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| 16TEFC01 NUMERICAL METHODS IN THERMAL ENGINEERING |  |  |
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| **COURSE OBJECTIVE :*** To be familiar with solutions of linear system of equations numerical solution of nonlinear equations.
* To acquire knowledge of least square approximations when discrete set of observations known.
* To develop the skill of solving single and double variable integration numerically.
* To attain the fluency to solve ordinary and partial differential equations numerically.
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**NUMERICAL SOLUTIONS OF SYSTEM OF LINEAR AND NON – LINEAR EQUATIONS (9+6)**

System of linear equation: Gauss Elimination Method, Gauss Jordan Method, Choleski Method, Gauss- Seidal Method –System of Non Linear equations: Iteration Method, Newton –Raphson Method for single variable and simultaneous equations with two variables.

**EIGEN VALUE PROBLEMS, CURVE FITTING AND INTERPOLATION. (9+6)**

Eigen value problem: Power Method – Curve fitting: Least Square approximations – Fitting a straight line – Regression lines – Non-linear curve fitting. Interpolation: Cubic spline interpolation and Hermite’s Polynomials.

**NUMERICAL INTEGRATION (9+6)**

Trapezoidal Rule – Simpson’s one third and three eighth rule – Gaussian two and three point quadrature formula – Double integrals using Trapezoidal Rule – Simpson’s Rule.

**NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (9+6)**

Taylor’s series Method – Euler’s Method – Modified Euler’s Method – Runge-Kutta Method of fourth order – Milne’s and Adams Basforth Predictor and Corrector Methods.Numerical solution of Ordinary Differential Equation by Finite Difference Method.

**NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (9+6)**

Finite difference solution for Laplace equations: Gauss Jacobi and Gauss Seidal methods – Poisson equation – Parabolic equation: Bender Schmidt and Crank Nicholson Methods – Hyperbolic equation: Explicit Method.

 **LECTURE: 45 TUTORIAL:30 TOTAL: 75 PERIODS**

**Reference:**

1. *P. Kandasamy, K. Thilagavathy and K. Gunavathy,* ***“Numerical Methods”****, S. Chand & Co Ltd., New Delhi 2010.*
2. *James.G* **“Advanced Modern Engineering Mathematics”**, *Fourth edition, Pearson* *Education* Asia, 2011.
3. *Grewal.B.S.,* **“Numerical Methods in Engineering and Science*”****, Khanna Publishers* New Delhi, 2014.
4. *S.R.K.Iyengar, R.K Jain,* **“Numerical Methods”**, New Age International Publishers, New Delhi, 2009.
5. *Veerarajan.T and* Ramachandran.T **“Numerical Methods with Programming C”**, *Tata Mc Graw Hill* *Publishing Company Ltd*., New Delhi 2011.
6. *Grewal.B.S.,* **“Numerical Methods in Engineering and Science*”****, Khanna Publishers* New Delhi, 2014.

**COURSE OUTCOMES :**

On completion of this course, students will be able to

**CO1:** Understanding methods for solving linear system of equations.

**CO2:** Developing skill of least square approximations leading to fitting a curve and interpolation.

**CO3:** Evaluating numerical quadrature and numerical cubature using standard methods.

**CO4**: Understanding numerical solution to first order ordinary differential equations and second

Order partial differential equations.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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|  16TEPC01 - ADVANCED THERMODYNAMICS |  |  |  |
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| **COURSE OBJECTIVE :*** To make the students to learn the advanced concepts like maximum energy and minimum energy, combustion principles, energy at micro level, conversion of heat energy into electrical flux of a thermodynamic systems.
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 **AVAILABILITY AND THERMODYNAMIC PROPERTY RELATIONS (9+6)**

Reversible work, Availability, Irreversibility and Second-Law Efficiency for a closed System and Steady-State Control Volume. Thermodynamic Potentials, Maxwell relations, Generalized relations for changes in Entropy, Internal Energy and Enthalpy, Cp and Cv, Clausius Clayperon Equation, Joule-Thomson Coefficient, Bridgmann Tables for Thermodynamic relations.

**REAL GAS AND MULTI-COMPONENT SYSTEMS (9+6)**

Different Equations of State, Fugacity, Compressibility, Principle of Corresponding States, Use of generalized charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kessler generalized 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, Gibbs phase rule for non-reactive components.

**CHEMICAL THERMODYNAMICS AND EQUILIBRIUM (9+6)**

Thermo chemistry, First Law analysis of reacting systems, Adiabatic Flame temperature, Entropy change of reacting systems, Second Law analysis of reacting systems, Criterion for reaction equilibrium, Chemical availability, Equilibrium constant for gaseous mixtures, evaluation of equilibrium composition, Availability of reacting systems.

**STATISTICAL THERMODYNAMICS (9+6)**

Microstates and Macrostates, Thermodynamic probability, Degeneracy of energy levels, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein Statistics, Microscopic Interpretation of heat and work, Evaluation of entropy, Calculation of the Macroscopic properties from partition functions, Equilibrium constant statistical thermodynamics approach.

**IRREVERSIBLE THERMODYNAMICS (9+6)**

Conjugate Fluxes and Forces, Entropy Production Onsager’s Reciprocity relations, thermoelectric phenomena, formulations, Power Generation, Refrigeration.

**LECTURE: 45 TUTORIAL:30 TOTAL: 75 PERIODS**

***Reference :***

1. *Kenneth Wark Jr.,* ***Advanced Thermodynamics for Engineers****, McGraw-Hill Inc., 1995.*
2. *Bejan, A.,* ***Advanced Engineering Thermodynamics****, John Wiley and Sons, 3rd edition, 2006.*
3. *Holman, J.P.,* ***Thermodynamics****, Fourth Edition, McGraw-Hill Inc., 1988.*
4. *Smith, J.M. and Van Ness., H.C.,* ***Introduction to Chemical Engineering Thermodynamics****, Fourth Edition, McGraw-Hill Inc., 2005.*
5. *Sonntag, R.E., and Van Wylen, G,* ***Introduction to Thermodynamics, Classical and Statistical****, Third Edition, John Wiley and Sons, 1991.*
6. *Sears, F.W. and Salinger G.I.,* ***Thermodynamics, Kinetic Theory and Statistical Thermodynamics****, Third Edition, Narosa Publishing House, New Delhi, 1993.*
7. *DeHotf, R.T.,* ***Thermodynamics in Materials Science****, McGraw-Hill Inc., 2006.*
8. *Rao, Y.V.C.,* ***Postulation and Statistical Thermodynamics****, Allied Publisher Limited, New Delhi, 1994*

**COURSE OUTCOMES :**

On completion of this course, students will be able to

**CO1:** Apply different sources of energy gain and energy loss to operate thermodynamic systems.

**CO2:** Evaluate equilibrium of thermodynamic systems.

**CO3:** Analyze energy of particles at micro-level and conversion of energy into electrical flux.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| 16TEPC02 - DESIGN OF CONDENSERS, EVAPORATORS AND COOLING TOWERS |  |  |  |
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| **COURSE OBJECTIVE :*** To make the students to learn the heat transfer processes and design of heat transfer equipments.

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**INTRODUCTION (9+6)**

Principles of heat transfer, Types of heat exchangers, Standard Representation, Parts description, TEMA classifications, Applications.

#### CONDENSERS (9+6)

Estimation of heat transfer coefficient, Fouling factor, Friction factor. Design procedures, Wilson plots, Design of different types of condensers, BIS Standards.

#### EVAPORATORS (9+6)

Different types of evaporators, Design procedure, Factors affecting the evaporator capacity, Thermal Stress calculations, matching of components, Design of evaporative condensers.

#### COOLING TOWERS (9+6)

Types of Cooling towers, Analytical and graphical design procedures, Tower Characteristics Parametric analysis, Range of cooling tower, Tower efficiency, cooling tower load, Energy conservation.

#### SELECTION OF CONDENSERS, EVAPORATORS AND COOLING TOWER (9+6)

Condenser selection – Water cooled – Air cooled, Selection of evaporators, Selection of cooling tower, Selection of Pumps and Fans.

 **LECTURE: 45 TUTORIAL:30 TOTAL: 75 PERIODS**

***Reference :***

1. *Ozisik, M.N.,* ***Design of Heat exchangers , condensers and evaporators*** *, John Wiley , New York , 1985.*
2. *Kern K.H.,* ***Process heat transfer****, McGraw-Hill, 2002.*
3. *Ozisik M.N.,* ***Heat transfer****, McGraw-Hill, 1993.*
4. *Nicholas Cheremisioff ,* ***Cooling tower*** *, Ann Arbor Science pub. 1981.*
5. *TEMA Hand book,* ***Tubular Exchanger Manufacturer Association****, New York, 9th edition, 2007.*
6. *Andrew.D.Althouse, Carl.H.Turnquist,* ***Modern Refrigeration and Air Conditioning****, GoodHeard-Wilcox Company, Inc, Publishers, 2000.*
7. *Ramesh K Shah, Dusan P. Sekulic* ***Fundamentals of Heat Exchanger Design*** *John Wiley & Sons,2003.*

**COURSE OUTCOMES :**

On completion of this course, students will be able to

**CO1:** Utilize the principles of heat transfer for industrial applications.

**CO2:** Design condensers, evaporators and cooling towers.

**CO3:** Select suitable heat transfer equipment.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| 16TEPC03 ADVANCED ENGINEERING FLUID MECHANICS |  |  |  |
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| **COURSE OBJECTIVE :*** To make the students to learn the advanced concepts and equations of various type of flow of fluids and realize the special effects due to turbulence, friction and shock.
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**INTRODUCTION (9+6)**

Ideal and non-ideal flows, general equations of fluid motion, Navier - stokes equations and their exact solutions. Boundary layer theory, wedge flows, laminar flow over plates and through cylinders.

**TWO DIMENSIONAL FLOW (9+6)**

Subsonic flow, physical significance of irrotational motion – Kelvin’s theorem – Differential equation in terms of velocity Potential and stream function – Flow with small perturbation – flow past a wave shaped wall – Gothert’s rule – Prandtl Glanert rule – Hodograph method.

**TURBULENT FLOW (9+6)**

Turbulence, models and flow equations: steady and unsteady turbulent boundary layers.

**COMPRESSIBLE FLOW THROUGH DUCTS (9+6)**

Introduction to compressible viscous flow, governing equations, flow with friction - flow with heat transfer flow through nozzle and diffuser.

**SHOCK WAVE (9+6)**

Normal and oblique shocks – Prandtl – Meyer expansion – Rankine Hugnoit relation. Application of method of characteristics applied to two dimensional case – simple supersonic wind tunnel Design of supersonic wind tunnel and nozzle.

**LECTURE: 45 TUTORIAL:30 TOTAL: 75 PERIODS**

***Reference :***

*1. Mohanty, A. K.,* ***Fluid Mechanics****, Prentice Hall of India, 2nd edition, 1997*

*2. Shapiro, A. F.,* ***The Dynamics of Compressible flow*** *Vol. I, The Ronald Press Company 1963*

*3. Shames,* ***Mechanics of Fluids****, Mc Graw Hill L96M Book Company, 4th edition, 2005*

*4. Schlichting, H.,* ***Boundary layer theory****, Mc Graw Hill Book Company,8th edition, 2003*

*5. E. Rathakrishnan,* ***Gas Dynamics****, Prentice Hall, New Delhi 2013.*

*6. Yahya S.M,* ***Fundamentals of Compressible flow****, New Age International (P) Ltd.New Delhi, 1996.*

*7. Yunus A Cengel, John M.Cimbala,* ***Fluid Mechanics: Fundamentals and Applications****, McGraw-Hill, Hrd*

*Edition, 2014.*

*8.K. Muralidhar,* ***Advanced Engineering Fluid Mechanics****, Alpha Science International Ltd, Second Edition 2005.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Apply conservation of energy and momentum principles for the flow of fluids.

**CO 2:** Analyze the effects of turbulent boundary layer profile for the given fluid flow conditions.

**CO 3:** Evaluate the exit condition of nozzle and diffuser for the given inlet conditions and applies

the concepts of shock waves in the design of wind tunnel and nozzles.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| 16TEPC04 - FINITE ELEMENT METHODS IN THERMAL ENGINEERING |  |  |  |
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| **COURSE OBJECTIVE :*** To make the students to learn different discretization methods for solving heat transfer and fluid flow problems.
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**INTRODUCTION (5)**

Overview of numerical methods - Discretized representation of physical systems - thermal resistance – Governing equations and Boundary conditions for thermal and flow systems.

**ONE DIMENSIONAL HEAT CONDUCTION (6)**

Principles of variations calculus - applications of variational approach to one dimensional heat conduction – element matrix contribution and assembly.

**HEAT FUNCTIONS AND ANALYSIS (10)**

Weighted residual methods - Galerkin’s approach - Shape functions. Application of Galerkin’s weighted residual approach to one dimensional heat conduction - Three nodded triangular elements- M-D steady state conduction using triangular elements - Radiation and natural convective boundary conditions –incorporation of variations in thermal properties.

**CONVECTIVE HEAT TRANSFER (12)**

Higher order elements and numerical integration solution of heat conduction and creeping flow using higher order element - Solution of convective heat transfer.

**HEAT EXCHANGER APPLICATIONS (12)**

Incompressible laminar flow simulation - Stream function / Vorticity methods, Velocity Pressure formulation, mixed order interpolation for incompressible flow modifications for turbulent flow. Application to heat exchanger.

 **TOTAL: 45 PERIODS**

***Reference :***

***1.*** *S.S.Rao,* ***“The Finite Element Method in Engg****.****”****, Pergamon Press, 5th ed., 2011.*

***2.*** *Larry Segerlind* ***“Applied Finite Element Analysis”****, John Wiley & Sons, 2nd ed, 2005.*

***3.*** *C.S.Krishnamoorthy,* ***“Finite Element Analysis Theory and Programming”,*** *Tata McGraw-Hill, 2nd ed, 2011.*

***4.*** *J.N.Reddy,* ***“An Introduction to Finite Elements Methods”****,McGraw-Hill,2005.*

***5.*** *O.C.Zienkiewiez,* ***“Finite Element Methods”,*** *McGraw-Hill, 2002.*

***6.*** *T.R.Chandrapatla and Belegundu,* ***“Introduction to Finite Elements in Engg****.****”****, Prentice Hall of India, 2002.*

***7.*** *A.J.Baker,* ***“Finite Element Computational Fluid Mechanics”,*** *McGraw-Hill, 2003.*

**COURSE OUTCOMES :**

On completion of this course, students will be able to

**CO 1:**Understand the basic numerical methods and governingequations of heat transfer and fluid flow conditions.

**CO 2:** Evaluate temperature distribution in one and two dimensional conduction problems numerically.

**CO 3:** Analyse the laminar and turbulent flow problems to evaluate the performance of heat exchangers.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| 16TEPC05 -INSTRUMENTATION IN THERMAL ENGINEERING |  |  |  |
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| **COURHHSE OBJECTIVE:*** To make the students to learn different techniques of instrumentation involved in thermal quantity measurement and the concept of microprocessors in measurement, different kind of errors involved and the transducers for different types of thermo-physical quantities.
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**MEASUREMENT CHARACTERSTICS (9)**

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.

#### MICROPROCESSORS AND COMPUTERS IN MEASUREMENT (9)

Data logging and acquisition, use of intelligent instruments for error reduction, elements of micro-computer interfacing, intelligent instruments in use.

#### MEASUREMENT OF PHYSICAL QUANTITIES (9)

Measurement of thermo-physical properties, instruments for measuring temperature, pressure and flow, use of intelligent instruments for the physical variables.

**FLOW VISUALISATION (9)**

Techniques, shadow graph, Schlieren, interferometer, Laser Doppler anemometer, heat flux measurement, Telemetry in engines.

#### MEASUREMENT ANALYSIS (9)

Chemical, thermal, magnetic and optical gas analyzers, measurement of smoke, dust and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques.

**TOTAL: 45 PERIODS**

***Reference :***

1. *Holman, J.P., Experimental* ***methods for engineers****, McGraw-Hill, 8th edition 2011.*
2. *Barney,* ***Intelligent Instrumentation****, Prentice Hall of India, 1988.*
3. *Prebrashensky, V.,* ***Measurements and Instrumentation in Heat Engineering****, Vol.1 and 2, MIR Publishers, 1980.*
4. *Rangan, C.S., Sharma, G.R., Mani, V.S.V. ,* ***Instrumentation Devices and Systems****, Tata McGraw Hill, 2nd edition New Delhi, 1997.*
5. *Doeblin,* ***Measurement System Application and Design****, McGraw Hill, 2012.*
6. *Morris.A.S,* ***Principles of Measurements and Instrumentation****, Prentice Hall of India, 1998.*
7. *D Patranabis* ***Transducers, Mechanical Measurement and Industrial Instrumentation,*** *Tata McGraw - Hill Education (2010).*

**COURSE OUTCOMES :**

On completion of this course, students will be able to

**CO1:** Gain knowledge on various measuring instruments and advance measurement techniques.

**CO2:** Evaluate various steps involved in error analysis and uncertainty analysis.

**CO3:** Analyze various thermal and flow systems and their behavior.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| 16TEPC06-ADVANCED HEAT AND MASS TRANSFER |  |  |  |
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| **COURSE OBJECTIVE :**To make the students to learn the concepts of modes of heat transfer, heat exchangers along with numerical formulation of heat equations and to analyze various heat transfer correlations.  |  |  |  |

**CONDUCTION AND RADIATION HEAT TRANSFER (9+6)**

One dimensional energy equations and boundary condition, three dimensional heat conduction equations, extended surface heat transfer, Conduction with moving boundaries, Porous-media heat transfer, Radiation in Gases and vapor.

#### TURBULENT FORCED CONVECTIVE HEAT TRANSFER (9+6)

Momentum and Energy Equations, Turbulent Boundary Layer Heat Transfer, Mixing length concept, Turbulence Model- k- Model, Analogy between Heat and Momentum Transfer –Reynolds, Colburn, Von Karman, Turbulent flow in a Tube, High speed flows.

#### PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER (9+6)

Condensation with shear edge on bank of tubes, Boiling – pool and flow boiling, Heat exchanger,  – NTU approach and design procedure, compact heat exchangers.

#### NUMERICAL METHODS IN HEAT TRANSFER (9+6)

Finite difference formulation of steady and transient heat condition problems – Discretization schemes – Explicit, Crank Nicolson and Fully implicit schemes, Control volume formulation, Steady one dimensional convection and Diffusion problems, Calculation of the flow field – Simpler Algorithm.

#### MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION (9+6)

Mass Transfer, Vaporization of droplets, combined heat and mass transfer problems, Heat Transfer Correlations in I.C. Engines.

 **LECTURE: 45 TUTORIAL:30 TOTAL: 75 PERIODS**

***Reference :***

1. *Incropera F.P. and DeWitt.D.P,* ***Fundamentals of Heat & Mass Transfer****, John Wiley & Sons, Seventh edition,2013*
2. *Eckert.E.R.G., and Drake.R.M,* ***Analysis of Heat and Mass Transfer****, McGraw Hill Co., 1987.*
3. *Ozisik.M.N.,* ***Heat Transfer - Basic Approach****, McGraw-Hill Co., 1985.*
4. *Bejan.A.,* ***Convection Heat Transfer****, John Wiley and Sons,4th edition 2013.*
5. *Rohsenow.W.M., Harnett.J.P, and Ganic.E.N,* ***Handbook of Heat Transfer Applications****, McGraw-Hill, NY 1985.*
6. *Patankar.S.V.,* ***Numerical heat Transfer and Fluid Flow****, Hemisphere Publishing Corporation, 2011.*
7. *Carnahan.B., Luther.H.A, and Wilkes, J.O.,* ***Applied Numerical Methods****, Wiley & Sons, 1990*
8. *Yunus A.Cengal,* ***Heat and Mass Transfer – A practical Approach****,5 th edition, Tata McGraw - Hill, 2015.*

**COURSE OUTCOMES :**

On completion of this course, students will be able to

**CO1:** Use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows.

**CO2:** Evaluate the concepts of phase change in heat and mass transfer processes.

**CO3:** Apply numerical methods for solving heat transfer problems.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPC07 - COMPUTATIONAL FLUID DYNAMICS** |  |  |  |
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| **COURSE OBJECTIVE:** * To make the students to learn finite difference and finite volume discretized forms of CFD equations and their solutions.

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**GOVERNING EQUATIONS AND BOUNDARY CONDITIONS (9+6)**

Basics of CFD, Governing equations of Fluid Dynamics – Continuity, Momentum and Energy Equations, Physical Boundary conditions, Mathematical behavior of PDEs on CFD – Elliptic, Parabolic and Hyperbolic equations.

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| **DISCRETISATION TECHNIQUES AND SOLUTION METHODOLOGIES** |  **(9+6)** |

Methods of deriving discretization equations – Finite difference & Finite volume methods, Finite difference discretization of wave equation, Laplace equation, Burger’s equation, numerical error and stability analysis. Time dependent methods – Explicit, Implicit – Crank – Nicolson methods, time split methods.

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| **CALCULATION OF FLOW-FIELD FOR N-S EQUATIONS** |  **(9+6)** |

Finite volume formulation of steady one-dimensional convection and Diffusion problems, Central, upwind, hybrid and power-law schemes – Discretization equations for two dimensional convection and diffusion. Representation of the pressure – Gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and velocity corrections – Pressure – Correction equation. SIMPLE algorithm and its variants.

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| **TURBULENCE MODELING** |  **(9+6)** |
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Time – averaged equation for turbulent flow, Turbulence models – Zero equation model, one equation model, two equation K-I models, and advanced models.

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| **GRID GENERATION**  | **(9+6)** |

Algebraic Methods – Methods – Differential Equation methods – Adaptive grids.

**LECTURE: 45 TUTORIAL:30 TOTAL: 75 PERIODS**

***References* :**

1. *Versteeg, H.K, and Malalasekera, W.,* ***“An Introduction to Computational Fluid Dynamics: The Finite Volume Method”****, Longman, 2008 .*
2. *D. A, Anderson, John C. Tanne hill, Richard H. Pletcher –* ***Computational Fluid Mechanics and Heat Transfer****,*

*Hemisphere publishing corporation, McGraw – Hill book company,2012.*

1. *Muralidhar, K., and Sundararajan, T.,* ***Computational Fluid Flow and Heat Transfer****, Narosa Publishing House,*

*New Delhi, 2011.*

1. *Ghoshdasdidar, P.S.,* ***Computer Simulation of flow and heat transfer*** *Tata McGraw- HillPublishing Company*

*Ltd., 1998.*

1. *Subas, V.Patankar,* ***Numerical heat transfer fluid flow****, Hemisphere Publishing Corporation, 1980.*
2. *Taylor, C and Hughes****, J.B. Finite Element Programming of the Navier Stokes Equation****, Pineridge Press*

*Limited, U.K., 1981.*

1. *Fletcher, C.A.J.,* ***Computational Techniques for Fluid Dynamics I****, Fundamental and General Techniques,*

*Springer – Verlag, 1996.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Appreciate different types of PDEs that arise in fluid flow and heat transfer problems.

**CO 2:** Design of Numerical Schemes for 1D model equations of flow fluid andimplement large scale linear system

solvers (iterative and direct)

**CO 3:** Propose the concepts of numerical schemes for unsteady viscous flows.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPC08-COMBUSTION IN ENGINES** |  |  |  |
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**COURSE OBJECTIVE:**

To make the students to learn the combustion phenomena in CI & SI engines and Gas turbines.

**COMBUSTION PRINCIPLES** **(9)**

Thermodynamics, concepts of combustion – Combustion equations, heat of combustion Theoretical flame temperature, chemical equilibrium and dissociation, Combustion cycles.

**CHEMICAL KINETICS** **(9)**

Stoichiometry , Theories of Combustion, Pre-flame reactions, Reaction rates, Rankine-Hugoniot relations – detonation branch-Analysis of the deflagration - Chapman- Jouguet waves, Laminar and Turbulent Flame propagation.

**COMBUSTION IN S.I. ENGINES (10)**

Initiation of combustion, stages of combustion, flame - velocities, structure and speed - laminar and turbulent flames, normal and abnormal combustion, knocking combustion, pre-ignition, knock and engine variables, factors affecting combustion and effect on performance and emissions. Stratified charge combustion, concepts of lean burn engines.

**COMBUSTION IN C.I. ENGINES (9)**

Various stages of combustion, vaporization of fuel droplets and spray formation, air motion, swirl, squish, tumble flow, velocities, swirl measurement, delay period correlations, diesel knock and engine variables, features and design considerations of combustion chambers, heat release correlations. Influence of the injection system on combustion.

**COMBUSTION** **IN GAS TURBINES (8)**

Flame stability, Flame swirling stabilization, Combustion efficiency, Diffusion zone, re-circulation zone and requirements, fuel spray types, Combustion chamber Configuration, flame tube cooling.

**TOTAL : 45 PERIODS.**

***Reference :***

1. *Forman A Williams,****Combustion Theory,*** *The Cambridge mass: perseus book, 2000*
2. *Ganesan, V,* ***Internal Combustion Engines****, Tata McGraw Hill Book Co., 2013.*
3. *John B.Heywood,* ***Internal Combustion Engine Fundamentals****, McGraw Hill Book, 1998*
4. *Ramalingam, K.K.,* ***Internal Combustion Engines****, SciTech Publications (India) Pvt. Ltd.,2009.*
5. *Obert, E.F.,* ***Internal Combustion Engine and Air Pollution****, International Text Book Publishers, 1983*
6. *Cohen, H, Rogers, G. E.C, and Saravanamuttoo, H.I.H.,* ***Gas Turbine Theory****, Longman Group Ltd.,1980*
7. *C.R. Ferguson, A. T. Kirkpatrick,* ***Internal Combustion Engines****, Mnd Edition, John Wiley & Sons, 2016.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO1:** Calculate appropriate stoichiometry level for perfect combustion.

**CO2:** Analyze the factors affecting combustion mechanism in CI and SI engines.

**CO3:** Apply flame stability and combustion configurations in gas turbines.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| 16TEPC09- ADVANCED THERMAL ENGINEERING LABORATORY |  |  |  |
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| **COURSE OBJECTIVE :*** To make the students to learn the importance of various types of I.C engines and analyze them using commercial and open source software.
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**PART- A PERFORMANCE TESTS & SIMULATION**

1. Performance test on Spark Ignition engines using Alternate fuels such as ethanol and Bio-fuels
2. Emission measurement in Spark Ignition and Compression Ignition Engines.
3. Performance test using pressure transducers in SI engines.
4. Performance test using pressure transducers in CI Engines.
5. Performance test on variable compression ratio petrol and diesel engines.
6. Performance test on Solar Collector.
7. Performance test on Computerized I.C. Engine Test Rig.
8. Performance test on Computerized Two Stage Air Compressor Test Rig.
9. Determination of temperature distribution using Thermal Imager.
10. CFD analysis for fluid flow problems with heat transfer.

#### TOTAL: 45 PERIODS.

**COURSE OUTCOMES :**

On completion of this course, students will be able to

**CO1:** Evaluate the performance of both spark ignition and compression ignition engines.

**CO2:** Analyze the given thermodynamic systems using simulation software.

**CO3:** Identify the methods of obtaining optimum working levels of a thermodynamic system.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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 **16TEEE01 PROJECT-PHASE I**

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**COURSE OBJECTIVE:**

* To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature and to develop the methodology to solve the identified problem then publish paper at least in conference.

**COURSE CONTENT:**

1. The learner individually works on a specific topic approved by the head of the division under the guidance of a faculty member who is familiar in this area of interest.
2. The student can select the specific topic related to the area of manufacturing engineering. The topic may be theoretical or industrial case studies.
3. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work.
4. The learners will be evaluated through a viva-voce examination by a panel of examiners including one external examiner

 **COURSE OUTCOMES:**

Learners will be able to

**CO1:** Identify the project work scientifically in a systematic way

**CO2:** Analyze the problem and data of literatures clearly to explore the ideas and methods.

**CO3:** Formulate the objectives and methodology to solve the identified problem

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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**16TEEE02 PROJECT-PHASE II**

 **L T P C**

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**COURSE OBJECTIVE:**

To solve the identified problem based on the formulated methodology and to develop skills to analyze and discuss the test results and make conclusions.

**COURSE CONTENT:**

1. The learner should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor.
2. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department.
3. The learners will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner

**COURSE OUTCOME:**

Learners will be able to

**CO1:** Execute the project work on challenging practical problem in a structured manner

**CO2:** Investigate the findings and infer observations logically

**CO3:** Evaluate the results and confirm the solution to the practical application and social benefit

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE01 -SOLAR ENERGY AND WIND ENERGY** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn properties, types, energy conversion techniques of solar and wind energy systems |  |  |  |

**SOLAR RADIATION (9)**

Availability - Measurement and Estimation - Isotropic and an isotropic models - Introduction to solar collectors flat - plate collectors, Air heater and Concentrating collectors and Thermal storage - Steady state transient analysis - Solar Pond - Solar Refrigeration.

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| **MODELLING OF SOLAR THERMAL SYSTEMS AND SIMULATIONS IN PROCESS DESIGN**  |  **(9)** |

Design of active systems by f-chart and utilizability methods - water heating systems – Active and passive - Passive heating and cooling of buildings - Solar distillation - Solar Drying.

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|  **PHOTOVOLTAIC SOLAR CELL** |  **(9)** |

P-N Junction – Metal – Schottky junction, Electrolyte – Semiconductor Junction, Types of solar cell - their Applications- Experimental Techniques to determine the characteristics of Solar cells Photovoltaic Hybrid Systems Photovoltaic Thermal Systems – Storage Battery – Solar Array Characteristics, Evaluation – Solar Chargeable Battery.

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| **WIND TURBINE**  |  **(9)** |

Structure – Statistics – Measurements and Data Presentation – Wind Turbine Aerodynamics –Momentum Theories – Basics Aerodynamics – Airfoils Characteristics – HAWT – Blade Element Theory – Prandt’ls Lifting Line Theory (prescribed wake analysis) – VAWT Aerodynamic Loads in Steady Operation – Wind Turbulence – Yawed Operation and Tower Shadow.

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| **WIND ENERGY CONVERSION SYSTEM (WECS)**  |  **(9)** |

Sitting – Rotor Selection – Annual Energy Output – Horizontal Axis Wind Turbine (HAWT) Vertical Axis Wind Turbine– Rotor Design Considerations – Number of Blades – Blade Profile – M/H Blades and Teetering – Coning – Upwind/ Downwind – Power Regulation – Yaw system – Tower – Synchronous and Asynchronous Generators and Loads – Integration of Wind Energy Converters to Electrical Networks – Inverters – Testing of WECS – WECS Control System-Requirements and Strategies – Miscellaneous Topics – Noise – Other Applications.

 **TOTAL: 45 PERIODS.**

***References :***

1. *L.L.Freis,* ***Wind Energy Conversion Systems****, Prentice Hall, 1990.*
2. *D.A.Spera,* ***Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering****, ASME Press, 2nd edition, 2009*
3. *S.P.Sukhatme,J.K.Nayak-****Solar Energy: Principles of Thermal Collection and Storage****, Tata McGraw-Hill, 3rd edition, 6th reprint,2010..*
4. *F.A.Duffie and W.A.Beckman-****Solar Engineering of Thermal Processes****-John Wiley (2013).*
5. *J.F.Krider and F.Kreith-****Solar Energy Handbook*** *McGraw-Hill (1986).*

***Web References:***

1. *http://www.ises.ors*
2. *http://www.windpower-monthly.com*
3. [*http://www.solarpv.com*](http://www.solarpv.com)

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1**: Find the availability of solar radiation for different places.

**CO 2:** Identify the designing procedure of solar thermal system using simulation process.

**CO 3:** acquire the knowledge of wind turbine systems and its conservation.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE02 – ENERGY AUDITING AND MANAGEMENT** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn concepts of energy scenario, energy auditing identifying the ways of energy conservation and management. |  |  |  |

**INTRODUCTION (8)**

Global energy requirements – Depletion of conventional energy sources -Energy Scenario – Principles and Imperatives of Energy Conservation – Energy Consumption Pattern – Resource – Availability – Role of Energy Managers in Industries.

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| **THERMAL ENERGY AUDITING**  |  **(12)** |

Energy Audit -Purpose, Methodology with respect to process Industries –Power plants, Boilers, Characteristic method Employed in Certain Energy Intensive Industries – Various Energy Conservation Measures in Steam System – Losses in Boiler, Methodology of Upgrading Boiler Performance – Energy Conservation in pumps, Fans and Compressors, Air Conditioning and Refrigerating systems, Steam Traps – Types, Function, Necessity.

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| **ROLE OF INSTRUMENTATION IN ENERGY CONSERVATION**  |  **(10)** |

Total Energy Systems – Concept of Total Energy – Advantages and Limitations – Total Energy System and Application– Various Possible Schemes Employing Steam Turbines Movers Used in Total Energy Systems – Potential and Economical of Total Energy Systems- Energy conservation in transportation.

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| **ELECTRICAL ENERGY AUDITING**  |  **(10)** |

Potential Areas for Electrical Energy Conservation in various Industries – Energy Management Opportunities in Electrical Heating, Lighting system, Cable Selection – Energy Efficient Motors – Factors involved in Determination of Motor Efficiency Adjustable AC Drives, Applications and its use variable speed Drives/Belt Drives.

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| **ENERGY MANAGEMENT**  |  **(5)** |

Importance of Energy Management- Energy pricing- Energy Economics – Discount Rate, Payback period, Internal rate of Return, Life Cycle Costing.

 **TOTAL: 45 PERIODS.**

***References :***

1. *Amlan Chakrabarthi,* ***Energy Engineering and Management,*** *PHI Learning Pvt. Ltd, New Delhi, 2011.*
2. *Roy L. Nersesian,* ***Energy for the 21st Century****, Yes Dee Publishing Pvt Ltd, 2011.*
3. *Craig B Smith,* ***Energy Management Principles****, Pergamon Press, NewYork, 2nd edition 2015.*
4. *Hamies,* ***Energy Auditing and Conservation; Methods, Measurements, Management & Case study****, Hemisphere, Washington, 2010.*
5. *Trivedi, PR, Jolka KR,* ***Energy Management****, Commonwealth Publication, New Delhi, 2000.*
6. *Witte, Larry C,* ***Industrial Energy Management & Utilization****, Hemisphere Publishers, Washington, 2000.*
7. *Diamant, RME,* ***Total Energy, Pergamon****, Oxford, 1970.*

**COURSE OUTCOMES:**

 On completion of this course, students will be able to

**CO 1**: Appreciate the energy auditing techniques and use them accordingly.

**CO 2:** Apply the methodology to find out boiler performance.

**CO 3:** Design suitable types of auditing methods for various applications.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE03 - BOILER TECHNOLOGY** |  |  |  |
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| COURSE OBJECTIVE:To make the students to learn various power generation units, steam generators and describing heat balance and safety standards of various boiling units.  |  |  |  |

**INTRODUCTION (10)**

Parameter of a steam Generator – Thermal calculations of Modern steam Generator – Tube Metal Temperature Calculation and choice of Materials – Steam purity Calculations and Water treatment.

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| **HEAT BALANCE** | **(10)** |

Heat transfer in Furnace – Furnace Heat Balance –Calculation of Heating Surfaces – Features of Firing systems for solid – Liquid and Gaseous Fuels – Design of Burners.

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| **BOILER DESIGN** | **(10)** |

Design of Boiler Drum – Steam Generator Configurations for Industrial Power and Recovery Boiler – Pressure Loss and circulation in Boilers.

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| **DESIGN OF ACCESSORIES** | **(8)** |

Design of Air Preheaters – Economisers and Super heater for high pressure steam Generators – Design Features of Fuel Firing Systems and Ash Removing Systems.

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| **BOILER CODE** | **(7)** |

IBR and International Regulations – ISI Code’s Testing and Inspection of Steam Generator – Safety Methods in Boilers – Factor of safety in the Design of Boiler Drum and Pressure parts-Safety of Fuel Storage and Handling – Safety Methods of Automatic Operation of Steam boilers.

**TOTAL: 45 PERIODS.**

***References :***

1. ***David Gunn, Robert Horton,*** *Industrial Boilers* ***– Longman Scientific & Technical Publication, 2000.***
2. ***Carl schields,*** *Boilers – Type Characteristics and function****, McGraw Hull Publishers,2002..***
3. *Modern Power Station Practice(8 vol)* ***–Central Electricity Generation Board ,2000.***
4. *Large Boiler Furnaces****, Richard Dolezal Elsevier Company, 2008.***
5. *Boilers: A Practical Reference* ***Kumar Rayaprolu,*** *CRC Press, 2012*
6. ***The Boiler Book*** *(A Complete Guide To Advanced Boiler Technology For the Specifying Engineer) Paperback – 1993.*
7. *Kumar Rayaprolu* ***Boilers for Power and Process*** *April 23, 2009 by CRC Press.*

***Web References :***

1. *http://www.volund.uk*
2. *http://www.aee.vatech.co.at*
3. *http://www.thermomax.com*
4. [*http://www.pages.hotbot.com*](http://www.pages.hotbot.com)

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1**: Gain knowledge in different types of boilers used in different industries and problems raised in boiler maintenance and solve them.

**CO 2:** Economically utilize the heat in industries within the knowledge of Indian boiler regulation act.

**CO 3:** Know about the kind of boilers being used in various industries and their applicability.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE04 – ADVANCED GAS DYNAMICS AND SPACE PROPULSION** |  |  |  |
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**COURSE OBJECTIVE:**

To make the students to learn the compressible flow through different system and propulsion systems for jet and space vehicle.

**BASIC CONCEPTS AND ISENTROPIC FLOWS (9)**
Energy and momentum equations of compressible fluid flows – isentropic flow - Mach waves and Mach cone. Flow regimes, effect of Mach number on compressibility. Stagnation, static, critical properties and their interrelationship. Isentropic flow through variable area ducts – nozzles and diffusers. Use of Gas tables.

**FLOW THROUGH DUCTS (9)**
[The Shock Tube: Propagating Expansion Fan](http://nptel.ac.in/courses/112106056/19) - Flows through constant area ducts with heat transfer and Friction - variation of flow properties Use of tables and charts - [Unsteady Shock Waves: The Shock Tube](http://nptel.ac.in/courses/112106056/19) - [Application of The Method of Characteristics: Flow through a diverging channel](http://nptel.ac.in/courses/112106056/19).

**NORMAL AND OBLIQUE SHOCKS (10)**
Governing equations - Rankine-Hugoniot Relation. Variation of flow parameters across the normal and oblique shocks - [Supersonic Flow over a Wavy wall](http://nptel.ac.in/courses/112106056/19) - [Finite Wave Theory: An introduction to the Method of Characteristics](http://nptel.ac.in/courses/112106056/). Prandtl – Meyer expansion and relation. [Supersonic Flow past a HD Cone at an angle of attack](http://nptel.ac.in/courses/112106056/19) - [Supersonic Flow past a HD Bluff Body at an angle of attack](http://nptel.ac.in/courses/112106056/19) - [Supersonic Flow past a HD Cone at an angle of attack: Flow Visualization-](http://nptel.ac.in/courses/112106056/19)Use of table and charts.

**JET PROPULSION (8)**
Theory of jet propulsion – thrust equation – thrust power and propulsive efficiency. Operation, cycle analysis and performance of ram jet, turbojet, turbofan and turbo prop engines.

**SPACE PROPULSION (9)**
Types of rocket engines and propellants. Characteristic velocity.Theory of single and multistage rocket propulsion.Liquid fuel feeding systems.Solid propellant geometries.Space flights – orbital and escape velocity.Rocket performance calculations – nuclear and electrical rocket propulsion.

**TOTAL: 45 PERIODS.**

***REFERENCES:***
*L. Anderson, J.D.,* ***Modern Compressible flow****, McGraw Hill, 2013.
M. S.M. Yahya,* ***Fundamentals of Compressible Flow with Aircraft and Rocket propulsion****, New Age International (P) Limited, 4th Edition, 2010.
H. Saravanamutto HIH, Cohen H., Rogers CEC.&Straznicky PV,* ***Gas Turbine Theory****, 6th Edition, Printice Hall, 2009..
4. Sutton, G.P.* ***Rocket Propulsion Elements****, John wiley, 2010, New York
5. Radhakrishnan, E.,* ***Gas Dynamics****, Printice Hall of India, 8th edition, 2010
6. Shapiro,* ***Dynamics and Thermodynamics of Compressible fluid Flow,*** *, prentice hall, 6th edition, 2009.
7. Hill and Peterson,* ***Mechanics and Thermodynamics of Propulsion****, Addison – Wesley, 1992.
8. Zucrow, N.J.,* ***Aircraft and Missile Propulsion****, vol.I & II, John Wiley, 1975*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO1:** Understand the basic concepts of compressible flow and isentropic flow.

**CO2:** Analyze the steady and unsteady shock waves by considering friction effect.

**CO3:** Evaluate the thrust power, propulsion efficiency, performance of jet engines and space propulsion engines.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE05- FUELS AND COMBUSTION** |  |  |  |
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| **COURSE OBJECTIVE:**To make the students to learn various types of fuels and their combustion stiochiometry to design the burner. |  |  |  |

**INTRODUCTION (9)**

General, Conventional Energy Sources, Solar Energy, Nuclear Power, Energy from Biomass, Wind Power, Tidal Power, Geothermal Energy, Energy Survey of India , Rocket Fuels.

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| **SOLID, LIQUID AND GASEOUS FUELS** | **(9)** |

Coal - Analysis and Properties of Coal, Classification of Coal, Oxidation of Coal, Hydrogenation of Coal, Efficient use of Solid Fuels, Manufactured Fuels, Agro Fuels, Solid Fuel Handling, Properties Related to Combustion, Handling Storage, Origin and Classification of Petroleum, Refining and Other Conversion Processes, Composition of Petroleum Various Petroleum Products, Storage and Handling of Liquid Fuels, Liquid Fuel Combustion Equipment, Gaseous Fuels, Through Non-Thermal Route-Biogas, Refinery Gas, LPG, Cleaning and Purification of Gaseous Fuels.

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| **THEORY OF COMBUSTION PROCESS** | **(9)** |

Stoichiometry and Thermodynamics, Combustion Stoichiometry General, Rapid Methods of Combustion Stoichiometry, Combustion Thermodynamics, Problem, Combustion Problems with Chemical Reactions Burners.

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| **STOICHIOMETRY** | **(9)** |

Stoichiometry Relations, Theoretical Air Required for Complete Combustion, Calculation of Minimum Amount of Air Required for a Fuel of Known Composition, Calculation of Dry Flue Gases If Fuel Combustion is Known, Calculation of the Composition of Fuel and Excess Air Supplied from Exhaust Gas Analysis, Dew Point of Products, Flue Gas Analysis(OM, COM, CO, NOx, SOx).

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| **BURNER DESIGN** | **(9)** |

Ignition, Concept of Ignition, Auto Ignition, Ignition Temperature, Flame Propagation, Various Methods of Flame Stabilization, Incorporation in Burner Design, Basic Features and Types of Solids, Liquid and Gaseous Fuel Burner, Design Consideration of Different Types of Coal-Oil and Gas Burners, Recuperative and Regenerative Burners.

**TOTAL: 45 PERIODS.**

***References :***

1. *Samir Sarkar****, Fuels & Combustion****, Hrd Edition, Orient Logman,latest Edition 2009.*
2. *Bhatt, Vora* ***Stoichiometry****,5th Edition, tata Mcgraw Hill, 2010.*
3. *Blokh AG,* ***Heat Transfer in Steam Boiler Furance****, Hemisphere Publishing Corpn,2000.*
4. *Civil Davies,* ***Calculations in Furance Technology****, Pergamon Press,Oxford,2000*
5. *Sharma SP,Mohan Chander,****Fuels & Combustion****, Tata Mcgraw Hill,1987.*

***Web References***

1. *http://Shop.ieee.org.*
2. *http://opus.utah.edu.*
3. *http://www.creada..org.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Understand the various sources of energy and fuels.

**CO 2:** Distinguish between various types of fuels and combustion methods and balancing the combustion equation.

**CO3:** Choose correct stoichiometric ratio for combustion process and design burners for industrial applications.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE06 - FLUIDISED BED SYSTEMS** |  |  |  |
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**COURSE OBJECTIVE:**

To make the students to learn fluidization and heat transfer in fluidized beds.

**FLUIDIZED BED BEHAVIOUR (12)**

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

**HEAT TRANSFER**  (**6)**

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

**COMBUSTION AND GASIFICATION (6)**

Fluidized bed combustion and gasification – stages of combustion of particles – performance - start- up methods. Pressurized fluidized beds

**DESIGN CONSIDERATIONS (9)**

 Design of distributors – stochiometric calculations – heat and mass balance – furnace design – design of heating surfaces – gas solid separators

**INDUSTRIAL APPLICATIONS (12)**

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

**TOTAL: 45 PERIODS.**

**REFERENCES**

L. Howard,J.R**., Fluidized Bed Technology**: Principles and Applications, Adam Hilger, NewYork, 1989.

M. Geldart, D., **Gas Fluidization Technology**, John Willey and Sons, 1986.

H. Kunii, D and Levespiel, O., **Fluidization Engineering**, Elsevier Butter worth, New York, 2nd edition 1969.

4. Howard, J.R. (Ed), **Fluidized Beds: Combustion and Applications,** Applied Science Publishers, New York, 1983.

5. Botteril, J.S.M**., Fluid Bed Heat Transfer**, Academic Press, London, 1975.

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO1**: Understand the working principles, merits and limitations of fluidized bed systems.

**CO2**: Apply fluidized bed systems for a specific engineering applications.

**CO3**: Analyse the fluidized bed systems to improve and optimize its performance.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE07 - FANS, BLOWERS AND COMPRESSORS** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn different applications, types and design of Pumps, Fans, blowers & Compressors.  |  |  |  |
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**PRINCIPLES OF TURBO MACHINERY** **(10)**

Introduction to turbo machines- Transfer of energy to fluids- performance characteristics- fan laws- dimensionless parameters- specific speed- selection of centrifugal, axial, mixed flow, Axial flow machines.

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| **ANALYSIS OF CENTRIFUGAL BLOWERS** | **(10)** |

Centrifugal blowers: Theoretical characteristic curves, Eulers characteristics and Eulers velocity triangles, losses and hydraulic efficiency, flow through impeller casing inlet nozzle. Volute, diffusers, leakage disc friction mechanical losses, multivane impellers of impulse type, cross flow fans.

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| **ANALYSIS OF AXIAL FLOW** | **(10)** |

Axial flow fans: rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist stage design, surge and stall, stator and casing, mixed flow impellers.

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| **TESTING AND CONTROL OF FANS** | **(05)** |

Fan testing, noise control, material and components blower regulation, speed control, throttling control at discharge and inlet.

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| **DESIGN AND APPLICATIONS OF BLOWERS** | **(10)** |

Special design and applications of blower, induced and forced draft fans for air-conditioning plants, cooling towers, ventilation systems, booster systems.

 **TOTAL: 45 PERIODS.**

***References :***

1. *Stepanoff A.J.* ***Turboblowers****, John Wiley & sons, 2000*
2. *Bruno E C K,* ***Fans****, Pergamon Press, 1973.*
3. *Austin H. Chruch,* ***Centrifugal pumps and blowers****, John Wiley and sons, 1989.*
4. *Dixon, Fluid mechanics,* ***Thermodynamics of turbomachinery*** *,Elsevier, 7th edition,1984.*
5. *Dixon.* ***Worked examples in turbomachinery****, Pergamon press, 1984.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Apply the principles of turbo machinery to fans, blowers, and compressors.

**CO 2:** Analyze different type of flow arrangements in turbo machinery.

**CO 3:** Design and testing of Pump, Blower, fan and compressor for a given application.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE08 – ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL** |  |  |  |
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| **COURSE OBJECTIVE:**To make the students to learn sources and effects of air pollution, water pollution and soil contamination |  |  |  |

**AIR POLLUTION (10)**

Definition - sources and effect - air sampling and measurements – dispersion of air pollutants – diurnal effects on the air pollutants dispersion – meteorological aspects – analysis of air pollutants - control methods and equipments - issues in air pollution control

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| **SOLID WASTE MANAGEMENT** | **(10)** |

Sources and Classification - Characteristics of solid waste-Potential methods of solid waste Disposal – Process and Equipments for Energy Recovery from Municipal Solid Waste and Industrial Solid Waste – Hazardous waste disposal – Secure landfill.

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| **WATER POLLUTION AND TREATMENT** | **(10)** |

Water and waste water – standards of potable water for various purposes - Sources and Classification of Water Pollutants - Characteristics wastewater - Waste Water Sampling techniques – types of treatment and choice of wastewater treatment – utilization and Disposal of Sludge.

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| **OTHER TYPES OF POLLUTION AND LEGISLATIONS** | **(7)** |

Sources, health impact on humans, animals and plants, control strategies – for noise pollution Oil Pollution – Pesticides pollution - Radioactivity Pollution – laws governing air, water and soil pollution

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| **CASE STUDIES** | **(8)** |

Industrial process description – pollution sources – methods available in abatement of pollution – treatment technologies – for thermal power, nuclear power, automobile, aeronautical and mining plants

 **TOTAL: 45 PERIODS.**

***References* :**

1. ***Environmental Considerations in Energy Development, Asian Development Bank (ADB), Manilla(1991)***
2. *G.Masters (1991):* ***Introduction to Environmental Engineering and Science,*** *Prentice -Hall International Editions.*
3. *H.S.Peavy, D.R..Rowe, G.Tchobanoglous (1985):* ***Environmental Engineering*** *- McGraw- Hill Book Company, NewYork.*
4. *H.Ludwig, W.Evans (2006):* ***Manual of Environmental Technology in Developing Countries,*** *W.Y. Brockelman and B.N.Lohani, International Book Company, Absecon Highlands, N.J.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Identify and value the effect of the pollutants on the environment: atmosphere, water and soil.

**CO 2:** Analyze an industrial activity and identify the environmental problems.

**CO 3:** Plan strategies to control, reduce and monitor pollution with the application of environment management system(EMS).

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE09 - SUPERCHARGING AND SCAVENGING** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn effects of supercharging and scavenging in I.C engines and design of exhaust systems |  |  |  |

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| **SUPERCHARGING** |  |  | **(8)** |

Objectives - Effects on engine performance – engine modification required - Thermo-dynamics of Mechanical supercharging and Turbo charging - Turbo charging methods - Engine exhaust manifolds arrangements.

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| **SUPERCHARGERS** | **(10)** |
| Types of compressors - Positive |  displacement blowers - Centrifugal compressors - Performance characteristic curves |

- Suitability for engine application - Surging - Matching of supercharger compressor and Engine – Matching of compressor, Turbine Engine.

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| **SCAVENGING OF TWO STROKE ENGINES** | **(12)** |

Peculiarities of two stroke cycle engines - Classification of scavenging systems - Mixture control through Reed valve induction - Charging Processes in two stroke cycle engine - Terminologies - Shankey diagram – Relation between scavenging terms - scavenging modeling - perfect displacement, Perfect mixing Complex scavenging models.

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| **PORTS AND MUFFLER DESIGN** | **(8)** |

Porting - Design considerations - Design of intake and Exhaust Systems - Tuning.

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| **EXPERIMENTAL METHODS** | **(7)** |

Experimental techniques for evaluating scavenging - Firing engine tests - Non firing engine tests – Port flow characteristics - Kadenacy system - Orbital engine combustion system, Sonic system.

**TOTAL: 45 PERIODS.**

***References* :**

1. *Obert, E.F.,* ***Internal Combustion Engines and Air Pollution,*** *Intext Education Publishers,1980.*
2. *Richard Stone,* ***Internal Combustion Engines****, SAE,2012.*
3. *Vincent,E.T.,* ***Supercharging the I.C.Engines,*** *McGraw-Hill,2002.*
4. *Watson,N. and Janota, M.S.,* ***Turbocharging the I.C. Engine,*** *MacMillan Co.,2000.*
5. *Schweitzer, P.H.,* ***Scavenging of Two Stroke Cycle Diesel Engine****, MacMillan Co.1996.*
6. *John B.Heywood,* ***Two Stroke Cycle Engine****, SAE Publications,1999.*

**COURSE OUTCOMES:**

 On successful completion of this course students will be able to:

**CO 1:** Design and make thermal analysis of the supercharging system and scavenging processes

**CO 2:** Design and tune Intake and Exhaust Systems to achieve desired performance Results.

**CO 3:** Address specific issues arising in laboratory testing of modified Engines.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE10 - CRYOGENIC ENGINEERING** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn different processes in cryogenic systems and to conduct activities related to design and the experimental study of low-temperature plant facilities and related industries. |  |  |  |
| **INTRODUCTION** |  |  | **(9)** |

Insight on Cryogenics, Methods of producing cold - thermodynamic basis, first and second law analyses, Vapour compression systems, Properties of Cryogenic fluids, and Material properties at Cryogenic temperatures.

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| **LIQUEFACTION CYCLES** | **(9)** |

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, Helium Refrigerated Hydrogen Liquefaction Systems. Critical components in Liquefaction Systems.

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| **SEPARATION OF CRYOGENIC GASES** | **(9)** |

Binary Mixtures, T-C and H- C Diagrams, Principle of Rectification, Rectification Column Analysis – McCabe Thiele Method. Adsorption Systems for purification.

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| **CRYOGENIC REFRIGERTORS** | **(9)** |

J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators, Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators.

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| **HANDLING OF CRYOGENS AND APPLICATIONS** | **(9)** |

Cryogenic Dewar Construction and Design, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Different Types of Vacuum Pumps, Instrumentation to measure Flow, Level and Temperature. Applications of Cryogenics in Space Programmes, Superconductivity, Cryo Metallurgy, Medical applications

**TOTAL: 45 PERIODS.**

***References* :**

1. *Thomas M.Flynn,* ***Cryogenic Engineering****, Marcel Dekker, New York 2nd edition, 2005.*
2. *Klaus D.Timmerhaus and Thomas M.Flynn,* ***Cryogenic Process Engineering****, Plenum Press, New York, 2013.*
3. *Randall F.Barron,* ***Cryogenic Systems****, McGraw Hill, 2002.*
4. *Scott R.B.,* ***Cryogenic Engineering****, Van Nostrand and Co., 2002.*
5. *Robert W. Vance,* ***Cryogenic Technology****, Johnwiley & Sons, Inc.2010, New York, London*
6. *G.Venkatarathnam, Cryogenic Mixed Refrigerant Processes, Springer Publication, 2010.*

***Web References* :**

1. *http://www.wiley-vch.de/contents/ullmann/ull\_10211.html.*
2. *http://www.onecro.com*
3. *http://www.caddet-ee.org/search/produce.cfm?ID=R072*
4. *http://www.sumkasons.20m.com/In2.html*
5. *http://www.thtcryogenics.freeserve.co.uk/crogenics.html*

**COURSE OUTCOMES:**

On successful completion of this course students will be able to:

**CO1:** Understand basic concepts of cryogenic systems and processes of liquefaction techniques

**CO2:** Perform Necessary Calculations for a Selecting particular Refrigerator.

**CO3:** Assess storage systems and insulation techniques used in cryogenic applications.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE11 - GAS TURBINES** |  |  |  |
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**COURSE OBJECTIVE:**

To make the students to learn aircraft applications of power plant cycles and turbo machines like compressors, axial & radial flow turbines and combustors.

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| **INTRODUCTION** |  |  | **(9)** |

Power plant cycles for stationary and aircraft applications, component behaviors, Industrial applications, Marine and land transportation, Environmental issues, analysis of ramjet, turbojet and turbo-propeller, Inlets and nozzles.

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| **COMPRESSORS** | **(9)** |

Principle and operations of Centrifugal and axial flow compressors momentum and energy transfer in rotors, velocity diagrams, calculation of stage performance, compressibility effects, cascade testing and characteristics.

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| **AXIAL AND RADIAL FLOW TURBINE** | **(9)** |

Elementary theory of axial and radial flow turbine, Vortex theorem, choice of blade profile, Pitch and Chord Stage velocity diagrams, reaction stages, losses and coefficients, blade design principles, materials, testing and performance characteristics.

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| **COMBUSTORS (9)** |
| Different types and flow pattern, material requirement and cooling systems, air pollution and reduction. |
| **MATCHING (9)** |
| Matching procedure of power plant components, engine off-design performance. |
|  |
|  **TOTAL: 45 PERIODS.****REFERENCES:** |
| *L.* | *Cohen, H., Rogers, G.E.C., and Saravanamuttoo, H.I.H.,* ***Gas Turbine Theory****, Longman Group Ltd, 2009.* |
| *M.* | *Gordon C, Dates,* ***Aero-thermodynamics of Gas Turbine and Rocket Propulsion*** *– AIAA Education* |
|  | *Series, 3rd edition NY 1997.* |

1. *Kerrebrock, J.L.,* ***Aircraft engines and gas turbines****, The MIT Press 2nd ed, 1996.*
2. *Yahya, S.H.,* ***Turbines, Compressors and Fans****, Tata McGraw-Hill,4th edition 2013.*
3. *Earl Logan, Jr.,* ***Hand book of Turbo machinery****, Marcel Dekker, Inc., USA,2nd edition 2003.*
4. *Dixon, S.L.,* ***Fluid******Mechanics and Thermodynamics of Turbo machinery****, Pergamon Press,7th edition 2014.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Utilize the understanding in designing and assess the performance of compressors and utilize various power plant cycles applications.

**CO 2:** Make the thermal design and analysis for various turbo machines like axial and radial flow turbines and combustors.

**CO 3:** Match various power plant components.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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**16TEPE12- REFRIGERATION MACHINERY AND COMPONENTS**

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| **COURSE OBJECTIVE:** To make the students to learn different refrigeration system components, air conditioning equipments and their testing methods. |  |  |

**REFRIGERATION SYSTEM COMPONENTS (9)**

Refrigeration Compressors-Types, Performance, Capacity Control – Evaporators, Evaporator types, Evaporators Circuitry, Applications– Condensers, Types, Evaporative Condenser, Optimum Cooling Water Rate and Velocity, Cooling Towers, Range and Approach, Air Washers, Spray Ponds, Natural and Induced Draught System – Expansion Devices.

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| **COMPONENTS TESTING AS PER (BIS CODES)** | **(9)** |

Testing of Condensers and Evaporators, Testing of Cold Storages – Code of Practice for Fire Safety ,Storage, Specification and Testing of All type of Air conditioners.

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| **AIR CONDITIONING EQUIPMENTS AND ACCESSORIES** | **(9)** |

Construction Details of Room Air Conditioner – Window Type, Package Type, Split type, VRF , Central Units – Air Distribution Devices – Air Circuits – Air handling System.

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| **APPLICATIONS OF AIR CONDITIONING** | **(9)** |
| Air Conditioning in Automobiles, Railway Wagons, Marine Vessels, Aircraft and Other Commercial Applications. |  |
| **REFRIGERATION ACCESSORIES & CONTROL** | **(9)** |

Piping System, Valves, Receivers, Oil Trap, Oil Regenerators, Driers and Strainers. Control System of Temperature, Pressure, Oil Flow, Compressor Motor – Protection Devices.

**TOTAL: 45 PERIODS.**

***References :***

1. *Dossat, R. J.* ***“Principles of Refrigeration”****, John Wiley & Sons,4th edition, 2010.*
2. *Hains, J.B.* ***“Automatic Control of Heating & Air conditioning”*** *McGraw-Hill, 1981.*

*H. Althouse, A.D. &Turnquist, C.H.* ***“Modern Refrigeration and Air conditioning”*** *Heart – Wilcox Co. Inc.,1985.*

1. ***Recent release of BIS Code for relevant testing practice.***
2. ***ASHRAE Hand book (Fundamentals &Equipments) 2012***
3. *Cooper & Williams, B.* ***“Commercial, Industrial, Institutional Refrigeration, Design, Installation and TroubleShooting”*** *Eagle Wood Cliffs (NT) Prentice Hall, 1989.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Work on various refrigeration system components.

**CO 2:** Test the refrigeration components and air conditioners.

**CO 3:** Select the types of air conditioning for various commercial applications.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE13 - THERMAL ENERGY SYSTEMS** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn design, modeling and optimization of thermal energy systems used in various energy production applications and ensuring the dynamic behavior of the thermal system.  |  |  |  |
| **DESIGN OF THERMAL SYSTEM** |  |  |  **(6)** |

Design systems, Workable Systems, Optimal Systems, Matching of system Components, Economic analysis, Depreciation, gradient present worth factor.

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| **MATHEMATICAL MODELLING** |  **(8)** |

Equation fitting – Nomography, Empirical equation, Regression analysis, Different modes of mathematical models, selection, computer programmes for models.

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| **MODELLING THERMAL EQUIPMENTS** |  **(8)** |

Modelling heat exchangers. Evaporators, condensers, absorption and rectification columns, compressor, pumps, simulation studies, information flow diagram, solution procedures.

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| **SYSTEMS OPTIMIZATION** |  **(15)** |

Objective function formulation, Constraint equations, Mathematical formulation, Calculus method, Dynamic programming, programming, Linear programming methods, solution procedures.

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| **DYNAMIC BEHAVIOUR OF THERMAL SYSTEM** |  **(8)** |

Steady state simulation, Laplace transformation, Feedback control loops, Stability analysis, Non linearities.

**TOTAL :45PERIODS.**

***References :***

1. *J.N.Kapur,* ***Mathematical Modelling****, Willey Eastern Ltd., New York, 2015.*
2. *W.F.Stoecker,* ***Design of Thermal Systems****. McGraw Hill, 2002.*
3. *W.F.Stoecker,* ***Refrigeration and Airconditioning****, TMH, 2nd edition 2014.*
4. *Fanger P.O.,* ***Thermal Comfort****, McGraw Hill, USA, 1982.*
5. *McQuiston FC & Parker TD,* ***Heating, Ventilating and Air conditioning, Analysis and Design****, John Wiley & Sons, USA,6th edition 2005.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1:** Use the techniques, skills and modern engineering tools necessary for engineering practice.

**CO 2:** Develop model equations for the given system.

**CO 3:** To impart the knowledge of the linear programming methods andapply concepts, laws and principles of thermal systems to operate and maintain them for efficient use of energy and its conservation as per industrial norms.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE14- DIESEL EMISSION CHARACTERISTICS** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn combustion in diesel engines and extent of the problem of pollutant formation and control in internal combustion engines and testing measures. | ` |  |  |

**DIESEL EMISSION CHARACTERISTICS (9)**

Vehicle emission Test Programme - Effect of ambient Temperature on “HC”, “OC” and emission - Different fuel system.

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| **EFFECT OF HIGH PRESSURE INJECTION ON SOOT FORMATION PROCESS** | **(9)** |

High Pressure Injection - Experimental apparatus and measuring principles - Measurement of Non-Evaporating spray

– Measurement of Evaporating spray and flame.

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| **DIESEL SOOT SUPPRESSION** | **(9)** |

Soot Suppression by kind and content of fuel additives - Under various operating conditions - Effect of combustion chamber type and swirl ratio.

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| **SIMULTANEOUS REDUCTION OF SOOT AND NOx** | **(9)** |

Experimental procedure - Steady state and test cycle - Transient test cycle.

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| **EFFECTS OF DIESEL FUEL PROPERTY ON EXHAUST VALVE STICKING** | **(9)** |

Test engine bench - Test fuel engine - ignition limit test - Investigation of white smoke - Measurement of valve sticking force - Valve Train fracture test.

**TOTAL: 45 PERIODS.**

***References :***

1. *Satora, Yasuhiro Iton Gutaka Higuchi and Tateo Nagai,* ***NIIGATA Ultra Lean Burn SI Gas Engines -Achieving High Efficiency and Low NOx Emission;*** ***SAE – 901608, 1990.***
2. *SW Cootes and G.G.Lassanska,* ***Measurement and Analysis of Gaseous Exhaust Emissions from Recreational and Small Commercial Marine Craft; SAE – 901597, 1990.***
3. *G.Greeves and CHT Wang,* ***Origins of Diesel Particulate Mass Emission; SAE – 810260, 1981.***
4. *Yuzo.Aoyagi, Takeyuki Kamimoto Yokio Matsui and Shim Matsuoka,* ***A Gas Sampling Study on the Formation Processes of Soot and NO in a DI Diesel Engine; SAE – 800254.*** *1980.*
5. *Kenneth Carpenter and John H.Johnson,* ***Analysis of the Physical Characteristics of Diesel Particulate Matter Using Transmission Electron Microscope Techniques; SAE – 790815.*** *1979.*
6. *Harvet A. Bybket and Thoedore L.Rjosebrock,* ***Automotive Diesel Engines-Fuel Composition vs Particulates SAE – 790923.1****979.*
7. *Charles M.Urban and Robert D.Waner,* ***Evaluation of Heavy-Duty Engine Exhaust Particulate Traps; SAE – 850147.*** *1985*

**COURSE OUTCOMES:**

On successful completion of this course the student will be able to

**CO 1**: Understand the concepts of the Emission in engines.

**CO 2:** Analyse the formation of emission and its control in engines.

**CO 3:** Test the emission characteristics of I.C engines.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE15 - MODELING OF CI ENGINE PROCESSES** |

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| **COURSE OBJECTIVE:** To make the students to understand the concepts of combustion and flow modeling of CI engines.

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| **GENERAL CONSIDERATIONS OF MODELING**  |  |  | **(9)** |

Governing equations, conservation of mass, conservation of energy, second law Analysis, Numerical methodology, computing mesh, Discretisation, Grid Formation.

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| **SPRAY MODELING**  |  **(9)**  |

Spray equation Models, Thin spray models, Thick Spray Models, Droplet turbulence inter- actions, Droplet impingement on walls.

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| **IN-CYLINDER FLOW MODELING**  |  **(9)** |

Full Field Model, K-e Model, laminar flow modeling, probability density functions, Ekman layers roll-up vortex, vortex structures. Compression generated turbulence, effective viscosity turbulent diffusivity.

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| **INTRODUCTION TO COMBUSTION MODELING** |  **(9)** |

Classification, zero-dimensional modeling, quasi-dimensional modeling, multidimensional modeling, comparison of of different combustion systems, combustion efficiency, applications

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| **COMBUSTION MODELS** |  **(9)** |

Multi zone Models, Kono’s model, Cummins engine model, Hiroyasu’s model,. Single zone models, Premixed diffusive models, Heat Transfer Cp-relations Weibe’s function analysis, Whitehouse-way model, Two zone models, Mathematical modeling of Catalytic converters one dimensional model- MD axi-symmetric model of monolithic reactor, Computation of chemical reactions, two dimensional transient temperature field.**TOTAL: 45 PERIODS.** |
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**References :**

1. *J.I.Ramos* ***“Internal Combustion Engine Modeling”*** *Hemisphere Publishing Corporation, 1989.*
2. *James N.Mattavi and Charles A.Amann* ***“Combustion Modeling in Reciprocating Engines”****. Plenum Press – 1980*.
3. *John.B.Heywood,* ***“Internal Combustion Engine Fundamentals”*** *McGraw-Hill International Editions, Automotive technology Series, 2012.*
4. *I.kandylas,G.Koltsakis and A.Stamatelos* ***“Mathematical Modeling of Precious Metals Catalytic Converters for Diesel Nox Reduction”****. Journal of automobiles engineering, 213, no. D3(1993): 279-292.*
5. *Sandeep Maju, Robert I.Sager.Jr., and Benny J.Srider,* ***“Predicting Durability”*** *Mechanical engineering Vol. 64, March 1999.*
6. *.J.Baxendale* ***“Computational Fluid Dynamics in Exhaust System Design and Development”*** *SAE Paper.No.931072,1993.*

**COURSE OUTCOMES:**

On completion of this course, students will be able to

**CO 1**: Develop flow modeling equation and analyze the effects of it.

**CO 2:** Develop in-cylinder flow modeling of CI engines.

**CO 3:** Develop combustion models based on practical applications.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE16 - ENGINE ELECTRONICS** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn concepts of Automotive Electronics and its evolution and trends of sensor monitoring mechanisms to design and model various automotive ignition and injection systems control for different vehicle.

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| **SENSORS** |  |  | **(9)** |

Types – Air flow, Pressure, Temperature, Speed Oxygen, Detonation, Position – Principle of Operation, Arrangement and material.

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| **GASOLINE INJECTION SYSTEM** | **(9)** |

Open loop and closed loop systems, Mono point, Multi point and direct injection systems –Principles and Features, Bosch injection systems.

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| **DIESEL INJECTION SYSTEM** | **(9)** |

Inline injection pump, Rotary pump and injector – Construction and principle of operation, Common rail and unit injector system – Construction and principle of operation.

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| **IGNITION SYSTEMS** | **(9)** |

Ignition fundamentals, Types of solid state ignition systems, high energy ignition distributors, Electronic spark timing and control.

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| **ENGINE MAPPING** | **(9)** |

Combined ignition and fuel management systems. Digital control techniques – Dwell angle calculation, Ignition timing calculation and Injection duration calculation, Hybrid vehicles and fuel cells.**TOTAL: 45 PERIODS.*****References :***1. ***Bosch Technical Instruction Booklets,*** *1999.*
2. *Tom Denton,* ***Automotive Electrical and Electronic Systems****, Edward Amold, 2016*
3. *Robert N.Brady,* ***Automotive Computers and Digital Instrumentation****, Prentice Hall, 1988.*
4. *Duffy Smith.,* ***Auto Fuel Systems****, The god Heart Willcox Company Inc., Publishers, 1992.*
5. *Heinz Heisler.,* ***Advanced Engine Technology****. SAE Publications, 1995*
6. *Boltzharol, A., Materials Handling Handbook, Elsevier butter worthheinemenn Company, 2005.*

**COURSE OUTCOMES:**  On completion of this course, students will be able to **CO 1**: Obtain an overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today’s automotive industry.**CO 2:** Interface automotive sensors and actuators with microcontrollers.**CO 3:** Develop, simulate and integrate digital control techniques. **CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE17 - ENGINE POLLUTION AND CONTROL** |  |  |  |
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| **COURSE OBJECTIVE:**  To make the students to learn engine pollution formation, control, Measurement techniques and impact of them in the society to match pre-requisite course specialized studies and research. |  |  |  |

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| **POLLUTION – ENGINES AND TURBINES** |  |  | **(5)** |

Atmospheric Pollution from piston engines and gas turbines, global warming.

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| **POLLUTANT FORMATION** | **(10)** |

Formation of Oxides of Nitrogen, Carbon monoxide, hydrocarbon, aldehydes and Smoke Particulate emission, effects of pollutions on environment.

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| **POLLUTION MEASUREMENT** | **(10)** |

Non dispersive infrared gas analyzer, gas chromatography, chemi-luminescent analyzer and flame ionization detector, smoke measurement, noise pollution, measurement and control.

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| **CONTROL OF ENGINE POLLUTION** | **(10)** |

Engine component, fuel modification, evaporative emission control, EGR, air injection in thermal reactors, In cylinders control of pollution, catalytic converters, application of microprocessors in emission control.

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| **DRIVING CYCLES AND EMISSION STANDARDS** | **(10)** |

Use of driving cycles for emission measurement, chassis dynamometer, CVS system, National and International emission standards.

**TOTAL: 45 PERIODS.**

***References :***

1. *Crouse William,* ***Automotive Emission Control****, Gregg Division / McGraw-Hill 2000.*
2. *Ernest, S.,Starkman,* ***Combustion Generalized Air Pollutions****, Plenum Press, 1993.*
3. *George, Springer and Donald J.Patterson,* ***Engine emissions, pollutant Formation and Measurement****, Plenum Press, 2012.*
4. *Obert,E.F.,* ***Internal Combustion Engines and air Pollution****, Intext Educational Publishers, 2000.*

**COURSE OUTCOMES:**

 On successful completion of this course students will be able to:

**CO 1:** Identify the emission and its effect on human health and environment.

**CO 2:** Outline the formation of pollutant in SI engine and C.I engine

**CO 3:** Develop knowledge on Emission control, measurement and standardization techniques.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE18 - MANUFACTURING AND TESTING OF IC ENGINES AND COMPONENTS** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn a comprehensive module on the aspects of materials, manufacture and testing of piston engine assemblies, components, subsystems and Engine Standards.  |  |  |  |

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| **CYLINDER BLOCK AND CYLINDER HEAD** |  |  | **(9)** |

Casting practice and special requirements, materials, machining, methods of testing, Cylinder liners – Mat, Types and Manufacture.

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| **PISTON ASSEMBLY** | **(9)** |

Types, requirements, casting, forging, squeeze casting, materials, machining, testing, manufacture piston rings – material, types and manufacture – surface treatment, bimetallic pistons, articulated pistons.

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| **DRIVE SYSTEMS** | **(9)** |

Requirements, materials, forging practice, machining, balancing of crankshaft, testing, CR, CS, CAS, VT.

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| **COMPUTER INTEGRATED MANUFACTURING** | **(9)** |

Integration of CAD, CAM and Business functions CIM- Networking, CNC programming for machining of I.C.Engines Components.

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| **QUALITY AND TESTING** | **(9)** |

SPC - Introduction to ISO 9000, ISO L4000, TS L6949, its importance, BIS codes for testing various types of engines, equipments required, instrumentation, computer aided engine testing, metrology for manufacturing I.C.Engine Components, In site measurement – Telemetry and sensors.

**TOTAL: 45 PERIODS.**

***References :***

1. *Grover, M.P.,* ***CAD/CAM****, Prentice Hall of India Ltd., 1985.*
2. *Heldt, P.M****., High speed internal combustion engines****, Oxford & IBH Publishing Co., 1965.*
3. *Judge, A.W.,* ***Testing of high speed internal combustion engines****, Chapman & Hall.,2016.*
4. *Richard, W., Heine Carl R. Loper Jr. and Philip, C., Rosenthal,* ***Principles of Metal Casting****, McGraw-Hill Book Co., 2001.*
5. ***IS: 1602 – 1960 Code for testing of variable speed internal Combustion engines for Automobile Purposes , 1998.***
6. ***SAE Handbook, 2011.***
7. *P.Radhakrishnan and S.Subramaniayn,* ***CAD/CAM/CIM****, New Age International (P) Limited, Publishers, 2013.*
8. *Mikett P.Groover****, Automation, production Systems and Computer – Integrated Manufacturing*** *Prentice Hall of India Private Limited, 1999.*

**COURSE OUTCOMES:**

On successful completion of this course students will be able to:

**CO 1:** Specify the component material and manufacturing method for a particular I.C.Engine.

**CO 2:** Implement advanced Computer integrated Techniques in Manufacturing I.C.Engine components.

**CO 3:** Relate and Quality Check a Component with International Standards.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE19 - ALTERNATIVE FUELS FOR IC ENGINES** |  |  |  |
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| **COURSE OBJECTIVE :**To make the students to learn various types properties, availability of alternate fuels to identify the physical significance of alternate fuel. |  |  |  |

**INTRODUCTION (9)**

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

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| **ALCOHOLS** | **(9)** |

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

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| **NATURAL GAS, LPG, HYDROGEN AND BIOGAS** | **(9)** |

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

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| **VEGETABLE OILS** | **(9)** |

Various vegetable oils for engines, esterification, performance in engines, performance and emission characteristics, bio diesel and its characteristics.

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| **ELECTRIC, HYBRID, FUEL CELL AND SOLAR CARS** | **(9)** |

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

**TOTAL: 45 PERIODS.**

***References :***

1. *Richard.L.Bechfold –* ***Alternative Fuels Guide Book*** *- SAE International Warrendale, 2007.*
2. *Maheswar Dayal - “****Energy today a tomorrow****”- I and B Horishr India, 1982.*
3. *Nagpal - “****Power Plant Engineering****” - Khanna Publishers, 1991.*
4. *“****Alcohols as motor fuels progress in technology****” - Series No.19 - SAE Publication USE, 1980.*
5. *SAE paper nos. 840367, 841333, 841334, 841156, Transactions, SAE, USA.*
6. *Hybrid and alternative fuel vehicles ,* ***Jack R. merad*** *2007*
7. *Groover M.P* ***CAD/CAM*** *2004*

***Web References :***

1. .http://aimforhigh.blogspot.com/2011/12/at2022-alternate-fuels-and-energy.html#ixzzLuBElr9rW

**COURSE OUTCOMES :**

 On completion of this course, students will be able to

**CO1:** Understand the various types of fuel options available for the conventional fuels.

**CO 2:**Analyze the performance and emission characteristics of alternate fuels.

**CO 2:**Understand the recent development in the I.C engines using alternate fuels.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEPE20 - BIO-ENERGY CONVERSION TECHNIQUES** |  |  |  |
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| **COURSE OBJECTIVE:** To make the students to learn types of biomass, its surplus availability and characterizing the conversion techniques of biomass to energy and do economic analysis. |  |  |  |
| **INTRODUCTION** |  |  | **(9)** |
| Bio Energy - Bio Conversion Mechanism - Utilization of Photosynthate. |  |  |  |
| **THERMAL BIOMASS CONVERSION** |  |  | **(9)** |

Combustion, Pyrolysis, Gasification and Liquefaction - Biological Conversion - Methanol, Ethanol Production - Fermentation - Anaerobic Digestion Biodegradation and Biodegradability of Substrate - Hydrogen Generation from Algae – Biological Pathways.

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| **POWER GENERATION TECHNIQUES** | **(9)** |

Through Fermentation and Gasification - Biomass Production from different Organic Wastes - Effect of Additives on Biogas Yield - Biogas production from Dry Dung Cakes.

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| **INDUSTRIAL APPLICATION** | **(9)** |

Industrial Application - Viability of Energy Production - Wood Gasifier System, Operation of Spark Ignition and Compression Ignition with Wood Gas. Operation and Maintenance.

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| **ECONOMICS AND ENVIRONMENTAL ASPECTS** | **(9)** |

Energy Effectives and Cost Effectiveness - History of Energy Consumption and Cost - Environmental Aspects of Bio-energy Conversion.

**TOTAL: 45 PERIODS.**

***References:***

1. *David Boyles,* ***Bio Energy Technology Thermodynamics and costs****, John wiley, 1984*
2. *Khandelwal KC, Mahdi SS,* ***Biogas Technology - A Practical Handbook****, Tata McGraw Hill, 1986*
3. *R.C.Maheswari,* ***Bio Energy for Rural Energisation*** *, Concepts Publication, 1997*
4. *Anthony San Pietro,* ***Biochemical and Photosynthetic aspects of Energy Production****, Academic Press, New York, 1980*
5. *EL - Halwagi MM,* ***Biogas Technology : Transfer and Diffusion****, Elsevier Applied SC, London 1986*

***Web References:***

1. [*http://www.bio-energy.at*](http://www.bio-energy.at)
2. [*http://www.abchansen.dk*](http://www.abchansen.dk)*.*
3. [*www.soest.hawaii.edu/csf*](http://www.soest.hawaii.edu/csf)

**COURSE OUTCOMES**:

On completion of this course, students will be able to

**CO1:** A practical understanding on the various biomass energy conversion technologies and its relevance towards solving the present energy crisis.

**CO2:** Provide a thorough understanding of basic principles and system constructions of biomass energy conversion technology and utilization.

**CO3: A**nalyze economic optimality and environmental aspects of bio energy conversion techniques

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEOC01 TECHNICAL SEMINAR** |
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**COURSE OBJECTIVE:**

To work on a specific technical topic in engineering fields in order to acquire the skills of oral presentation.

**COURSE CONTENT**

1. Prepare on the specific topic related to developments and innovations in engineering
2. Present the seminar for fifteen minutes to thirty minutes on the technical topic
3. Engage in group discussion with the learners
4. Interact with learners and answer the queries on the topic
5. Submit the summary of discussions
6. Evaluation based on the technical presentation, the report and on the interaction during the seminar

**LECTURE: 0 TUTORIAL:0 PRACTICAL:30 TOTAL: 30 PERIODS**

**COURSE OUTCOMES:**

Learners will be able to

**CO1:** Comprehend concepts and methods adequate to apply inductive and deductive reasoning for enhancing the problem solving skills.

**CO2:** Develop communicative capabilities in speaking, listening, reading and writing

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEOC02 ENTREPRENEURSHIP SKILLS** |
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| **COURSE OBJECTIVE:** |
| To provide learners with skills needed to effectively organize, develop, create, evaluate and manage an event or business. |
| **COURSE CONTENT:**1. Event management and entrepreneurship, communication and interpersonal skills,
2. Economics, trading and project related business ownerships.
3. Developing an enterprise, computer and technology applications, real and simulated occupational experiences.
4. Developing leadership abilities, expand workplace- readiness skills, and broaden opportunities for personal and professional growth

 **LECTURE: 0 TUTORIAL:0 PRACTICAL:30 TOTAL: 30 PERIODS****COURSE OUTCOME:****CO 1:** Learners influenced and enhanced with skill development on self-employability and able to achieve attitudes necessary to become successful in business or event management.**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

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| **16TEOC03 HUMAN VALUES AND PROFESSIONAL ETHICS** |
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| **COURSE OBJECTIVES:** |
|  To provide learners * Engineering Ethics and Human Values
* Social responsibility of an Engineer
* Ethical dilemma while discharging duties in Professional life.

**COURSE CONTENT:****ENGINEERING ETHICS**Senses of Engineering Ethics- variety of moral issues- types of inquiry – moral dilemmas- moral autonomy- Kohiberg’s Theory- Gilligen’s Theory- Consensus and controversy- Models of Professional roles- theories about right actions- self-interest – customs and religion – uses of ethical theories- Valuing time- cooperation- commitment.**ENGINEERING AS SOCIAL EXPERIMENTATION**Engineering as experimentation- engineers as responsible experimenters- codes of ethics- a balanced outlook on law – the challenger case study – engineers as managers – consulting engineers – Moral leadership.**SAFETY, RESPONSIBILITIES, RIGHTS AND GLOBAL ISSUES**Safety and risk – assessment of safety and risk – risk benefit analysis and reducing risk – the three mile island and Chernobyl case studies – Environmental ethics – computer ethics – weapons development – Multinational corporations – engineers as expert witness and advisors. **LECTURE: 15 TUTORIAL:0 PRACTICAL:0 TOTAL: 15 PERIODS****Reference:**1. *Mike Martin and Roland Schinzinger, ‘Ethics in Engineering , McGraw Hill, New York, 1996*
2. *M. Govindarajan, S. Natarajan and V.S. Senthil Kumar, “Engineering Ethics(including human values)”, Eastern Economy Edition, Printice Hall of India Ltd.,2004*
3. *Charles D.Fleddermann, “Engineering Ethics”, Pearson Education, 2004*
4. *Edmund G Seebauer and Robert L. Berry,’ Fundementals of Ethics for Scientists and Engineers’, 2001, Oxford University Press*
5. *Charles E. Harris, Micheal S. Protchard and MichealJ.Rabins, “Engineering Ethics- Concepts and Casses”, Thomson Leaning , 2000.*
6. *John R. Boatright, “Ethics and Conduct of Business”, Pearson Education, 2003.*
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**COURSE OUTCOMES:**

 Upon completion of this course the students will be able to

**CO1:** Understand and appreciate Human Values, exhibit self-confidence and develop good character

**CO2:** Practice code of ethics, assess safety and risk thereby capable of doing risk benefit analysis.

**CO3:** Develop and exhibit moral leadership qualities in exercising Engineering Consultations without compromising environmental, legal and ethical issues.

**CORRELATION BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | PO 1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
| CO1 | \*\* | \*\* | \* | \* | - | - | - | - | \* | \* | \* |
| CO2 | \*\* | \* | \* | \* | - | - | - | - | \* | \* | \* |
| CO3 | \*\* | \* | \* | \* | - | - | - | - | \* | \* | \* |