan, Amaro Olimpio Pereira Junior, Dmitrii Glushkov, M. Angkayarkan Vinayakaselvi “Waste to Profit-Environmental Concerns and Sustainable Development”, Taylor & Francis, CRC Press, 2023 |



**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Understand the principles of cogeneration systems, waste heat recovery systems |
| **CO2** | Describe the economic analysis of combined heat and power systems |
| **CO3** | Describe the significance of waste heat recovery systems and carry out its economic analysis |
| **CO4** | Understand the environmental consideration waste heat recovery and cogeneration |
| **CO5** | Formulate and propose practical solutions for the adoption and enhancement of cogeneration and waste heat recovery systems. |

| | | |
|---|---|---|
| **Course Code** | **:** | **ME 627** |
| **Course Title** | **:** | **ADVANCED IC ENGINES** |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To study the combustion phenomena and performance analysis of a SI and CI engines. |
| **CLO2** | To understand the formation of exhaust gases, control strategies and its measurement techniques. |
| **CLO3** | To study the mechanism of different subsystem used in an engine test bed facility |
| **CLO4** | To study the recent technologies adopted for improving the engine performance and emission characteristics |
| **CLO5** | To apply the advanced imaging techniques used for combustion and spray characterization. |

**Course Content**

**SI and CI engines:** Mixture requirements – Stages of combustion – Normal and Abnormal combustion, Knock and Pre-ignition – Factors influencing knock – Gasoline and diesel Fuel injection systems Fuel Spray behavior – Spray structure and spray penetration – Air motion: Tumble, Swirl & Squish – Different Combustion chamber geometries – Super charging and Turbo charging

**Emission Formation and Control:** Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Exhaust Gas Analysis – Methods of controlling emissions – In-cylinder treatments: Injection strategies, Exhaust gas recirculation, Spark Advancement – After treatment systems: Three Way Catalytic converter, SCR, LNT, DOC, DPF and Particulate Traps.

**Engine Testing and Measurement Systems:** Test cells and dynamometer – Fuel and airflow measurement system – in-cylinder pressure transducers and crank angle encoders – Emission standards and driving cycles – Methods and principles of emission measurement – Non-dispersive infrared gas analyzer, chemi-luminescent analyzer, flame ionization detector, smoke meters and soot analyzer

**Advanced Combustion concepts:** Low Temperature Combustion – Homogeneous charge compression ignition (HCCI) – Reactivity Controlled Compression Ignition (RCCI) – Advanced Ignition system – Gasoline Compression Ignition – Multi-stroke engines – Recent technological developments

**Combustion Visualization:** Optical Engine, Endoscopic access & optical chambers – In-cylinder flow and species measurements: Particle image velocimetry – Laser Doppler Anemometry – Planar Laser induced Fluorescence – Schlieren and shadowgraphy techniques – Chemi-luminescence Imaging.

**References**


| | |
|---|---|
| 1. | Heywood, JB., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988. |
| 2. | Ganesan, V., Internal Combustion Engines, 4th edition, McGraw-Hill, 2017. |
| 3. | R.K. Maurya, Reciprocating Engine Combustion Diagnostics, Springer, 2018. |
| 4. | G. Kalghatgi, Fuel and Engine Interactions, SAE Publications, 2014. |
| 5. | Heinz Heisler, Advanced Engine Technology, SAE Publications, 1995 |
| 6. | R.K. Maurya, Characteristics and Control of Low Temperature Combustion Engines, Springer, 2018. |
| 7. | Hua Zhao, Laser Diagnostics and Optical Measurement Techniques in Internal Combustion Engine, SAE Publications, 2008. |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Understand the combustion phenomena and performance of SI and CI engines. |
| **CO2** | Identify the pollutants formation mechanism and measurement techniques. |
| **CO3** | Understand the mechanism of different subsystem used in an engine test bed facility |
| **CO4** | Explain the advanced combustion concepts used to increase engine efficiency and reduce emission levels |
| **CO5** | Illustrate the advanced imaging techniques used for combustion and spray characterization. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME628 |
| **Course Title** | **:** | Power Plant Instrumentation |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To provide knowledge on various measuring instruments for thermal engineering. |
| **CLO2** | To familiarize with static and dynamic features of instruments |
| **CLO3** | To understand the various steps involved in error analysis and uncertainty analysis. |
| **CLO4** | To provide knowledge on advance measurement techniques. |
| **CLO5** | To impart knowledge on different control systems |

**Course Content**

Generalized instrumentation system – Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity- Signal conditioning systems.

Static and dynamic characteristics of instruments zero order, first order, second order instruments.

Error analysis - Uncertainty propagation – Oscilloscope for analysis of dynamic and transient events.

Principles and analysis of measurement systems used for measurement of flow, power, pressure, and temperature.

Basics of control system - Types of control – proportional control, Derivative control, Integral control, PID control-Programmable logic controllers.

**References**


| | |
|---|---|
| 1. | Doebelin, EO., *Measurement Systems - Application and Design, 5th* ed., McGraw-Hill, 2004. |
| 2. | Beckwith, TG., Buck, L., and Marangoni, RD., *Mechanical Measurements,* Narosa Pub. House,1987. |
| 3. | Hewlett Packard, *Practical Temperature Measurements* - Application Note 290, 1995. |
| 4. | Barnery, Intelligent Instrumentation, Prentice Hall of India, 1988. |
| 5. | Bolton, W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001. |
| 6. | Holman JP., Experimental methods for engineers, McGraw-Hill, 2012. |
| 7. | Webster, JG., The measurement, Instrumentation and sensors Handbook, CRC and IEE Press, 1999. |
| 8. | Morris, AS, Principles of Measurements and Instrumentation Prentice Hall of India, 1998. |
| 9. | Nakra, BC., Choudhry KK., Instrumentation, Measurements and Analysis Tata McGraw Hill, New Delhi, 2nd Edition 2003. |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Employ knowledge on various measuring instruments for thermal engineering. |
| **CO2** | Familiarize with static and dynamic features of instruments |
| **CO3** | Understand the various steps involved in error analysis and uncertainty analysis. |
| **CO4** | Analyze on advance measurement techniques. |
| **CO5** | Explain on different control systems |

| | | |
|---|---|---|
| **Course Code** | **:** | ME629 |
| **Course Title** | **:** | Refrigeration and Cryogenics |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To build a solid foundation in the fundamentals of Refrigeration and cryogenics |
| **CLO2** | To Evaluate the merits of Refrigeration and Cryogenic systems and their usage |
| **CLO3** | To Analyse the performance of Refrigeration and Cryogenic systems |
| **CLO4** | To Select and identify refrigeration and Cryogenic system for any given application |
| **CLO5** | To understand the properties of engineering materials at low temperatures |

**Course Content**

Introduction about Refrigeration – Definitions of various terms. Methods of refrigeration. Air refrigeration system. Bell – Coleman cycle.

Properties of refrigerants. Selection of refrigerants. Sustainable refrigerants. Analysis of Vapour compression cycle, Modifications to basic cycle. Multi pressure systems. Multi-evaporator system and Cascade systems. Discussion of components of V.C system, Vacuuming and charging of refrigerant.

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics - Space Programs, Superconductivity, Medical applications.

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve-Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claude Cycle Dual Pressure Cycle. J.T. Cryocoolers, G.M. Cryocoolers. Cryogenic Dewar, Cryogenic Transfer Lines. Insulations in Cryogenic Systems.

**References**


| | |
|---|---|
| 1. | Arora, R.C., Refrigeration and Air Conditioning, PHI Pvt Ltd, 2010 |
| 2. | Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2000 Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985. |
| 3. | Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989. |
| 4. | Randall F. Barron, Cryogenic heat transfer, CRC Press,1999. |
| 5. | Stoecker N.F and Jones, Refrigeration and Air Conditioning, TMH NewDelhi,2nd edition 1982. |

**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Introduce the working principles of basic methods to achieve low temperature by using adiabatic expansion, provide a thorough understanding of applications. |
| **CO2** | Able to apply classical thermodynamics to different cryogenic technologies, gas separation and purification system, and low power cryocoolers. |
| **CO3** | Understand the functions and working principles of insulations and various low temperature measuring and storage devices. |
| **CO4** | Assess the advantages of refrigeration and cryogenic systems and their applications. |
| **CO5** | Comprehend the characteristics of engineering materials at reduced temperatures. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME630 |
| **Course Title** | **:** | Analysis of Thermal Power Cycles |
| **Type of Course** | **:** | PC / PE / OE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

### Course Learning Objectives (CLO)

| | |
|---|---|
| **CLO1** | To describe sources of energy and types of power plants. |
| **CLO2** | To analyze different types of steam cycles and estimate efficiencies in a steam power plant. |
| **CLO3** | To define the performance characteristics and components of power plants. |
| **CLO4** | To analyze how Thermal efficiency enhancement methods improve the efficiency of gas turbine systems. |
| **CLO5** | To study and analyse various refrigeration cycles |

### Course Content

Steam power plant cycle - Rankine cycle - Reheat cycle - Regenerative cycle with one and more feed heaters - Types of feed heaters - Open and closed types - Steam traps types.

Cogeneration - Condensing turbines - Combined heat and power - Combined cycles - Brayton cycle Rankine cycle combinations - Binary vapour cycle.

Air standard cycles - Cycles with variable specific heat - fuel air cycle - Deviation from actual cycle.

Brayton cycle - Open cycle gas turbine - Closed cycle gas turbine - Regeneration - Inter cooling and reheating between stages.

Refrigeration Cycles - Vapour compression cycles - Cascade system - Vapour absorption cycles - GAX Cycle.

### References


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|---|---|
| 1. | Culp, R., *Principles of Energy Conversion,* McGraw-Hill, 2000. |
| 2. | Nag. P.K., *Power Plant Engineering, 2nd* Tata McGraw-Hill, 2002. |
| 3. | Nag. P.K., *Engineering Thermodynamics, 3rd* ed., Tata McGraw-Hill, 2005. |
| 4. | Arora, C.P., *Refrigeration and Air Conditioning, 2nd* ed., Tata McGraw-Hill, 2004. |


### Course Outcomes (CO)

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Identify energy sources and power plants. |
| **CO2** | Analyze steam cycles and calculate efficiencies. |
| **CO3** | Describe power plant components and performance. |
| **CO4** | Evaluate efficiency improvement in gas turbines. |
| **CO5** | Analyze various refrigeration cycles and applications. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME631 |
| **Course Title** | **:** | Design and Optimisation of Thermal Energy Systems |
| **Type of Course** | **:** | PE / OE |
| **Prerequisites** | **:** | Nil |
| **Contact Hours** | **:** | 3 |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To describe energy system design and recall regression analysis and equation fitting |
| **CLO2** | To design thermal equipment like heat exchangers, evaporators, condensers, turbomachines, distillation equipment, absorber, generator, GAX. |
| **CLO3** | To apply the successive method and Newton Raphson method in energy systems |
| **CLO4** | To construct mathematical representation for optimization problems in energy systems |
| **CLO5** | To analyze the cost involved in energy system by present worth-annual cost method |

**Course Content**

Introduction to Energy System Design - Modeling of thermal equipment - heat exchangers, evaporators, condensers, turbomachines, distillation equipment. Absorber, generator, GAX.

System simulation - Application of successive method and Newton Raphson Method to Energy Systems.

Regression analysis and Equation fitting, best fit - Least Square Regression, Exact fit - Lagrange interpolation.

Mathematical Representation for Optimization Problems in Energy Systems- Applications of various search methods to Energy Systems - Waste Heat Recovery System - design of energy recovery systems-Genetic Algorithm.

Thermoeconomic analysis-Exergy analysis-Estimation of cost of investment, cost of fuel, cost balance, cost of product-Thermoeconomic optimization.

**References**


| | |
|---|---|
| 1. | Hodge, BK. and Taylor, RP., *Analysis and Design of Energy Systems, 3rd Edition*, Prentice Hall, 1999. |
| 2. | Stoecker, WF., *Design of Thermal Systems*, McGraw-Hill, 1989, |
| 3. | Burmeister, LC., *Elements of Thermal-Fluid System Design*, Prentice Hall, 1998. |
| 4. | Jaluria, Y., *Design and Optimisation of Thermal Systems*, McGraw-Hill, 1998. |
| 5. | Janna, WS., *Design of Fluid Thermal Systems*, PWS-Kent Publishing, 1993. |
| 6. | Balaji, C., *Essentials of Thermal system Design and Optimization*, Ane Book pvt. Ltd., 2011. |
| 7. | Bejan, A., Tsatsaronis, G., and Moran, M., *Thermal Design and Optimization*, Wiley- India Edition, 2013. |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Describe energy system design and recall regression analysis and equation fitting |
| **CO2** | Design thermal equipment like heat exchangers, evaporators, condensers, turbomachines, distillation equipment, absorber, generator, GAX. |
| **CO3** | Apply the successive method and Newton Raphson method in energy systems |
| **CO4** | Construct mathematical representation for optimization problems in energy systems |
| **CO5** | Analyze the cost involved in energy system by present worth-annual cost method |

| | | |
|---|---|---|
| **Course Code** | : | ME632 |
| **Course Title** | : | Hydrogen Production, Handling And Storage |
| **Type of Course** | : | PE / OE |
| **Prerequisites** | : | Nil |
| **Contact Hours** | : | 3 |
| **Course Assessment Methods** | : | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To understand the various methods of hydrogen production, including conventional and renewable approaches. |
| **CLO2** | To explore the technologies and safety measures involved in the handling and storage of hydrogen. |
| **CLO3** | To analyze the economic, environmental, and technical challenges associated with hydrogen as an energy carrier. |
| **CLO4** | To evaluate the role of hydrogen in the context of sustainable energy systems and its potential in various applications. |
| **CLO5** | To develop strategies for the implementation and optimization of hydrogen technologies in various sectors. |

**Course Content**

Historical Perspective and Evolution of Hydrogen Use, Hydrogen's Role in the Energy Transition, Physical and Chemical Properties of Hydrogen, Hydrogen Handling and Safety: Hydrogen Properties and Hazard Identification, Safety Protocols for Handling Hydrogen, Hydrogen Leak Detection and Mitigation. Materials Compatibility and Hydrogen Embrittlement, Codes, Standards, and Regulations for Hydrogen Safety

Hydrogen Production Technologies- Conventional Methods: Steam Methane Reforming, Coal Gasification, Partial Oxidation of Hydrocarbons. Renewable Methods: Water Electrolysis (Alkaline, PEM, Solid Oxide), Biomass Gasification, Photoelectrochemical Water Splitting, Thermochemical Water Splitting, Biological Hydrogen Production. Emerging Technologies: Plasma-Assisted Hydrogen Production, Green Hydrogen via Wind and Solar Integration

Hydrogen Storage Technologies: Physical Storage: Compressed Gas Storage, Liquid Hydrogen Storage, Cryogenic Storage Systems. Material-Based Storage: Metal Hydrides, Chemical Hydrides, Carbon-Based and Novel Materials for Hydrogen Adsorption. Advanced Storage Solutions: Solid-State Storage Technologies, Challenges in Scaling Up Hydrogen Storage Solutions

Hydrogen Transportation and Infrastructure: Hydrogen Pipelines and Distribution Networks, Road and Rail Transport of Hydrogen, Marine Transport of Liquid Hydrogen, Development of Hydrogen Refueling Infrastructure. Case Studies: Global Hydrogen Infrastructure Projects, Economic and Environmental Aspects of Hydrogen, Cost Analysis of Hydrogen Production Methods, Life Cycle Assessment of Hydrogen Production and Use, Carbon Footprint and Environmental Impact, Hydrogen Economy: Opportunities and Barriers, Policy and Incentives for Hydrogen Deployment

Applications of Hydrogen, Hydrogen in Fuel Cells: PEMFC, SOFC, and MCFC. Hydrogen as a Fuel for Transportation, Industrial Applications of Hydrogen, Hydrogen in Power Generation and Grid Integration, Hydrogen for Energy Storage and Backup Power Systems. Research Directions: Advances in Hydrogen Production and Storage Technologies, Hydrogen Blending in Natural Gas Grids, Potential for Hydrogen in

Decarbonizing Hard-to-Abate Sectors, Research and Development Priorities in Hydrogen Technology

**References**


| | |
|---|---|
| 1. | S.A. Sherif, D. Yogi Goswami, E.K. (Lee) Stefanakos, Aldo Steinfeld, "Handbook of Hydrogen Energy", 1st Edition, 2014. |
| 2. | zimas, E., Filiou, C., Peteves, S.D., &Veyret, J.B. "Hydrogen storage: state-of-the-art and future perspective. Netherlands": European Communities, 2003. |
| 3. | Gupta, R. B., Hydrogen Fuel: Production, Transport and Storage, CRC Press, Taylor & Francis Group, 2009. |
| 4. | Michael Hirscher, "Handbook of Hydrogen Storage", Wiley-VCH, 2010. |
| 5. | Gupta, R. B., Hydrogen Fuel: Production, Transport and Storage, CRC Press, Taylor & Francis Group, 2009 |
| 6. | Anand Ramanathan, Babu Dharmalingam, Vinoth Thangarasu "Advances in Clean Energy Production and Application", Taylor & Francis, CRC Press, 2020 |
| 7. | Anand Ramanathan, Meera Begum, Amaro Pereira, Claude Cohen "A Thermo-economic Approach to Energy from Waste", Elsevier, 2021. |


**Course Outcomes (CO)**

At the end of the course student will be able to

| | |
|---|---|
| **CO1** | Understand and explain various hydrogen production technologies, including both conventional and renewable methods. |
| **CO2** | Demonstrate knowledge of the safety considerations, handling, and storage technologies for hydrogen. |
| **CO3** | Perform economic and environmental assessments of hydrogen as an energy carrier, considering its production, storage, and application. |
| **CO4** | Critically evaluate the potential and challenges of hydrogen in future sustainable energy systems and its applications in industry, transportation, and power generation. |
| **CO5** | Formulate and propose practical solutions for the adoption and enhancement of hydrogen production, handling, and storage systems. |

| | | |
|---|---|---|
| **Course Code** | **:** | ME633 |
| **Course Title** | **:** | Industrial ventilation and air conditioning systems |
| **Type of Course** | **:** | PE |
| **Prerequisites** | **:** | |
| **Contact Hours** | **:** | |
| **Course Assessment Methods** | **:** | Continuous Assessment, End Assessment |

**Course Learning Objectives (CLO)**

| | |
|---|---|
| **CLO1** | To learn climate variation and its effects on the building heat load. |
| **CLO2** | To learn building material characteristics and their influence on building heating /cooling load for all weather conditions. |
| **CLO3** | To study various conversation techniques related to build environment and codes for the same. |
| **CLO4** | To study various Testing and Balancing Air Systems. |
| **CLO5** | To study various techniques involved in industry air conditioning systems. |

**Course Content**

Introduction to Air Conditioning and Refrigeration – Basic Thermodynamics of HVAC, Types of Refrigeration Systems, the Refrigeration Cycle, Refrigerants and their Properties, Plotting the Refrigeration Cycle, Piping and Tubing, Soldering and Brazing, Refrigerant Leak Testing, Refrigerant System Evacuation, Refrigerant System Charging, Control Systems.

Heating systems - Gas Furnaces, Gas Furnace Controls, Gas Furnace Installation, Troubleshooting Gas Furnaces, Oil Fired Heating Systems, Oil Furnace and Boiler Service, Residential Oil Heating Installation, troubleshooting of oil heating systems, Electric Heat, Electric Heat Installation, troubleshooting of electric heat, Heat Pump System Fundamentals, Heat Pumps Applications, Geothermal Heat Pumps, Heat Pump Installation, Troubleshooting of Heat Pump Systems.

Comfort and Psychometrics - Fundamentals: Psychometrics & Airflow, Air Filters, Ventilation and Dehumidification, Heat transmission in building structures -Solar radiation -Infiltration and Ventilation-Cooling/heating load calculations, Residential Load Calculations, Green Buildings and Systems, Indoor Air Quality (IAQ), Building energy calculations

Duct Installation, Duct Design, Zone Control Systems, Testing and Balancing Air Systems.

Chilled Water Systems, Cooling Towers, Commercial Refrigeration Systems, Supermarket Equipment, Ice Machines.

**References**


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|---|---|
| 1. | Hand book of heating, ventilation and Air-conditioning, Jan. F. Kreider, CRC press. |
| 2. | Automotive heating and Air-conditioning, Mike Stubblefield and John H Haynes |
| 3. | Heating ventilation and air conditioning – Jan F. Kreider |
| 4. | Control systems for Heating, ventilating and air conditioning, Roger W. Haines, Springer |
| 5. | HVAC Equations, Data, and Rules of Thumb - Arthur A. Bell Jr., PE, McGraw-Hill |

**Course Outcomes (CO)**

At the end of the course student will be able

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| **CO1** | Estimate heating loads, space heat gains and space cooling loads using accepted engineering methods. |
| **CO2** | Determine the coil loads for cooling and heating systems. |
| **CO3** | Select equipment and design systems to provide comfort conditions within the building. |
| **CO4** | Understand different testing and balancing air conditioning systems |
| **CO5** | To apply the principles of producing air conditioning for human comfort and industry applications |