# KERALA TECHNOLOGICAL UNIVERSITY


## (THRISSUR CLUSTER - 07)

## SCHEME AND SYLLABI

## of

## M. TECH.

## in

# INTERNAL COMBUSTION ENGINES AND TURBOMACHINERY

**OFFERING DEPARTMENT**

# MECHANICAL ENGINEERING

## CLUSTER LEVEL GRADUATE PROGRAM COMMITTEE

| | | |
|---|---|---|
| 1. | Dr Devdas Menon, Professor, IIT Madras, Chennai | Chairman |
| 2 | Principal, Government Engineering College Trichur, Thrissur | Convener |
| 3 | Principal, AXIS College of Engineering & Technology, East Kodaly, Murikkingal, Thrissur | Member |
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| 7 | Principal, Vidya Academy of Science & Technology, Thalakkottukara, Thrissur | Member |
| 8 | Principal, Thejus Engineering College, Vellarakkad, Erumappetty, Thrissur | Member |
| 9 | Principal, Universal Engineering College, Vallivattom, Konathakunnu, Thrissur | Member |
| 10 | Principal, Sahrdaya College of Engineering & Technology, Kodakara, Thrissur | Member |

## CERTIFICATE

This is to certify that

1. The scheme and syllabi are prepared in accordance with the regulation and guidelines issued by the KTU from time to time and also as per the decisions made in the CGPC meetings.
2. The suggestions/modifications suggested while presenting the scheme and syllabi before CGPC on 25.6.2015 have been incorporated.
3. There is no discrepancy among the soft copy in MS word format, PDF and hard copy of the syllabi submitted to the CGPC.
4. The document has been verified by all the constituent colleges.

Coordinator in charge of syllabus revision of the programme

Dr.A.Ramesh

Associate Professor in Mechanical Engineering

Govt. Engineering College Trichur, Thrissur

Principal of the lead college

Dr. K.P Indiradevi

Principal

Govt. Engineering College Trichur, Thrissur

Principals of the colleges in which the programme is offered

| Name of the college | Principal's Name | Signature |
|---|---|---|
| Govt. Engineering College Trichur, Thrissur | Dr. K P Indiradevi | |

Date: Chairman

Place:

# PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The program educational objectives of the IC engines and Turbo Machinery M Tech course are to educate graduates who will be ethical, productive, and contributing members of society.

**PEO-1**: Graduates will be capable of utilizing foundation in engineering and science to improve lives and livelihoods through successful careers in society and to disseminate the acquired knowledge to the stakeholders.

**PEO-2**: To enable the graduates to pursue their career in Research and Development, applied research and strategic organizations to acquire competence to meet global needs.

**PEO-3**: Graduates will turn to be effective collaborators and innovators, leading or participating in efforts to address social, technical and business challenges and thereby contributing to nation building.

**PEO-4**: To promote student awareness of professional ethics and codes of professional practice with commitment towards sustainable development. The student will be familiarized with the issues of social and economical consequences of engineering solution and therefore should be prepared to address them with integrity and empathy for all stakeholders involved.

**PEO-5**: Student will get awareness of maintaining state of the art knowledge through life-long learning.

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# PROGRAMME OUTCOMES(POs)

1. In depth understanding of IC engines and Turbo machineries, their working principle, potential and challenges.
2. Exposure to the state of the art in the field of IC engines and Turbo machineries.
3. Ability to observe, understand, model, simulate, analyze and interpret a given problem.
4. Ability to design and develop energy efficient IC engines and economic fluid flow systems.
5. Ability to utilize energy resources in an optimum way.
6. Ability to keep abreast with the technology, seek out suitable professional careers or higher degrees.
7. Ability to develop numerical models, simulate various engineering systems and predict the performance to reduce to cost/time involved in experimentation.
8. Understanding on the recent developments in energy conversion systems and ability to design novel energy conversion systems.
9. Ability to formulate problems, design experiments, apply measurement techniques and principles to solve problems and generate knowledge.
10. Ability to plan, organise, execute and document various engineering projects.
11. Grow as an individual with strong moral values, professional ethics and social responsibility.
12. Commitment to quality, punctuality and continuous learning to meet the demands of the society.
13. Ability to communicate effectively both in written and verbal forms and learn to use technology in improving the efficiency of communication.

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# SCHEME

## CURRICULUM AND SCHEME OF EXAMINATIONS

## M.TECH in INTERNAL COMBUSTION ENGINES AND TURBO MACHINERY (MECHANICAL ENGINEERING)

## Dept. of Mechanical Engineering

### Semester - I

| EXAM SLOT | Course No: | Subject | Hours per week | | | Internal Marks | End semester exam | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P/D | | Marks | Duration (Hrs) | |
| A | 07ME 6401 | Computational Mathematics | 3 | 1 | 0 | 40 | 60 | 3 | 4 |
| B | 07ME 6103 | Advanced Fluid Mechanics | 3 | 1 | 0 | 40 | 60 | 3 | 4 |
| C | 07ME 6105 | Advanced Heat and Mass Transfer | 3 | 1 | 0 | 40 | 60 | 3 | 4 |
| D | 07ME 6107 | Principles of Turbo-machinery | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| E | 07ME 61X1 | Elective | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| | 07GN 6101 | Research Methodology | 0 | 2 | 0 | 100 | 0 | 0 | 2 |
| | 07ME 6109 | I C Engine Laboratory | 0 | 0 | 2 | 100 | 0 | 0 | 1 |
| | 07ME 6100 | Introduction to Seminar | 0 | 0 | 1 | 100 | 0 | 0 | 0 |
| | | TOTAL | 15 | 5 | 3 | | | | 21 |

### Semester - II

| EXAM SLOT | Course No: | Subject | Hours per week | | | Internal Marks | End semester exam | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P/D | | Marks | Duration (Hrs) | |
| A | 07ME 6102 | Advanced Thermodynamics and combustion | 3 | 1 | 0 | 40 | 60 | 3 | 4 |
| B | 07ME 6104 | Internal Combustion Engine Design | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| C | 07ME 6106 | Design of Thermal Turbomachines | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| D | 07ME 6XX2 | Elective | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| E | 07ME 6XX2 | Elective | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| | 07ME 6108 | Seminar | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
| | 07ME 6114 | Mini project | 0 | 0 | 4 | 100 | 0 | 0 | 2 |
| | 07ME 6116 | Computational Lab | 0 | 0 | 2 | 100 | 0 | 0 | 1 |
| | | TOTAL | 15 | 1 | 8 | | | | 21 |

## Semester - III

| EXAM SLOT | Course No: | Subject | Hours per week | | | Internal Marks | End semester exam | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P/D | | Marks | Duration (Hrs) | |
| A | 07ME 71X1 | Elective | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| B | 07ME 71X1 | Elective | 3 | 0 | 0 | 40 | 60 | 3 | 3 |
| | 07ME 7101 | Project (Phase I) | 0 | 0 | 12 | 50 | 0 | 0 | 6 |
| | 07ME 7103 | Seminar | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
| | | TOTAL | 6 | 0 | 14 | | | | 14 |

## Semester - IV

| EXAM SLOT | Course No: | Subject | Hours per week | | | Internal Marks | End semester exam | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P/D | | Marks | Duration (Hrs) | |
| | 07ME 7102 | Project (Phase II) | 0 | 0 | 21 | 100 | 0 | 0 | 12 |
| | | TOTAL | 0 | 0 | 21 | | | | 12 |

# The student has to undertake the departmental work assigned by HOD

Note:

L – Lecture, T – Tutorial, P – Practical

**Total number of Credits for the PG Programme: 21+21+14+12 = 68**

## List of Electives

### SEMESTER I

07ME 6111 Direct Energy Conversion Systems

07ME 6121 Engine Pollution and Control

07 ME 6131 Theory and Technology of Fuel Cells

07 ME 6141 Propulsion Engineering

### SEMESTER II

07 ME 6212 Advanced Finite Element Analysis

07 ME 6122 Computational Fluid Dynamics

07 ME 6132 Design and Optimization of Thermal Systems

07 ME 6142 Thermal Turbo Machines

07 ME 6152 Soft Computing Techniques

07 ME 6161 Energy Conservation in Thermal Systems

### SEMESTER III

07 ME 7111 Simulation of I C Engine processes

07 ME 7121 Industrial Energy Management

07 ME 7131 Alternative Fuels for I C Engines

07 ME 7141 Measurements in Thermal Systems

07 ME 7151 Automotive Engine systems

07ME 7161 Optimization Techniques

**Total number of Electives offered: 16**

# SYLLABUS & COURSE PLAN

## COMPUTATIONAL MATHEMATICS

**COURSE NO: 07ME 6401** **CREDITS: 3-1-0:4** **YEAR: 2015**

**Pre- requisites:** Nil

**Course Objectives:**

- To obtain insight into the mathematical concepts of computation
- To impart an idea of solving real life problems using computational methods

**Syllabus:**

Partial differential equations - Numerical solution: Euler and modified Euler methods, Runge-Kutta method- Power series solutions about ordinary point - Solution about singular points - Tensors - Symmetric and anti-symmetric tensors - Orthogonal tensor - Eigen values and Eigen vectors of a tensor - Tensor Calculus - Application of Finite Difference Methods – Discretization - Crank Nicolson scheme - Criteria for numerical stability - Finite volume method for 1-D steady state diffusion - Introduction to FEM - Computational procedures - Introduction to isoparametric elements - Matlab/Scilab tutorials to develop 1D FE codes.

**Course Outcomes:**

The student will have obtained mathematical basis of computation which can be applied to Mechanical Engineering problems.

**References:**


1. Ervin Kreyszig, Advanced Engineering Mathematics, Wiley, Nineth Edition.
2. Steven Chapra, Raymond Canale, Numerical Methods for Engineers, McGraw-Hill Education, Seventh Edition.
3. H.K. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education, Second Edition.
4. John D Anderson, Computational Fluid Dynamics: The Basics with Application, McGraw Hill Education (India) Private Limited, First Edition.
5. W Micheal Lai, David Rubin, Erhard Krempl, Introduction to Continum Mechanics, Elsevier Science, Fourth Edition.
6. P. Seshu, Text book of Finite Element Analysis, Prentice Hall of India, 2003.

| COMPUTATIONAL MATHEMATICS<br>COURSE NO: 07ME 6401 L-T-P : (3-1-0) CREDITS: 4 | | |
|---|---|---|
| **MODULES** | **Contact hours** | **End Sem. Exam Marks; %** |
| **MODULE: 1** First order PDE's – Linear equations – Lagrange method – Cauchy method - Charpit's method – Jacobi method. Second order PDE's – Classifications, Formulations and method of solutions of Wave equation, Heat equation, Laplace equation. | 10 | 15 |
| **MODULE: 2** Numerical solution of ordinary differential equations: Taylor series method – Euler and modified Euler methods – Runge-Kutta methods – Solution of boundary value problems in ordinary differential equations – Finite difference methods for solving two dimensional Laplace's equation for a rectangular region. | 8 | 15 |
| FIRST INTERNAL TEST | | |
| **MODULE:3** Power series solutions about ordinary point – Legendre Equation – Legendre Polynomials – Solution about singular points – The method of Frobenius – Bessel equation - Bessel functions – Strum-Liouville problem – Generalized Fourier series. | 8 | 15 |
| **MODULE: 4** Application of Finite Difference Methods, Discretization – Taylor series method – Central, Forward and Backward differencing – Estimation of truncation and discretization errors – Explicit, Implicit and semi-Implicit techniques – Crank Nicolson scheme – Criteria for numerical stability. Finite volume method for 1D steady state diffusion, FVM for 1D convection – diffusion problem. | 10 | 15 |
| SECOND INTERNAL TEST | | |
| **MODULE: 5** Tensors: Indicial notation – Kronecker Delta – Permutation symbol- Manipulation with indicial notation – Linear transformation – Symmetric and anti-symmetric tensors – Dyadic products of tensors – Orthogonal tensor – Eigen values and Eigen vectors of a tensor.<br>Tensor calculus: Tensor valued function of a scalar, Vector field and gradient, Divergence of tensor field – Curl of vector field. | 10 | 20 |
| **MODULE: 6** Introduction to FEM: Introduction – Finite element formulation techniques applied to 1D problems – Axially loaded bar and heat transfer problems. Computational procedures – Assembly of element matrices, Boundary conditions, Shape functions.<br>Introduction to isoparametric elements, – Gaussian quadrature, Convergence, Symmetry, Sources of error. (Matlab/Scilab tutorials to develop 1D FE codes) | 10 | 20 |
| END SEMESTER EXAM | | |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| **Assessment procedure:** | | **Marks** |
| Two internal tests | | 15x2=30 |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | | 10 |

***NOTE:*** *The end semester exam will consist of PART - A and PART - B which should be* ***answered in separate answer books****. PART - A consist of modules 1, 3 & 5 and PART - B consist of modules 2, 4 & 6.*

**COURSE TITLE: ADVANCED MECHANICS OF FLUIDS**

**COURSE NO: 07ME 6103 CREDITS: 3-1-0:4 YEAR:2015**

**Pre-requisites:** Fluid mechanics, Thermodynamics.

**Course Objectives:**

To give the student:-

1. To impart knowledge of various basic principles and equations of fluid flow
2. To understand the concepts of normal shock, oblique shock
3. To develop the knowledge on Fanno flow and Reyleigh flow

**Syllabus**

Reynolds transport theorem, differential and integral forms of law of conservation of mass, momentum and energy, some exact and approximate solutions of Navier-Stokes equations, isentropic flow of variable area, normal shock wave, oblique shocks and expansion waves, flow with friction, flow with heat transfer.

**Course Outcome**

The student will have a sound knowledge on the various types compressible and incompressible flows. The student will be able to calculate the stagnation properties required for a particular compressible flow. They will be able to calculate the properties of the fluid through a refrigeration duct and combustion chamber.

**References**


1. Gupta. V & Gupta .S, Fluid Mechanics and its Applications, Wiley Eastern Ltd
2. White F.M., Viscous fluid flow, McGraw Hill
3. Muralidhar K. & Biswas G, Advanced Engineering Fluid Mechanics, Narosa Publishing House.
4. John D. Anderson Junior, Modern compressible flow with historical perspective, McGraw Hill
5. Gas dynamics: S.M Yahya, New Age International Publishers.
6. Rathakrishnan E., Gas Dynamics, Prentice Hall India
7. Zuckrow.M.J. & Hoffman.D.H.,Gas Dynamics, McGraw Hill
8. V. Babu , Fundamentals of Compressible Flows, Ane Publishers

**COURSE PLAN**

| **COURSE TITLE: ADVANCED MECHANICS OF FLUIDS**<br>**COURSE NO: 07ME 6103** | | **(L-T-P: 3-1-0) CREDITS: 4** |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Basic equations of fluid flow: Reynold's transport equation-integral and differential formulations, integral form of the equations of continuity, momentum and energy equations, use of integral equations, differential form of these equations, Stoke's postulates and constitutive equations, Navier-Stokes equations and energy equations for Newtonian fluids | 10 | 9 (15 %) |
| MODULE : 2<br>Some exact solutions of the Navier-Stokes equations: Plane Poisseuille flow: velocity distribution, maximum velocity, volume flow rate, average velocity, shear stress distribution, maximum shear stress, pressure drops in terms of average velocity.Coutte flow: velocity distribution, maximum velocity, volume flow rate, average velocity, shear stress distribution, maximum shear stress, Plane Coutte flow | 9 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Hagen- Poiseuille flow: velocity distribution, maximum velocity, volume flow rate, average velocity, shear stress distribution, maximum shear stress, pressure drops in terms of average velocity, relation between frictional coefficient and Reynold number. Approximate solutions of the Navier-Stokes equations**:** Creeping flow past a sphere- theory of hydro dynamic lubrication-boundary layer on a flat plate-Blassius solution and use of momentum integral equation | 9 | 9 (15 %) |
| MODULE :4<br>Introduction to compressible flows: basic concepts, equations for one dimensional flow through stream tubes, speed of sound, qualitative difference between incompressible, subsonic and supersonic flows, characteristic velocities, adiabatic flow ellipse. Isentropic flow with variable area: Isentropic flow of an ideal gas, stagnation properties, critical state, geometric chocking, area ratio as a function of Mach number, isentropic flow through a convergent, convergent divergent nozzle | 9 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Normal shocks in one dimensional flow: Occurrence of shocks, analysis of normal shocks, Prandtl's equation, Rankine-Hugoniot equation and other normal shock relations, impossibility of shock in subsonic flow, strength of a shock. Oblique shocks and expansion waves: sources of oblique shock, oblique shock relations, θ-β-M relations, shock polar, regular reflections from a solid boundary, Prandtl-Meyer expansion waves | 10 | 12 (20 %) |
| MODULE: 6<br>Flow with friction: Fanno lines, effect of friction on properties, friction choking, isothermal flows with friction. Flow with heat transfer: Rayleigh lines, effect of heat addition, thermal choking choking | 8 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: ADVANCED HEAT AND MASS TRANSFER**

**COURSE NO: 07ME 6105 CREDITS: 3-1-0:4 YEAR:2015**
**Pre-requisites:** Thermodynamics, Fluid mechanics.

**Course Objectives:**

To give the student:-

- To enable the students to grasp the principles of Heat and Mass transfer
- Impart knowledge on the various modes of heat transfer, factors related with them and their physical significance.
- Application of the concepts for the analysis and design of physical problems.
- Analysis and further development of various heat and mass transfer systems/applications

**Syllabus**

Basics of conduction, numerical and analytical methods, unsteady and steady heat conduction. Convection heat transfer, forced convection, Reynolds Colburn analogies, basics law of radiation, radiation shape factor, shape factor algebra, basics of boiling and condensation, mass transfer, evaporation

**Course Outcome**

The student will be able to understand a real life heat transfer problem accounting for all the variables connected with it. He will be able to trouble shoot a heat transfer system and suggest changes to enhance the performance of a system. The student will be able to design a thermal system and optimize it for the best performance.

**References**


1. Arpaci, V.S., Conduction Heat Transfer, Addison Wesley, 1966.
2. E.R.G. Eckert and R.M. Drake, Analysis of Heat Transfer, McGraw Hill, 1972.
3. E.M. Sparrow, R.D. Cess, Radiative Heat Transfer, McGraw Hill, 1972.
4. Holman. J.P, Heat Transfer, McGraw Hill, 2009
5. R.C. Sachdeva, Fundamental of Engineering. Heat and Mass Transfer", New age International, 2003.
6. Bird R.B and J.R. Howell, Transport Phenomena, Wiley International, 1960.
7. PatricoOostiuson, Convective heat and mass Transfer, McGraw Hill
8. Frank P Incropera and David P Dewitt, Fundamentals of Heat and Mass Transfer , $6^{th}$ Edition
9. Adrian Bejan, Convective Heat Transfer, Wiley and Sons

**COURSE PLAN**

| **COURSE TITLE: ADVANCED HEAT AND MASS TRANSFER**<br>**COURSE NO: 07ME 6105** | | **(L-T-P: 3-1-0) CREDITS: 4** |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>General heat conduction equation in Cartesian, cylindrical and spherical co-ordinates, Composite geometries, Variable thermal conductivity , Uniform heat generation, Extended surfaces, Two and three dimensional heat conduction , Numerical and analytical methods. | 9 | 9 (15 %) |
| MODULE : 2<br>Unsteady heat conduction; Lumped heat systems, Infinite and semi-infinite bodies, Numerical and analytical methods, Periodic variation of surface temperature , Moving boundaries. | 9 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Convective heat transfer; Boundary layers, Continuity, momentum and energy equations; Boundary layers equations, Dimensional analysis, Exact and approximate solutions to forced convection in laminar and turbulent, internal and external flow, Reynolds and Colburn analogies, forced convection correlations, Solution to free convection problems , Heat transfer at high velocity and incompressible fluid, Liquid metal heat transfer | 10 | 9 (15 %) |
| MODULE :4<br>Radiation heat transfer , Basic laws of radiations, Emissive power , Stefan – Boltzmann, Lambert's, Wien's and Kirchhoff's laws , Emissivity, Radiation intensity - Radiative exchange between black isothermal surfaces, diffuse grey surfaces, Reflecting surfaces, Radiation shape factor; Shape factor algebra, Radiation shields, Combined convective and radiation, Electrical network analogy solution, Radiosity; Solar radiation Radiation from gases and vapours. | 10 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Heat transfer with phase change, Boiling and Condensation, Flow boiling – Correlations. Mass Transfer, Concentration, velocities, Mass fluxes Fick's law, Species, Conservation equation, Steady state molecular diffusion, equimolar counter diffusion, diffusion through a stagnant gas film Chemical reaction. | 9 | 12 (20 %) |
| MODULE: 6<br>Convective mass transfer; Concentration boundary layer , Momentum, mass and heat transfer analogy , Convective mass transfer numbers, Flow over flat plates, flow through tubes, Correlations, Evaporation of water into air, Heat and mass transfer in separated flows. | 9 | 12 (20 %) |

| **Internal Continuous Assessment *(Maximum Marks: 40)*** | |
|---|---|
| Assessment procedure: | |
| Two internal tests: | 30 marks each |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks |

**COURSE TITLE: PRINCIPLES OF TURBOMACHINERY**

**COURSE NO: 07ME 6107 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Fluid mechanics, thermodynamics, heat transfer.

**Course Objectives:**

To give the student:-

- In depth understanding on various types of turbomachines
- Knowledge on the thermodynamics of turbomachine design
- Ability to identify factors affecting efficiency and performance of turbomachines

**Syllabus**

Introduction to turbomachines, basic principles, efficiency; Two dimensional cascades, compressor and turbine cascade performance; Axial flow turbines, velocity diagram, multistage turbines; Axial flow compressors, stage loss and efficiency, off-design performance; Three dimensional flows in axial turbines, direct and indirect problems; Radial flow turbines, types, losses and efficiency.

**Course Outcome**

The students will have sound understanding of the types and working principle of various turbomachines. They will be able to apply their theoretical knowledge in designing energy efficient turbomachines.

**References**


1.S. L. Dixon, Cesare A. Hall, Fluid Mechanics and Thermodynamics of Turbo machinery, Butterworth Heinemann, 7th Ed., 2013.

1. H. I. H. Saravanamuttoo, G F C Rogers, H Cohen, P.V Straznicky, Gas Turbine Theory, Pearson Prentice Hall, 6th Ed., 2009.
2. V. Ganesan, Gas Turbines, Tata McGraw Hill, 3rd Ed., 2010.
3. P. Hill, C. Peterson, Mechanics and Thermodynamics of Propulsion, Pearson, 2nd Ed., 2010.
4. S. M. Yahya: Turbines, Compressors and Fans, Tata McGraw-Hill, 4th Ed., 2011.
5. V. Kadambi and Manohar Prasad, Turbomachinery, New Academic Science, 3rd Ed., 2012.
6. G. F Wislicenus, Fluid Mechanics of Turbomachinery, Dover Publications, 1965.

**COURSE PLAN**

| **COURSE TITLE: PRINCIPLES OF TURBOMACHINERY**<br>**COURSE NO: 07ME 6107** | **(L-T-P: 3-0-0) CREDITS: 3** | |
|---|---|---|
| **MODULES** | **Contact Hours** | **End Sem. Exam Marks; %** |
| MODULE : 1<br>Introduction to turbo-machines, definition and classification, principles of operation, fundamental laws, Euler work, rothalpy and relative velocity, efficiency of turbines and compressors, polytropic efficiency, flow unsteadiness. | 8 | 9 (15 %) |
| MODULE : 2<br>Two dimensional cascades: cascade nomenclature, lift and drag, circulation and lift, losses and efficiency, compressor and turbine cascade performance, nominal deflection, fluid deviation. | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Axial flow turbines: velocity diagram, multistage turbines, stage losses and efficiency, stage reaction, diffusion within blade rows, efficiencies and characteristics, turbine blade cooling. | 6 | 9 (15 %) |
| MODULE :4<br>Axial flow compressors: velocity diagram, stage loss and efficiency, mean line calculation, off-design performance, multistage compressor performance, stall and surge phenomena. | 6 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Three-dimensional flows in axial turbines: theory of radial equilibrium, indirect and direct problems, compressible flow through a fixed blade row, constant specific mass flow, free vortex turbine stage. | 8 | 12 (20 %) |
| MODULE: 6<br>Radial flow turbines: types of inward flow radial turbines, thermodynamics, design point efficiency, Mach number relations, loss coefficient, optimum efficiency, specific speed, clearance and windage losses. | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

## COURSE TITLE: RESEARCH METHODOLOGY

**COURSE NO: 07GN 6101 CREDITS: 0-2-0:2 YEAR: 2015**

**Pre-requisites:** Engineering Mathematics, Statistics

**Course Objectives:**

The main objective of the course is to provide a familiarization with research methodology and to induct the student into the overall research process and methodologies. This course addresses:

- The scientific research process and the various steps involved
- Formulation of research problem and research design
- Thesis preparation and presentation.
- Research proposals, publications and ethics
- Important research methods in engineering

As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self study and group discussions. The faculty mainly performs a facilitator's role.

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**Syllabus**

Overview of research methodology - Research process, scientific method, research design process.
Research Problem and Design - Formulation of research task, literature review, web as a source, problem solving approaches, experimental research, and ex post facto research.
Thesis writing, reporting and presentation -Interpretation and report writing, principles of thesis writing- format of reporting, oral presentation.
Research proposals, publications and ethics - Research proposals, research paper writing, considerations in publishing, citation, plagiarism and intellectual property rights.
Research methods – Modelling and Simulation, mathematical modeling, graphs, heuristic optimization, simulation modeling, measurement design, validity, reliability, scaling, sample design, data collection methods and data analysis

**Course Outcome**

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

- Discuss research methodology concepts, research problems, research designs, thesis preparations, publications and research methods.
- Analyze and evaluate research works and to formulate a research problem to pursue research
- Prepare a thesis or a technical paper, and present or publish them
- Apply the various research methods followed in engineering research for formulation and design of own research problems and to utilize them in their research project.

**References**


1. 1. C. R. Kothari, Research Methodology, Methods and Techniques, New Age International Publishers
2. K. N. Krishnaswamy, Appa Iyer Sivakumar, M. Mathirajan, Management Research Methodology, Integration of principles, Methods and Techniques, Pearson Education
3. R. Panneerselvam, Research Methodology, PHI Learning
4. Deepak Chawla, Meena Sondhi, Research Methodology–concepts & cases, Vikas Publg House
5. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
6. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
7. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.
8. Fred M Kerlinger , Research Methodology
9. Ranjit Kumar, Research Methodology – A step by step guide for beginners, Pearson Education
10. John W Best, James V Kahan – Research in Education , PHI Learning
11. Donald R. Cooper, Pamela S. Schindler, Business Research Methods, 8/e, Tata McGraw-Hill Co Ltd
12. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes
13. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
14. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
15. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
16. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
17. Donald H.McBurney, Research Methods, 5th Edition, Thomson Learning, ISBN:81-315-0047- 0,2006
18. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers..
19. Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing
20. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
21. Additional suitable web resources
22. Guidelines related to conference and journal publications

**COURSE PLAN**

| **COURSE TITLE: RESEARCH METHODOLOGY**<br>**COURSE NO: 07GN 6101** | **(L-T-P: 0-2-0) CREDITS: 2** | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Overview of Research Methodology-Research concepts – meaning – objectives – motivation - types of research –research process – criteria for good research – problems encountered by Indian researchers - scientific method - research design process – decisional research | 5 | (10 %) |
| MODULE : 2<br>Research Problem and Design-Formulation of research task – literature review – methods – primary and secondary sources – web as a source – browsing tools -formulation of research problems – exploration - hypothesis generation - problem solving approaches-introduction to TRIZ(TIPS)-experimental research – principles -Laboratory experiment - experimental designs - ex post facto research - qualitative research | 5 | (10 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Thesis writing, reporting and presentation-Interpretation and report writing – techniques of interpretation – precautions in interpretation – significance of report writing – principles of thesis writing- format of reporting - different steps in report writing – layout and mechanics of research report - references – tables – figures – conclusions. oral presentation – preparation - making presentation – use of visual aids - effective communication | 4 | (10 %) |
| MODULE :4<br>Research proposals, publications, ethics and IPR-Research proposals - development and evaluation – research paper writing – layout of a research paper - journals in engineering – considerations in publishing – scientometry-impact factor- other indexing like h-index – citations - open access publication -ethical issues - plagiarism –software for plagiarism checking- intellectual property right- patenting case studies | 5 | (10 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Research methods- Modelling and Simulation-Modelling and Simulation – concepts of modelling – mathematical modelling - composite modelling – modelling with – ordinary differential equations – partial differential equations – graphs heuristics and heuristic optimization - simulation modeling | 5 | (10 %) |
| MODULE: 6<br>Research Methods – Measurement, sampling and Data acquisition<br>Measurement design – errors -validity and reliability in measurement - scaling and scale construction - sample design - sample size determination - sampling errors - data collection procedures - sources of data - data collection methods - data preparation and data analysis | 4 | (10 %) |

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests and assignments. There are three tests for the course (3 x 20 = 60 marks) and assignments (40 marks). The assignments can be in the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher. The assessment details are to be announced to students at the beginning of the semester by the teacher.

## COURSE TITLE: INTERNAL COMBUSTION ENGINE LABORATORY

**COURSE NO: 07ME 6109 CREDITS: 0-0-2:2 YEAR: 2015**

**Course Objective:**

- To build knowledge about the parameters affecting the performance of IC engines and Turbo machines.
- To get experience in the analysis of exhaust gas emission and it's controlling.

**LIST OF EXPERIMENTS**

1. Performance and combustion analysis of I C engine
2. Performance, Combustion and Emission Studies on S.I. Engine fuelled with alternative fuels
3. Performance, combustion and Emission Studies on C.I. Engines fuelled with alternative fuels.
4. Study on the effect of varying fuel injection pressure and fuel injection Timing on the engine Performance, Combustion and Emission
5. Study on the effect of preheating air and fuel on the Performance, Combustion and Emission characteristics
6. Study of construction and principle of operation of Emission/Smoke analyzers
7. Performance studies on Turbo machines.
8. Assembly of Engine and its Components

**Course Outcomes:**

The student gets a practical knowledge on engine performance under different aspects. He will be able to identify engine parts and their working.

## COURSE PLAN

| **COURSE TITLE: INTERNAL COMBUSTION ENGINE LABORATORY**<br>**(COURSE NO: 07ME 6109 (L-T-P : 0-0-2) CREDITS: 1** | |
|---|---|
| **Internal Continuous Assessment *(Maximum Marks-100)*** | |
| **Assessment Procedure** | **Weightage (%)** |
| Practical Records/outputs: | 40 |
| Regular class Viva-Voce: | 20 |
| Final Test (Objective) | 40 |

**COURSE TITLE: INTRODUCTION TO SEMINAR**

**COURSE NO: 07ME 6100** **CREDITS: 0-0-1:0** **YEAR: 2015**

**Pre- requisites:**Nil

**Course Objectives:**

1. To improve the debating capability of the student to present a technical topic
2. To impart training to the student to face audience and present his ideas and thus creating self esteem and courage essential for an engineer

## Outline:

Individual students are required to choose a topic of their interest and give a seminar on that topic for about 30 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar. The committee will provide feedback to the students about the scope for improvements in communication, presentation skills and body language. Each student shall submit one copy of a write up of the seminar topic.

## Course Outcomes:

The graduate will have improved the debating capability and presentation skills in any topic of his choice.

**COURSE PLAN**

| **COURSE TITLE: INTRODUCTION TO SEMINAR** | | |
|---|---|---|
| **COURSE NO: 07ME 6100** | **(L-T-P : 0-0-1)** | **CREDITS: 0** |

**COURSE TITLE: ADVANCED THERMODYNAMICS AND COMBUSTION**

**COURSE NO: 07ME 6102 CREDITS: 3-1-0:4 YEAR: 2015**

**Pre-requisites:** Fluid mechanics, thermodynamics, heat and mass transfer, basic chemistry.

**Course Objectives:**

To give the student:-

- Expertise on the thermodynamic analysis of combustion
- Knowledge on the stages of combustion
- Understanding on the types of fuels used and their properties
- Knowledge on causes and control on emission

**Syllabus**

Properties of gases and gas mixtures, enthalpy of formation, heat of reaction, theoretical and excess air; Air fuel ratio, adiabatic flame temperature; Chemical equilibrium, degree of reaction, law of mass action, fugacity and activity; Fuels, calorific value, stages of combustion, flame propagation, flame structure and speed; Emissions, main pollutants from engines, emission control measures, Pollution norms and standards.

**Course Outcome**

The students will be able to do thermodynamic analysis of combustion phenomena. They will have sound knowledge on the stages of combustion and the various types of fuels used in internal combustion engines. They will have knowledge on the sources and types of emission and control measures to be taken to reduce pollution.

**References**


1. P K. Nag, Engineering Thermodynamics, McGraw-Hill Education, 5th Ed., 2013.
2. Yunus A. Cengel, Thermodynamics: An Engineering Approach, McGraw-Hill Education, 8th Ed., 2014.
3. M J. Moran, H N. Shapiro, D D. Boettner, M B.Bailey, Fundamentals of Engineering Thermodynamics, Wiley Global Education,7th Ed., 2010.
4. Ganesan, V, Internal Combustion Engines, Tata McGraw- Hill Book Co., 4th Ed., 2012.
5. John B.Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Education, 1998.
6. Edward F. Obert., Internal Combustion Engine and Air Pollution, Intext Educational Publishers, 1973.
7. S P. Sharma and Chander Mohan, Fuels and Combustion, Tata McGraw-Hill, 1984.

**COURSE PLAN**

| **COURSE TITLE: ADVANCED THERMODYNAMICS AND COMBUSTION**<br>**COURSE NO: 07ME 6102** **(L-T-P: 3-1-0) CREDITS: 4** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **End Sem. Exam Marks; %** |
| MODULE : 1<br>Introduction to thermodynamics – Equation of states – Properties of gases & gas mixtures – Enthalpy of formation – Heat of reaction –Combustion equations- theoretical & excess air, stoichiometric & equivalence ratio. | 8 | 9 (15 %) |
| MODULE : 2<br>Air fuel ratio from analysis of products, First law for reaction systems– Adiabatic flame temperature–Entropy change –Second law analysis of reaction systems. | 6 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Concept of chemical equilibrium – Degree of reaction–Chemical potential and equilibrium constant –Law of mass action – Vant Hoff's equation – Change in Gibbs free energy and equilibrium constant– Fugacity and activity – equilibrium composition of a chemical reaction–effect of non reacting gases. | 8 | 9 (15 %) |
| MODULE :4<br>Fuels and combustion – Classification of fuels –Calorific value of fuels– Determination of calorific values of solid, liquid & gaseous fuels. Combustion in IC engines–Stages of combustion, | 6 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Flame propagation in engines, normal and abnormal combustion, pre-ignition, knock and engine variables. Vaporization of fuel droplets and spray formation, air motion, swirl measurement, Flame structure and speed, Lean burn combustion, stratified charge combustion systems. | 8 | 12 (20 %) |
| MODULE: 6<br>Emissions- main pollutants from engines, NOx formation in SI and CI engines. unburned hydrocarbons, soot formation and oxidation, particulates in diesel engines, emission control measures for SI and CI engines, effect on environment and human beings. Pollution norms and standards. After treatment devices for engines. | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: INTERNAL COMBUSTION ENGINE DESIGN**

**COURSE NO: 07ME 6104 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:** Thermodynamics, heat and mass transfer, basics of combustion.

**Course Objectives:**

To give the student:-

- To gain knowledge on basic principles of Engine Design.
- To design various components of an Internal Combustion Engine accounting for all the pre requisites
- Design of various emission control systems for an engine.

**Syllabus**

General Consideration in engine design, noise vibration and harness, design of engine components, basics of ignition, lubrication and cooling. Design of two stroke engines, design of pollution control equipment, design of catalytic converters, particulate traps and EGR.

**Course Outcome**

By undergoing the course, one will be able to design various Internal Combustion Engine and its components for the required output at the given conditions.

**References**


1. Gordon P.Blair, Basic Design of Two-stroke Engines, S.A.E., 1992.
2. Gordon P.Blair, Advanced Concepts of Two-stroke Engines, S.A.E., 1990.
3. Pounder, C.C., Marine Diesel Engines, Butterworths, 1981.
4. A.Kolchin and V.Demidov, Internal Combustion Engine Design, MIR Publishers, Moscow, 1984.
5. Gordon P.Blair, Design and Simulation of Four-Stroke Engines, Society of Automotive Engineers, Inc., USA, 1999.
6. D.E.Winterbone and R.J.Pearson, Design Techniques for Engine Manifolds, Wave action methods for I.C.Engines, Professional Engineering Publishing Ltd., UK, 2000.
7. John Fenton (Editor), Gasoline Engine Analysis for Computer Aided Design, Mechanical Engineering Publishing Ltd., UK, 1986.
8. RodicaBaranescu and Bernard Challen (Editors), Diesel Engine Reference Book, Second Edition, Society of Automotive Engineers, Inc., USA, 1999.
9. SAE Special Publication SP-700, Adiabatic Engines and Systems, Society of Automotive Engineers, Inc., USA, 1987.

**COURSE PLAN**

| **COURSE TITLE: INTERNAL COMBUSTION ENGINE DESIGN**<br>**COURSE NO: 07ME 6104** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>General Consideration in engine design, Choice of material, stress and fatigue considerations, design for manufacture, Noise, Vibration and Harshness. | 6 | 9 (15 %) |
| MODULE : 2<br>Piston system, Power cylinder system, connecting rod assembly, crankshaft system, valve gearing, stress analysis | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Design of engine components, Inlet and exhaust manifolds, cylinder block, cylinder-head, crankcase, engine foundations and mountings, gaskets. | 6 | 9 (15 %) |
| MODULE :4<br>Design of bearings, flywheel, turbocharger, supercharger, computer controlled fuel injection system, Basics of ignition, lubrication and cooling -system design. | 8 | 9 (15 %) |
| MODULE: 6<br>Design of pollution control equipment, introduction to design of catalytic converters, particulate traps and EGR systemsPreparation of working drawings of designed components using CAD system. | 6 | 12 (20 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Design of two stroke engines, arrangement and sizing of ports, piston assembly, intake and exhaust system, scavenging, application to automotive gasoline and marine diesel engines. | 8 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: DESIGN OF THERMAL TURBOMACHINES**

**COURSE NO: 07ME 6106 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:** Fluid mechanics, heat and mass transfer, Thermodynamics.

**Course Objectives:**

To give the student:-

- To understand the working and design principles of thermal turbomachines.
- To study the fundamental concepts of energy balance in a turbine system and
- To understand the potential ways of designing and developing energy efficient turbines

**Syllabus**

Gas turbine and its classification, cycle analysis, introduction to Codes and Standards used in turbine design. Factors affecting design and performance of gas turbine combustion chamber, steam turbines, Mollier chart instructions, losses in turbines, estimation of turbine performance.

**Course Outcome**

The students will be capable of analyzing a turbine as a system and design energy efficient turbines. They will also know the codes, standards and detailed working of gas turbines and the factors affecting its performance thus being equipped to work with a practical gas turbine system.

**References**


1. GanesanV.,GasTurbines,Tata McGraw-Hill Education, New Delhi
2. Heinz P. Bloch and Murari P. Singh, "Steam turbines-Design, Applications and Re-Rating", McGraw Hill, New Delhi.
3. Dixon, S.L., "Fluid Mechanics and Thermodynamics of Turbomachines", Butterworth, Hinemann
4. Logan Earl, Jr., "Hand book of Turbomachinery" Marcel Dekker
5. Shepherd, D.G., " Principles of Turbomachinery", MacMillan
6. Cohen,H, Rogers,G,E.C, and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd., 1980.

**COURSE PLAN**

| **COURSE TITLE: DESIGN OF THERMAL TURBOMACHINES**<br>**COURSE NO: 07ME 6106** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Gas turbines-classification, thermodynamic analysis, open and closed cycles, cycle analysis, losses and efficiency, effect of incomplete combustion. | 6 | 9 (15 %) |
| MODULE : 2<br>Introduction to Codes and Standards used in turbine design. Introduction to turbine testing methods. | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Combustion chambers of gas turbines – requirements, factors affecting design and performance, combustion process, geometry, combustion zones, combustion chamber arrangements, limiting factors in combustion chambers. | 6 | 9 (15 %) |
| MODULE :4<br>Steam turbines-steam turbine types and controls, casing and packing, steam temperature, material considerations, Rotor blades and guide blades, erosion, Critical speed, Turbine selection-Mollier chart instructions, steam rate estimation. | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Design considerations in steam turbines-Flow of steam through turbine stages, Energy losses in steam turbines. | 8 | 12 (20 %) |
| MODULE: 6<br>Classification-losses in regulating valves, nozzles and moving blades, clearance losses, losses due to wetness of steam, efficiency of turbine. Heat drop calculation of multi stage turbines. Turbine performance. | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: SEMINAR**

**COURSE NO: 07ME 6108 CREDITS: 0-0-2:2 YEAR:2015**

**Course Objectives:**

- To improve debating capability of the student to present a technical topic.
- To improve communication and presentation skills of the student.

**Outline and evaluation procedure:**

Individual students are required to choose a topic of their interest, in consultation with any faculty member offering courses for the programme. The topic should be related to I C Engines and Turbomachinery, preferably from outside the M. Tech syllabus. The topic should be based on a journal/conference publication within a span of last 3 years. The duration of the seminar should be limited to 30 minutes. A committee with the Head of the department as the Chairman and two faculty members from the department as members shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee. Each student shall submit two copies of a write up on the topic. One copy certified by the Chairman shall be returned to the student and the other will be kept in the departmental library.

**Course Outcomes:**

The graduate will have acquired

- Debating capability and presentation skills in a technical topic of his interest.
- Knowledge about contemporary issues and research opportunities
- Capacity to communicate effectively and professionally in both verbal and written forms
- Capability for self education and lifelong learning

**COURSE PLAN**

| **COURSE TITLE: SEMINAR**<br><br>**COURSE NO: 07ME 6108 (L-T-P : 0-0-2) CREDITS: 2** | |
|---|---|
| **Internal Continuous Assessment *(Maximum Marks-100)*** | |
| A committee with the Head of the department as the Chairman and two faculty members from the department as members shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee. | |
| **Assessment Procedure** | **Weightage (%)** |
| Report: | 30 |
| Presentation: | 40 |
| Ability to answer the questions on the topic : | 30 |

**COURSE TITLE: MINI PROJECT**

**COURSE NO: 07ME 6114 CREDITS: 0-0-4:2 YEAR:2015**

**Pre-requisites:** Nil

**Course Objectives:**

- To practice the steps involved for the selection, execution, and reporting of the project.
- To train the students for group activities to accomplish an engineering task.

**Outline and evaluation procedure:**

Individual students are required to choose a topic of their interest in the field of I C Engine and Turbomachinery. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects. The choice of topic shall preferably be analytical in nature.

The final evaluation of mini project will be carried out by a committee with the Head of the department as the Chairman and two faculty members from the department as members. The students should bring the report duly authenticated by the respective guide. Students individually will present their work before the committee. The report complete in all respects should be submitted to the Head of the department.

**Course Outcomes:**

- The graduate will have acquired skills to select and execute projects.
- The graduate will have acquired technical report writing skills.

**COURSE PLAN**

| **COURSE TITLE: MINI PROJECT**<br>**COURSE NO: 07ME 6114 (L-T-P : 0-0-4) CREDITS: 2** | |
|---|---|
| **Internal Continuous Assessment *(Maximum Marks-100)*** | |
| The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects. The choice of topic shall preferably be analytical in nature. The final evaluation of mini project will be carried out by a committee with the Head of the department as the Chairman and two faculty members from the department as members. | |
| **Assessment Procedure** | **Weightage (%)** |
| Report: | 30 |
| Relevance and content | 40 |
| Ability to answer the questions on the topic : | 30 |

**COURSE TITLE: COMPUTATONAL LAB**

**COURSE NO: 07ME 6116 CREDITS: 0-0-2:1 YEAR: 2015**

**Course Objectives:**

- Develop codes for numerical methods to tackle simple problems.
- Obtain experience in the application of CFD analysis to real engineering designs.
- Understand the usage of various commercial CFD packages.

**List of experiments**

1. Introduction to CFD Softwares
2. Geometry creation tools
3. Mesh generation tools
4. Simulation tools: Fluent, openFOAM
5. 2D simulation of internal and external flow
6. 3D simulation of flow with heat transfer
7. Simulation of natural convection problem
8. Simulation of turbulent heat transfer problem
9. Simulation with combustion process.

**Course Outcomes:**

The student will get an experience in CFD software and will be able to solve flow problems on related to heat transfer and other flow domains.

**COURSE PLAN**

| **COURSE TITLE: COMPUTATIONAL LABORATORY**<br>**COURSE NO: 07ME 6116** **(L-T-P : 0-0-2) CREDITS: 1** | |
|---|---|
| **Internal Continuous Assessment *(Maximum Marks-100)*** | |
| **Assessment Procedure** | **Weightage (%)** |
| Practical Records/outputs: | 40 |
| Regular class Viva-Voce: | 20 |
| Final Test (Objective) | 40 |

**COURSE TITLE: PROJECT (Phase I)**

**COURSE NO: 07ME 7101 CREDITS: 0-0-12:6 YEAR: 2015**

**Pre-requisites:** Nil

**Objectives:**

- To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes.
- The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The student is required to undertake the project phase-I during the third semester and is continued in the 4th semester (Phase-II). The project work can be a design/experimental project and/or computer simulation project on a topic related to Internal combustion Engines and Turbomachinery. A project guide is allotted to each student based on the student's field of interest and the topic is finalised in consultation with the guide. The students shall be encouraged to do their project work in the parent institute itself. Provision is available to carry out the project in an industry/institute of repute. This is only possible in the fourth semester and the topic of investigation should be in line with the project part planned in the 3rd semester. Department will constitute an Evaluation Committee to review the project work with the Head of the department as the Chairman, guide and two faculty members from the department as members.

Phase-I consists of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review should highlight the topic, objectives, methodology and expected results. In the second review, progress of the work will be evaluated by the committee and marks will be awarded. A preliminary report consisting of the work completed and scope of the work for the 4th semester should be submitted to the Head of department.

**Course Outcomes:**

The graduate will have acquired

- Knowledge about contemporary issues and research opportunities
- Capacity to communicate effectively and professionally in both verbal and written forms
- Capability of self education and lifelong learning
- Understanding of professional and ethical responsibility.

**COURSE PLAN**

| **07ME 7101 PROJECT (PHASE I)**<br>**COURSE NO: 07ME 7101** **(L-T-P : 0-0-12) CREDITS: 6** | |
|---|---|
| **Internal Continuous Assessment *(Maximum Marks-50)*** | |
| **Project progress evaluation** | **Marks** |
| Progress evaluation by guide | 20 |
| Presentation and evaluation by the committee | 30 |

**COURSE TITLE: SEMINAR**

**COURSE NO: 07ME 7103** **Credits: 0-0-2: 2** **Year: 2015**

**Pre- requisites:** Nil

**Course Objectives:**

- To improve debating capability of the student to present a technical topic.
- To improve communication and presentation skills of the student.

**Outline and evaluation procedure:**

Individual students are required to choose a topic of their interest, in consultation with any faculty member offering courses for the programme. The topic should be related to I C Engines and Turbomachinery, preferably from outside the M. Tech syllabus. The topic should be based on a journal/conference publication within a span of last 3 years. The duration of the seminar should be limited to 30 minutes. A committee with the Head of the department as the Chairman and two faculty members from the department as members shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee. Each student shall submit two copies of a write up on the topic. One copy certified by the Chairman shall be returned to the student and the other will be kept in the departmental library.

**Course Outcomes:**

The graduate will have acquired

- Debating capability and presentation skills in a technical topic of his interest.
- Knowledge about contemporary issues and research opportunities
- Capacity to communicate effectively and professionally in both verbal and written forms
- Capability for self education and lifelong learning

**COURSE PLAN**

| **COURSE TITLE: SEMINAR**<br>**COURSE NO: 07ME 7103** **(L-T-P : 0-0-2) CREDITS: 2** | |
|---|---|
| **Internal Continuous Assessment *(Maximum Marks-100)*** | |
| A committee with the Head of the department as the Chairman and two faculty members from the department as members shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee. | |
| **Assessment Procedure** | **Weightage (%)** |
| Report: | 30 |
| Presentation: | 40 |
| Ability to answer the questions on the topic : | 30 |

**COURSE TITLE: PROJECT (PHASE II)**

**COURSE NO: 07ME 7102** **CREDITS: 0-0-21: 12** **YEAR: 2015**

**Pre-requisites:** Nil

**Course Objectives:**

- To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes.
- The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

**Outline and evaluation procedure:**

Project phase-II is a continuation of project phase-I started in the third semester. Before the end of the fourth semester, there will be two reviews, one at middle of the fourth semester and other towards the end to assess the progress of the work. The review will be conducted by the same committee constituted in the third semester. This would be a pre qualifying exercise for the students for getting approval for the submission of the thesis.

Final evaluation of the project will be taken up only on completion of the project in the fourth semester. This shall be done by a committee constituted for the purpose by the principal of the college. The concerned head of the department shall be the chairman of this committee. It shall have two senior faculty members from the same department, project supervisor and the external supervisor, if any, of the student and an external expert either from an academic/R&D organization or from Industry as members. Final project grading shall take into account the progress evaluation done in the third semester and the project evaluation in the fourth semester.

If the quantum of work done by the candidate is found to be unsatisfactory, the committee may extend the duration of the project up to one more semester, giving reasons for this in writing to the student. Normally further extension will not be granted and there shall be no provision to register again for the project. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

**Course Outcomes:**

The graduate will have acquired

- Knowledge about contemporary issues and research opportunities
- Capacity to communicate effectively and professionally in both verbal and written forms
- Capability of self education and lifelong learning
- Understanding of professional and ethical responsibility.

**COURSE PLAN**

| **COURSE TITLE: PROJECT (PHASE II)**<br>**COURSE NO: 07ME 7102** **(L-T-P : 0-0-21) CREDITS: 12** | |
|---|---|
| **Project Evaluation** | **Marks** |
| **Internal Continuous Assessment *(Maximum Marks-70)*** | |
| Progress evaluation by guide | 30 |
| Presentation and evaluation by the committee | 40 |
| **End Semester Evaluation *(Maximum Marks-30)*** | |
| Final evaluation of the project will be taken up only on completion of the project in the fourth semester. This shall be done by a committee constituted for the purpose by the principal of the college. The concerned head of the department shall be the chairman of this committee. It shall have two senior faculty members from the same department, project supervisor and the external supervisor, if any, of the student and an external expert either from an academic/R&D organization or from Industry as members. | |

**ELECTIVES OFFERED**

**FOR SEMESTER I**

**COURSE TITLE: DIRECT ENERGY CONVERSION SYSTEMS**

**COURSE NO: 07ME 6111 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:** Thermodynamics, Energy and environment, Non- Renewable energy

**Course Objectives:**

To give the student:-

- Introduction to the thermodynamic aspects of energy conversion
- The benefits and factors related to conversion of available energy resource to electricity.
- To provide a strong foundation on the various direct energy conversion methods like solar energy.
- To provide an insight on the novel technologies in the enegry sector thus keeping the students posted wth the latest trends.

**Syllabus**

Basics in energy conversion, reversible and irreversible engines, photoelectric phenomena, thermoelectric engine, photovoltaic cells, their production and design, maintenance of PV systems, thermionic emissions, thermionic converters, gaseous converters, MHD power generation systems, fuel cells and their practical considerations, future energy technologies.

**Course Outcome**

The students will be capable of taking appropriate decision on type of energy conversion system to cater the need. They will be capable of design various energy generators and systems using renewable energy sources and non-conventional energy sources.

**References**


1. S.S.L Chang: Energy Conversion, Prentice Hall, 1963
2. G. W. Sutton: Direct Energy Conversion, McGraw Hill, 1966
3. S.L. Soo: Direct Energy Conversion, Prentice Hall ,1968
4. S.W.Angrist: Direct Energy Conversion,4e,Allwyn & Bycon,1982
5. D.Merick and R.Marshall: Energy,Present and future options,VolI&II,John Wiley,1981
6. B.Sorenson: Renewable Energy, Academic Press,1989

**COURSE PLAN**

| **COURSE TITLE: DIRECT ENERGY CONVERSION SYSTEMS**<br>**COURSE NO: 07ME 6111** | | **(L-T-P: 3-0-0) CREDITS: 3** |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Basic science of energy conversion, Orderly and disorderly energy, Reversible and irreversible engines, Analysis of basically reversible engines, | 5 | 9 (15 %) |
| MODULE : 2<br>Duality of matter, Thermoelectric Vs photoelectric phenomena, Basic thermoelectric engine, Thermoelectric materials, Applications. | 5 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Physics of solar photovoltaic cells, Production of solar cells, Design concept of PV cell systems, Solar cells connected in series and parallel, Voltage regulation and energy storage, Centralized and decentralized PV systems, Maintenance of PV systems, Current developments. | 10 | 9 (15 %) |
| MODULE :4<br>Thermionic emission, Richardson's equation, Analysis of high vacuum thermionic converter, Gaseous converters, Introduction to MHD generators, Seeding and ionisation in MHD generators. | 5 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Analysis of MHD engines and MHD equations, Conversion efficiency and electrical losses in MHD power generation systems. | 6 | 12 (20 %) |
| MODULE: 6<br>Definition, general description, types, design and construction of fuel cells, Thermodynamics of ideal fuel cells, Practical considerations, Present status, Future energy technologies, Hydrogen energy, Nuclear fusion. | 11 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: ENGINE POLLUTION AND CONTROL**

**COURSE NO: 07ME 6121 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:**Thermodynamics, Thermal engineering, Environment Sciences

**Course Objectives:**

To give the student:-

- An awareness on the various environmental pollution aspects and issues.
- A comprehensive insight into the pollution in engine and gas turbines.
- Knowledge on pollutant formation and control.
- Brief idea on various emission testing instruments and techniques

**Syllabus**

Pollution, Emissions from engines, Greenhouse gases, Effects of pollution on environment, pollutants and its chemical kinetics, Factors affecting emissions from gases, detection and measurement of pollutants, various equipment used in testing, methods to reduce pollution, engine modifications and novel techniques associated with emission reduction, national and international standards in emission control.

**Course Outcome**

The student will have a deep understanding onthe various emissions from I C engines their effects onthe environment. The students will know the mechanism of pollutant formation thus being able to control it in a real life situation. They will know various emission measurement techniques and devices to control emissions.

**References**


1. Crouse William, Automotive Emission Control, Gregg Division /McGraw-Hill,1980
2. Ernest,S., Starkman, Combustion Generated Air Pollutions, Plenum Press, 1980.
3. George Springer and Donald J.Patterson, Engine emissions, Pollutant Formation and Measurement, Plenum press, 1972.
4. Obert, E.F., Internal Combustion Engines and Air Pollution, Intext Educational Publishers, 1980.

**COURSE PLAN**

| **COURSE TITLE: ENGINE POLLUTION AND CONTROL**<br>**COURSE NO: 07ME 6121** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Pollution in engine and turbines-atmospheric pollution from Automotive and Stationary engines and gas turbines, Global warming, Greenhouse effect and effects of I.C. Engine pollution on environment. | 6 | 9 (15 %) |
| MODULE : 2<br>Pollution formation and emission measurement, Formation of oxides of nitrogen, carbon monoxide, hydrocarbon, aldehydes and Smoke, Particulate emission. Effects of Engine Design, operating variables on Emission formation. | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Non dispersive infrared gas analyzer, gas chromatography, chemiluminesce analyzer and flame ionization detector, smoke meters, Noise measurement and control | 6 | 9 (15 %) |
| MODULE :4<br>Emission control, Engine Design modifications, fuel modification, evaporative emission control, EGR, air injection, thermal reactors | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Water Injection, catalytic converters, application of microprocessor in emission control. Common rail injection system, Particulate traps, NOx converters, SCR systems. GDI and HCCI concepts. | 8 | 12 (20 %) |
| MODULE: 6<br>Driving cycle and emission standards-Transient dynamometer, Test cells, Driving cycles for emission measurement, chassis dynamometer, CVS system, National and International emission standards. | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: THEORY AND TECHNOLOGY OF FUEL CELLS**

**COURSE NO: 07ME 6131 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Fluid mechanics, heat and mass transfer, basics of combustion.

**Course Objectives:**

To give the student:-

- An understanding on the types and working of fuel cells
- Awareness on challenges in fuel cell technology
- An introduction to fuel cell modelling and simulation
- Basics of hydrogen production and storage

**Syllabus**

Overview of fuel cells, polymer electrolyte membrane fuel cells, application; Fuel cell thermodynamics, electro-chemical reactions, losses and efficiency; Components of fuel cells, materials and properties; Fuel cell operating conditions, challenges in fuel cell technology; Fuel cell modelling and simulation; Balance of plant, hydrogen production and storage.

**Course Outcome**

The student will have a sound knowledge on the various types of fuel cells and their working. The student will be able to select proper materials and operating conditions to get maximum performance from a fuel cell. They will be able to model and simulate a fuel cell system to predict its performance.

**References**


1. Frano Barbir, PEM Fuel Cells: Theory and Practice, Elsevier Academic Press, 2nd Ed., 2013.
2. Matthew M. Mench, Fuel Cell Engines, John Wiley & Sons, Inc. 2008.
3. Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz, Fuel Cell Fundamentals, Wiely, 2009
4. James Larminie and Andrew Dicks, Fuel Cell Systems Explained, John Wiley & Sons Inc., 2nd Ed., 2003.
5. Gregor Hoogers, Fuel Cell Technology Hand book, CRC Press, 2003.
6. B. Viswanathan and M. Aulice Scibioh, Fuel Cells: Principles and Applications, Taylor & Francis Group, 2007.
7. Bent Sorensen, Hydrogen and Fuel Cells, Academic Press, 2nd Ed., 2012.

**COURSE PLAN**

| **COURSE TITLE: THEORY AND TECHNOLOGY OF FUEL CELLS**<br>**COURSE NO: 07ME 6131** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **End Sem. Exam Marks; %** |
| MODULE : 1<br>Overview of fuel cells: need for fuel cells, classification, low and high temperature fuel cells, polymer electrolyte membrane fuel cells, working of fuel cells, applications of fuel cells. | 6 | 9 (15 %) |
| MODULE : 2<br>Fuel cell thermodynamics: basic reactions, theoretical work, theoretical voltage, polarization curve, voltage losses, effect of temperature and pressure, fuel cell efficiency. | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Fuel cell components: membrane, gas diffusion layer, catalyst layer, flow field plates, bipolar plates, materials and properties. | 6 | 9 (15 %) |
| MODULE :4<br>Fuel cell operating conditions: pressure, temperature, flow rates, humidity. Challenges in fuel cell technology, flow distribution, water and thermal management in fuel cells. | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Fuel cell modeling: transport process, governing equations, computational domains, 1D, 2D and 3D models. Introduction to simulation of fuel cells. | 8 | 12 (20 %) |
| MODULE: 6<br>Balance of plant; Hydrogen production and storage; safety issues, cost expectation and life cycle analysis of fuel cells. | 6 | 12 (20 %) |

| **Internal Continuous Assessment *(Maximum Marks: 40)*** | |
|---|---|
| Assessment procedure: | |
| Two internal tests: | 30 marks each |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks |

**COURSE TITLE: PROPULSION ENGINEERING**

**COURSE NO: 07ME 6141 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Fluid mechanics, Thermodynamics

**Course Objectives:**

1. To familiarize on rocket propulsion
2. To provide knowledge on the analysis of turbo jet, turbo prop, turbofan and ramjet engine cycles.

**Syllabus**

Types of propulsive devices, combustion in jet engines, Analysis of Turbo jet engine cycle, Analysis of Turboprop, Turbofan and Ramjet engine cycles, Specific Propellant Consumption, Liquid propellant Rocket engines, Cooling of Thrust Chambers, Introduction to Hybrid, Solar, Electrical and Nuclear Rockets, Aspects of Launching

**Course Outcome**

At the end of this course, students should be able to do thrust calculation of rockets and specific propellant consumption

**References**

1. Sutton, G. P. and D. M. Ross, "Rocket Propulsion Elements", 4th Edn., John Wiley Publication, New York, 1991.

2. M. J. Zucrow, "Aircraft & Missile Propulsion", John Wiley & Sons, New York, 1958.

3. P. Hill and C. Peterson, "Mechanics and Thermodynamics of Propulsion", Addision Wesley, 1992 Edition.

4. A. H. Lefebvre, "Gas Turbine Combustion", Taylor & Francis, Philedelphia, 1980.

5. V. Babu, “Fundamentals of Propulsion”, Ane Publishers, 2008.

6. M. Barrere, A. Janmotte, B. F. de Venbeke, J. Vandenkerchove, " Rocket Propulsion", Elsevier Publications Company, London, 1960.

7. Cohen & Rogers, Gas Turbine Theory, Pearson Education., 1992.

**COURSE PLAN**

| **COURSE TITLE: PROPULSION ENGINEERING**<br>**COURSE NO: 07ME 6141** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Reaction principle, Essential features of propulsive devices, Momentum theory applied to propulsive devices, Types of propulsive devices-Turbo prop, Turbo jet, Turbo fan, Turbo shaft, Ram jet, Scramjet | 7 | 9 (15 %) |
| MODULE : 2<br>Combustion in jet engines, Types of combustion chambers, Factors limiting turbine design, Materials for turbine blades, Thrust augmentation, Noise suppression, Comparative study of performance characteristics, Supersonic inlets, Starting problem, Sub critical, critical and super critical mode of operations. | 7 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Thrust equation, Analysis of Turbo jet engine cycle, With and without After burner, Component efficiencies, Diffuser efficiency, Compressor efficiency, Burner efficiency, Turbine efficiency, Nozzle efficiency, Analysis of Turboprop, Turbofan and Ramjet engine cycles, Calculation of thrust, thrust power, propulsive efficiency, thermal efficiency, transmission efficiency and overall efficiency. | 7 | 9 (15 %) |
| MODULE :4<br>Rocket equation, Burn out velocity, Specific Impulse, Specific Propellant Consumption, Characteristic Velocity, Comparison of Air Breathing and Rocket Propulsion Systems, Classification of Rockets, Nozzle Expansion, Real Nozzles, Thrust vector control, Solid propellant Rocket Motors, Grain configuration, Propellant area ratio, Burning Rate, Temperature Sensitivity, Erosive burning, Igniters – Pyrotechnic & Pyrogen Igniters. | 7 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Liquid propellant Rocket engines, Gas pressure feed systems, Turbo-pump feed system, Cryogenic fluids as rocket propellants, Feed systems, Injectors, Combustion Mechanisms, Combustion Instability | 7 | 12 (20 %) |
| MODULE: 6<br>Cooling of Thrust Chambers – Radiation cooling, Ablative cooling, Regenerative cooling, Film cooling, Transpiration cooling, Testing of Rockets, Introduction to Hybrid, Solar, Electrical and Nuclear Rockets, Multi staging of Rockets, Boost dynamics, Aspects of Launching, Kepler's laws, Keplerian elements, Transfer orbits, Escape velocity, Orbit equation. | 7 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**ELECTIVES OFFERED**

**FOR SEMESTER II**

**COURSE TITLE: ADVANCED FINITE ELEMENT ANALYSIS**

**COURSE NO: 07ME 6212** **Credits: 3-0-0: 3** **Year: 2015**

**Pre- requisites:**

Basic knowledge of Partial differential equations, Structural Mechanics, Heat transfer, Fluid Mechanics and Elementary Finite Element Method.

**Course Objectives:**

- To master linear finite element procedures and programming techniques.
- To understand the basic mathematics of finite element analysis and equip the students to formulate finite element procedures for engineering problems.
- To train the students in structural, thermal and flow analysis problems using finite element software.
- To introduce finite element procedures and programming techniques for non-linear and transient problems.

**Syllabus:**

Review of tensors, elasticity - plasticity and principles of dynamics - Heat transfer and fluid flow problems - Review of computational procedures with 1-D elements - 2-D elements - Heat transfer and fluid flow problems - Convergence and completeness conditions-Applications - Isoparametric formulation - Coordinate transformation - Imposition of constraints - Error - Sources of error - Boundary value problems - Finite element formulation from a functional - Weighted-residual methods- Galerkin Finite Element formulation - Applications to structural, thermal and fluid flow problems - Finite element formulation for non-linear problems – solution methods - Convergence criteria - Applications – Transient Finite Element Procedures – Integration Techniques – Applications - Introduction to coupled analyses and contact problems.

**Course Outcome:**

- The Graduate will develop the capability to apply finite element concepts to solve engineering problems in manufacturing.

**Text Books:**

1. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, Concepts & Applications of Finite Element Analysis, John Wiley & Sons, Fourth Edition.
2. D. V. Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill, 2005.
3. S. S. Rao, The Finite Element Method in Engineering, Butterworth Heinemann,$4^{th}$ Edition.

**References:**

1. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill International, Third Edition.
2. K. J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 1996.
3. O. C. Zienkiewicz, R. L. Taylor, The Finite Element Method, McGraw Hill, Fifth Edition.

**COURSE PLAN**

| **COURSE TITLE: ADVANCED FINITE ELEMENT ANALYSIS**<br>**COURSE NO: 07 ME 6212** **(L-T-P : 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact hours** | **End.Sem. Exam Marks; %** |
| MODULE: 1<br>Review of tensors, elasticity, plasticity and principles of dynamics review of computational procedures with 1-D elements – interpolation and shape functions – 2-D elements – simple solid elements – element matrices for structural mechanics | 6 | 15 |
| MODULE: 2<br>Heat transfer and fluid flow problems – choice of interpolation functions convergence and completeness conditions – modeling considerations – symmetry applications. Isoparametric formulation – 1-D and 2-D elements – numerical integration – choice in numerical integration – patch test. | 8 | 15 |
| FIRST INTERNAL TEST | | |
| MODULE: 3<br>Coordinate transformation – transformation of characteristic matrix – transformation of restraint directions. Imposition of constraints – Lagrange multiplier and penalty function methods. Error –sources of error –ill conditioning–convergence–error estimates. | 7 | 15 |
| MODULE: 4<br>Boundary value problems – weak and strong forms – functional – Euler-Lagrange equations – Rayleigh-Ritz method – finite element formulation from a functional.<br>Weighted-residual methods – Galerkin, least-square and collocation methods – Galerkin finite element formulation – applications to structural, thermal and fluid flow problems. | 8 | 15 |
| SECOND INTERNAL TEST | | |
| MODULE: 5<br>Finite element formulation for non-linear problems – solution methods Newton-Raphson method – modified Newton-Raphson method – convergence criteria – applications. | 6 | 20 |
| MODULE: 6<br>Transient finite element procedures – FE equations and matrices - integration techniques – applications.<br>Introduction to coupled analyses (fluid-structure interaction, thermo-mechanical problems) and contact problems. | 7 | 20 |

| **Internal Continuous Assessment *(Maximum Marks: 40)*** | |
|---|---|
| Assessment procedure: | |
| Two internal tests: | 30 marks each |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks |

**COURSE TITLE: COMPUTATIONAL FLUID DYNAMICS**

**COURSE NO: 07ME 6122 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Fluid mechanics, Advanced Fluid Mechanics, Computational Methods in Engineering

**Course Objectives:**

To give the student:-

- Knowledge on computational methods in fluid flow and heat transfer
- Introduction about discretization using FDM and FVM
- Concepts in fluid flow modelling and simulation
- Introduction to turbulence modelling

**Syllabus**

Governing equations in fluid flow and heat transfer, classification of physical behaviour, Discretization using Finite Difference Method, implicit and explicit techniques, Numerical stability and convergence. Finite volume method applied to steady state diffusion problems, steady state convection with diffusion problems and unsteady diffusion problems. Implementation of boundary conditions, turbulence modelling.

**Course Outcome**

The student will have a good knowledge on the governing equations in fluid flow and heat transfer and its dicretization using Finite difference and finite volume method. The student will be able to model compressible and incompressible fluid flow problems and simulate it. They will be able to do turbulence modelling also.

**References**

**References**


1. H.K Versteeg & W. Malalasekera - "An Introduction to Computational Fluid Dynamics"– Pearson Education Ltd, 2007, Second Edition
2. John D Anderson Jr - "Computational Fluid Dynamics"– McGraw Hill Education ,1995
3. Suhas.V. Patankar - "Numerical Heat transfer and Fluid Flow" Hemisphere Publishing Corporation, 1980
4. K.Muralidhar & T Sundararajan-"Computational Fluid Flow and Heat Transfer" Narosa Publishing House ,1995
5. C.A.J.Fletcher-Computational Technique for Fluid Dynamics ,Volume 1- Springer-Verlag, 1988
6. Klaus A Hoffmann- " Computational Fluid Dynamics for Engineers"- Engineering Education System,1993, Second Edition

**COURSE PLAN**

| **COURSE TITLE: COMPUTATIONAL FLUID DYNAMICS**<br>**COURSE NO: 07 ME 6122** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Conservation laws of fluid motion and boundary conditions, Governing equations in fluid flow and heat transfer, Navier Stokes equation, Transport equations, Classification of physical behaviour, Equilibrium problems Marching problems, Elliptic equations, Parabolic equations, Hyperbolic equations | 6 | 9 (15 %) |
| MODULE : 2<br>Application of Finite Difference Methods, Discretization, Taylor series method, Central differencing, Forward and Backward differencing, Explicit, Implicit and Semi-Implicit Techniques, Crank Nicolson scheme, Estimation of truncation and discretization errors. Criteria for numerical stability, Convergence analysis. | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Flux formulation for Finite Volume Method, One dimensional steady state diffusion, two and three dimensional steady state diffusion problems, Steady one dimensional convection and diffusion- Central differencing, Upwind differencing scheme , QUICK and SIMPLE Algorithms | 8 | 9 (15 %) |
| MODULE :4<br>Finite volume method for unsteady flow, one dimensional unsteady heat conduction, Explicit, Crank Nicolson and Fully Implicit scheme | 6 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Modeling of flow problems, Implementation of Boundary conditions, Inlet and Outlet Boundary conditions, Wall Boundary condition, Symmetry and Periodic Boundary conditions | 6 | 12 (20 %) |
| MODULE: 6<br>Turbulence and its modeling, Transition to turbulence, Jet flow, Turbulence kinetic energy, Free turbulent flows, Viscous sub layer, Log-law layer, Outer layer, k-Є model, k-ω model, Spalart Allmaras model, LES model and DNS model . | 8 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: DESIGN AND OPTIMIZATION OF THERMAL SYSTEMS**

**COURSE NO: 07ME 6132 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:** Fluid mechanics, heat and mass transfer.

**Course Objectives:**

To give the student:-

- To present the basic ideas of optimization
- To design, analyse and optimize engineering systems
- Students will gain knowledge curve fitting, inverse methods

**Syllabus**

Introduction to design-system design- system simulation-curve fitting- optimization-search methods-non traditional optimization- understanding of inverse methods

**Course Outcome**

The student will have a sound knowledge on fundamental design of an engineering system. They will be able mathematically express the variables in the system and will be able to optimize the system using different techniques.

**References**


1. C. Balaji, Essentials of Thermal System Design and Optimization, Ane Books Pvt Ltd., 2011
2. Y. Jaluria, Design and Optimization of Thermal Systems, McGraw Hill, 1998
3. R.F. Boehm, Design and analysis of Thermal Systems, John Wiley, 1987
4. A. Bejan, Thermal Design and Optimization, John Wiley, 1995
5. W.F. Stoeker, Design of Thermal Systems, 3rd Edition, McGraw Hill, 1989
6. W.J. Gajda, and W.E. Biles, Engineering Modeling and Computation, Houghton Miffin, 1980

**COURSE PLAN**

| **COURSE TITLE: DESIGN AND OPTIMIZATION OF THERMAL SYSTEMS**<br>**COURSE NO: : 07ME 6132** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Engineering Design-Designing of workable system with examples | 6 | 9 (15 %) |
| MODULE : 2<br>Economics- Introduction- Different types of Interest calculations | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Curve fitting – Introduction –Exact fit and its types- Best fit- Non linear least squares System simulation- Some uses of simulation- Information flow diagram-Techniques for simulation- | 6 | 9 (15 %) |
| MODULE :4<br>Optimization - basic ideas-general representation of optimization problem search methods- monotonic and unimodal functions- concept of global and local minima- elimination method- multivariable unconstrained optimization | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Lagrange multipliers- the algorithm- economic significance of Lagrange multipliers- Test for Maxima/minima- Handling inequality constraints | 8 | 12 (20 %) |
| MODULE: 6<br>Non traditional optimization techniques –Genetic Algorithm- Simulated Annealing – inverse methods | 6 | 12 (20 %) |

| **Internal Continuous Assessment *(Maximum Marks: 40)*** | |
|---|---|
| Assessment procedure: | |
| Two internal tests: | 30 marks each |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks |

**COURSE TITLE: THERMAL TURBOMACHINES**

**COURSE NO: 07 ME 6142 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:** Thermodynamics, Fluid mechanics, Hydraulic Machinery.

**Course Objectives:**

To give the student:-

- An awareness on the various turbomachines used in the industry today
- The capability to design, analyse and troubleshoot systems involving turbomachines
- Sound base on the working of centrifugal pumps, compressors, axial flow pumps, compressor and turbine

**Syllabus**

Fluid flow in Cartesian co-ordinates, Vorticity, Three dimensional flow in turbomachines, Cascading turbines, Performance of cascade turbines, Centrifugal pumps, principles design and working of centrifugal pumps, different blades, axial flow pumps, centrifugal compressors, principles working and performance of centrifugal compressors, axial flow turbines, performance, working and principles, axial flow turbines, principles working and performance.

**Course Outcome**

The student will develop a sound base on the various turbomachinery used in industry, with knowledge in the design principles, working, performance of such machines thus being in a position to trouble shoot and modify such a system for optimum performance and long life. The student will have an overall idea on the recent developments in the field of turbomachinery

**References**


1. D.G. Sheperd, “Principles of turbomachinery”, The Macmillan Company, New York.
2. A. H. Church and JagadishLal, ”Centrifugal Pumps and Blowers”, Metropolitan Book Co. 1973
3. A.J. Stepanoff, “Centrifugal and Axial Flow Pumps”, Wiley & sons, 1966.
4. J.H. Horlock, “Axial Flow Compressors”, Butter worths Scientific Publications, 1958.
5. S.M. Yahya, “Turbine, Compressors and Fans”, Tata McGraw Hill Co. New Delhi, 1998.
6. V. Ganesan, “Gas Turbines”, Tata McGraw Hill Co. New Delhi, 2001.
7. M.H.Vavra, “Aerothermodynamics and Flow in Turbomachines”

**COURSE PLAN**

| **COURSE TITLE: THERMAL TURBOMACHINES**<br>**COURSE NO: 07 ME6142** | **(L-T-P: 3-0-0) CREDITS: 3** | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Equation of motion in Cartesian and cylindrical co, ordinates, Absolute potential flow, Potential and stream functions, Vorticity, circulation, rotational and irrotational flows – Two and three dimensional flows in turbo, machines | 6 | 9 (15 %) |
| MODULE : 2<br>Flow through cascade of blades, Annular, radial and compressor and turbine cascades, Cascade tunnel, Cascade performance, variables and losses, Blade forces, Performance parameters of compressible machines. | 6 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Incompressible fluid machines, Theory of centrifugal pumps, Ideal torque equation, pressure rise, Circulatory flow, Effect of blade angle, number of blade, speed and diameter, Losses, Cavitation, NPSH and Surging. Design of radial stage impeller, Simple curvature blades, Design of volutes and diffusers, Francis type impeller, Blade twist. Axial flow pumps , Experimental design factors , Aerofoil theory of design | 8 | 9 (15 %) |
| MODULE :4<br>Centrifugal compressors, stage velocity triangles, Blade shape, Enthalpy, entropy diagrams, Analysis of flow in impeller and diffuser, slip factor, stage losses, Degree of reaction, Performance characteristics, Surging and choking, Multistage compressors. | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Axial flow compressors, velocity triangles, Enthalpy, entropy diagrams, Blade loading, stage losses and efficiencies, Degree of reaction, Varying reaction stage, Flow through rotor and stator blade rows, Work done factor, Radial equilibrium, supersonic and transonic stages, Performance characteristics of design operation, Surging and stalling. | 8 | 12 (20 %) |
| MODULE: 6<br>Axial and radial flow turbines,Stage velocity triangles, Velocity and pressure compounding,reaction stages, Losses and efficiencies, Performance characteristics, Manufacture of blades, Blade fixing, High temperature cooled turbines, Blade cooling | 6 | 12 (20 %) |

| **Internal Continuous Assessment *(Maximum Marks: 40)*** | |
|---|---|
| Assessment procedure: | |
| Two internal tests: | 30 marks each |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks |

**COURSE TITLE: SOFTCOMPUTING TECHNIQUES**

**COURSE NO: 07 ME6152 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Programming fundamentals, Networking

**Course Objectives:**

To give the student:-

- To acquaint the students with soft computing methodologies such as neural networks, fuzzy logic, genetic algorithms and hybrid algorithms
- Enable the students to implement real time intelligent and adaptive systems.

**Syllabus**

Fuzzy set operations, Fuzzy relations, membership functions, fuzzy logic controller, neutral network architecture, perceptron networks, back propagation networks, Hopfield network, encoding methods, and genetic algorithm.

**Course Outcome**

The students will be capable of using engineering applications in project work with the help of computer software.

## References


1. S.Rajasekharan, G.A.VijayalakshmiPai, Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications, Prentice Hall India.
2. S.N.Sivanandam, S.N.Deepa, Principles of Soft Computing, Wiley India.
3. Timothy J Ross, Fuzzy logic with Engineering Applications, McGrawHill ,New York.
4. S.Haykins, Neural Networks a Comprehensive foundation, Pearson Education.
5. D.E.Goldberg, Genetic Algorithms in Search Optimisation and Machine Learning, Pearson Education.
6. Recent Literature.

**COURSE PLAN**

| **COURSE TITLE: SOFTCOMPUTING TECHNIQUES**<br>**COURSE NO: 07 ME 6152** | | **(L-T-P: 3-0-0) CREDITS: 3** |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Fuzzy sets, Fuzzy set operations- Fuzzy relations, Cardinality of Fuzzy relations, Operations on Fuzzy relations, Properties of Fuzzy relations- Membership Functions, Features of Membership functions | 6 | 9 (15 %) |
| MODULE : 2<br>Fuzzification-Methods of Membership value Assignments- Fuzzy Rule Base-Defuzzification-Deffuzzification methods- Fuzzy logic controller(Block Diagram) | 5 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Basic concepts, Neural network Architectures-Single layer feed forward network, Multilayer feed forward network, Recurrent Networks, Characteristics of Neural Networks | 5 | 9 (15 %) |
| MODULE :4<br>Learning methods. Perceptron networks Back Propagation networks-Radial base function network-Hopfield network, Kohonen Self organizing maps-ART | 5 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Basic concepts- working principle, encoding, different methods, fitness function, reproduction, different methods. Genetic modeling, inheritance, Crossover mutation-convergence of genetic algorithm. | 10 | 12 (20 %) |
| MODULE: 6<br>Neural network, fuzzy logic and genetic algorithm hybrids, Neuro fuzzy hybrids, neuro genetic hybrids, Fuzzy genetic hybrids, Genetic algorithm based back propogation network, Fuzzy back propagation networks -fuzzy logic controlled genetic algorithms. | 11 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: ENERGY CONSERVATION IN THERMAL SYSTEMS**

**COURSE NO: 07ME 6162 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Thermodynamics, Power plant Engineering, heat and mass transfer, Thermal Engineering

**Course Objectives:**

To give the student:-

- An understanding on the energy conservation techniques adopted in industries involving steam generation and usage.
- Brief idea on energy auditing, available energy in industrial process.
- An in depth knowledge on the thermodynamic analysis of various components of an industrial system, chemical reactions involved and the economics connected with it.
- An introduction to the novel techniques used in the field of power plants and steam generation.
- The basic principles of power generation and distribution in real life.

**Syllabus**

Overview on energy management, Optimisation of steam usage, Steam piping and insulation, energy diagrams, energy audits, Thermodynamic availability in physical systems, Steam pricing, Investment optimisation, limits and future of technology available, Co generation potential from a site and its linear programming, Analysis of thermal components in a system, Waste heat recovery and boiler performance improvement, novel techniques in steam generation.

**Course Outcome**

The student will have a sound knowledge on energy management, the optimisation of steam piping performance, industrial energy audits, steam pricing, utility economics and returns and cogeneration potential of plants. Students will know to analyse various components of a thermal systems like chemical reactors, heat exchangers, mixers, distillers and co-generation systems.The basic idea on the waste heat recovery techniques and novel methods in a thermal systems are also imparted through this course.

**References**


1. W.F.Kenney: Energy Conservation in the Process Industries, Academic Press,1984
2. A.P.E.Thummann:Fundamentals of Energy Engineering ,Prentice Hall,1984
3. M.H.Chiogioji:Industrial Energy Conservation,Marcel Dekker,1979
4. A.P.E.Thummann,Plant Engineers and Managers Guide to Energy conservation,Van Nostrand,1977
5. W.R.Murphy and G.Mc.Kay:Energy Management,Butterworth-Heinemann,2001
6. F.B.Dubin: Energy conservation Standards. McGraw Hill, 1978.

**COURSE PLAN**

| **COURSE TITLE: ENERGY CONSERVATION IN THERMAL SYSTEMS**<br>**COURSE NO: 07ME 6162 (L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Definition of energy management-Energy conservation schemes-Optimizing steam usage-Waste heat management-Insulation-Optimum selection of pipe size-Energy conservation in space conditioning-Energy and cost indices-Energy diagrams-Energy auditing. | 6 | 9 (15 %) |
| MODULE : 2<br>Thermodynamic availability analysis-Thermodynamic efficiencies-Available energy and fuel. Thermodynamics and economics-Systematic approach to steam pricing-pricing other utilities-Investment optimization-Limits of current technology-Process improvements-Characterizing energy use. | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Optimum performance of existing facilities- Steam trap principles-Effective management of energy use-Overall site interactions- Total site cogeneration potential-Linear programming approach. Thermodynamic analysis of common unit operations-Heat exchange-Expansion-Pressure let down-Mixing-Distillation-Combustion air preheating-Systematic design methods. | 6 | 9 (15 %) |
| MODULE :4<br>Process synthesis-Application to cogeneration system-Thermo economics-Systematic optimization-Improving process operations-Chemical reactions-Separation-Heat transfer-Process machinery-System interaction and economics. | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Potential for waste heat recovery- Direct utilization of waste heat boilers-Use of heat pumps-Improving boiler efficiency—Industrial boiler inventory.-Use of fluidized beds-Potential for energy conservation. | 8 | 12 (20 %) |
| MODULE: 6<br>Power economics-General economic problems-Load curves-Selection of plants-Specific economic energy problems-Energy rates. | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**ELECTIVES OFFERED**

**FOR SEMESTER III**

**COURSE TITLE: SIMULATION OF I C ENGINE PROCESESS**

**COURSE NO: 07 ME 7111 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:**Thermodynamics, Thermal engineering, Environment Sciences

**Course Objectives:**

To give the student:-

- The simulation of engine combustion based on first and second law of thermodynamics.

**Syllabus**

Simulation principles, properties of gas mixtures, open and closed cycle models, chemical reactions, laws of thermodynamics, heat transfer models for engines, simulation of combustion in CI and SI engines, multidimensional and spray modelling, Premixed-diffusive models, flows in engine manifolds.

**Course Outcome**

The students will get awareness about software simulations in thermodynamic process cycles and other heat release characteristics regarding I C engines.

**References**


1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.
3. V.Ganesan, Computer Simulation of Compression Ignition Engine Processes, Universities Press, 2002..
4. Gordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.
5. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.
6. J.I.Ramos, Internal Combustion Engine Modeling, Hemisphere Publishing Corporation, 1989.
7. J.N.Mattavi and C.A.Amann, CombustionModeling in Reciprocating Engines, Plenum Press, 1980.

**COURSE PLAN**

| **COURSE TITLE: SIMULATION OF I C ENGINE PROCESESS**<br>**COURSE NO: 07 ME 7111** **(L-T-P: 3-0-0)CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Simulation principles-First and second laws of thermodynamics, Estimation of properties of gas mixtures, Structure of engine models, Open and closed cycle models, Cycle studies, Chemical Reactions, First law application to combustion. | 6 | 9 (15 %) |
| MODULE : 2<br>Heat of combustion, Adiabatic flame temperature, Chemical Equilibrium and calculation of equilibrium composition, Heat transfer in engines, Heat transfer models for engines. | 5 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Simulation in S I engine, Combustion in SI engines, Flame propagation and velocity, Single zone models, Multi zone models, Mass burning rate, Turbulence models, One dimensional models, Chemical kinetics modeling, Multidimensional models. | 10 | 9 (15 %) |
| MODULE :4<br>Simulation in C I engine Combustion in CI engines Single zone models, Premixed-Diffusive models, Wiebe' model, Whitehouse way model, Two zone models, Multizone models | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Meguerdichian and Watson's model, Hiroyasu's model, Lyn's model, Introduction to Multidimensional and spray modeling, Thermodynamics of the gas exchange process | 8 | 12 (20 %) |
| MODULE: 6<br>Flows in engine manifolds, One dimensional and multidimensional models, Flow around valves and through ports Models for scavenging in two stroke engines, Isothermal and non-isothermal models. | 5 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: INDUSTRIAL ENERGY MANAGEMENT**

**COURSE NO: 07ME 7121 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Basic electrical engineering, Energy engineering, Mathematics

**Course Objectives:**

To give the student:-

- Basic understanding of energy engineering and the outlook of the world towards it.
- Sound base on the renewable energy sources and alternate energy methods.
- An idea on energy conservation and the various steps taken in the industry in this aspect.
- An understanding on the environmental effects caused by the use of various energy sources and ways to modify them.

**Syllabus**

Energy engineering, world energy outlook, energy conservation, industrial energy conservation systems, renewable energy sources, non-conventional energy resources, energy audit, economics connected with energy systems, energy management systems, Environment aspects of energy usage, Effects of environment and environment conservation.

**Course Outcome**

The student shall have a basic idea on the energy management, world outlook towards energy management, energy conservation in industry, the various energy consuming systems in an industry. The students shall have an in depth knowledge on the various effects energy consumption has brought on the environment and various measures used to rectify them.

**References**


1. A.P.E.Thumann, Fundamentals of Energy, Engineering,Prentice Hall,1984.
2. A.P.E.Thumann, Plant Engineers and Managers Guide to Energy Conservation, 7e,UNR,1977.
3. W.F.Kenney, Energy Conservation in the Process Industries, Academic press,1984
4. M.H.Chiyogioji, Industrial Energy Conservation, Marcel Dekker,1979
5. C.B. Smith, Energy Management Principles, Pergamon Press, New York, 1981.
6. AmitTyagi, Handbook on Energy Audit and Management, TERI, New Delhi, 2000
7. Environmental Considerations in Energy Development, Asian Development Bank (ADB) publication,Manila, 1991

**COURSE PLAN**

| **COURSE TITLE: INDUSTRIAL ENERGY MANAGEMENT**<br>**COURSE NO: 07 ME 7121** **(L-T-P: 3-0-0)CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Energy Engineering, World energy outlook. Application of Non Conventional and Renewable Energy Systems , Use of Energy Efficient Technologies , Solar energy, solar energy collectors and energy storage, applications of solar energy. | 6 | 9 (15 %) |
| MODULE : 2<br>Wind energy, basic components of a wind energy conversion system, performance of wind machines, applications of wind energy. Energy from biomass, biomass conversion technologies, types of biogas plants, Energy conservation schemes, case studies. | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Electrical system optimization, Importance of power factor, Power factor correction, Energy efficient motors, lighting basics, energy efficient light sources, domestic, commercial or industrial lighting. Energy conservation in lighting schemes, case studies. Energy conservation in HVAC system, energy conservation by cogeneration scheme, boiler efficiency improvement, waste heat recovery, case studies | 8 | 9 (15 %) |
| MODULE :4<br>Energy economics, payback analysis, energy auditing and accounting, types, energy use profiles, the energy survey, Sankey diagram for energy audit, Energy Audit Instruments, Thermal Energy Efficiency & Audits, Electrical Energy Efficiency, Audits , case studies | 6 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Energy management, Maintenance management, Preventive maintenance schedule, Energy management organization | 6 | 12 (20 %) |
| MODULE: 6<br>Energy and Environment. Environmental aspects of energy utilization- public health issues related to environmental pollution. Methods to measure pollution in industries, air pollution & water pollution. Compliance with standards, International Environmental Policy. Energy recovery by solid waste management. Environmental auditing, case studies | 8 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: ALTERNATIVE FUELS FOR I C ENGINES**

**COURSE NO: 07ME 7131 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Fuels and combustion, Internal Combustion Engines, Environmental science

**Course Objectives:**

To give the student:-

- Gain a working understanding of the engineering issues and perspectives affecting fuel and engine development. A comprehensive insight into the pollution in engine and gas turbines.
- Examine future trends and development, including hydrogen as an internal combustion engine fuel.
- Explore further fuel specification and performance requirements for advanced combustion systems.

**Syllabus**

Alternative fuels, their availability, properties, merits and demerits, requirements of fuels for IC engines, blends and other fuels used in CI engines, manufacturing, storage and performance analysis of alternative fuels, use of hydrogen, CNG, bio gas in SI engines, safety precautions, performance and emission characteristics.

**Course Outcome**

Identify the need of alternate fuels and list out some prospective alternate fuelsCategorize, interpret and understand the essential properties of fuels for petrol and diesel engines. Analyze the implement limitations with regard to performance, emission and materials compatibility.

**References**


1. Osamu Hirao and Richard K.Pefley, Present and Future Automotive Fuels, John Wiley and Sons, 1988.
2. Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications,1990.
3. Richard L.Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997.
4. Automotive Lubricants Reference Book, Second Edition, Roger F. Haycock and John E. Hillier, SAE International Publications, 2004.

**COURSE PLAN**

| **COURSE TITLE: ALTERNATIVE FUELS FOR I C ENGINES**<br>**COURSE NO: 07ME 7131** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Availability and Suitability and properties of Potential Alternative Fuels, Ethanol, Methanol, DEE, DME, Hydrogen, LPG, Natural Gas, Producer Gas, Bio gas and Bio-diesel, Properties, Merits and Demerits. | 10 | 9 (15 %) |
| MODULE : 2<br>Requirements of fuels for SI engines-Different Techniques of utilizing alternative liquid fuels, Blends, Neat form, Reformed Fuels | 6 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Manufacturing, Storage and Safety-Performance and Emission Characteristics of alternative liquid fuels, Requirements of fuels for CI engines- Different Techniques for their utilization, Blends, Fuel modifications to suit CI engines | 6 | 9 (15 %) |
| MODULE :4<br>Neat fuels, Reformed fuels, Emulsions, Dual fuelling, Ignition accelerators and other additives Performance and emission characteristics. | 6 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Use of Hydrogen, CNG, LPG, Natural Gas, Producer gas and Bio gas in SI engines, Safety Precautions, Engine performance and emissions. | 8 | 12 (20 %) |
| MODULE: 6<br>Use of Hydrogen, Producer Gas, Biogas, LPG, Natural gas, CNG in CI engines. Dual fuelling, Performance and emission characteristics. | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

## COURSE TITLE: MEASUREMENTS IN THERMAL SYSTEM

**COURSE NO: 07 ME 7141 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:**Thermodynamics, Fluid flow, Computer

**Course Objectives:**

To give the student:-

- An awareness on the various measurement techniques in industry
- A background materials in system response, measurement uncertainty.
- Idea on use of instruments and techniques for practical measurements required, automatic data acquisition.

**Syllabus**

Characteristics of Measurement, Analysis of experimental data, Causes and types of experimental errors, Temperature measurements, Heat Flux measurements, Pressure Measurements, Mechanical & Electrical types,Laminar & Turbulent flow measurements, Determination of Reynolds stresses, Flow visualization techniques, Measurements in combustion: Species concentration, Reaction rates, Flame visualization, Data Acquisition and Processing, General Data Acquisition system, Signal conditioning.

**Course Outcome**

After the completion of the course, one should be able to understand the flow properties and basic principles related to measuring systems.The students shall be exposed to the systems used in the industry thus making them better equipped to meet real life challenges. The student shall also be well versed in techniques connected with data acquisition and interpretation of thermal measurements from a system.

**References:**


1. J P Holman : Experimental methods for Engineers , Mcgraw-Hill,6th edition ,1994.
2. S. P. Venkatesan: Mechanical Measurements , Ane Books India and CRC Press in 2008
3. Ernest O Doebelin : Measurement Systems - Application & Design Mcgraw-Hill,5th edition ,2008.
4. W.Bolton: Mechatronics, McGraw-Hill,3rd edition,2009.
5. Donald P Eckman : Industrial Instrumentation , CBS Publisher, 1st edition , 2004.
6. Willard, Mertt, Dean,Settle : Instrumental Methods of analysis , Published by D. Van Nostrand Co., New York , 6th edition,1981
7. D. Patranabis : Principles of Industrial Instrumentation , Tata McGraw-Hill Education, 2 nd edition, 2001.
8. T.G Beckwith & N. L Buck : Mechanical Measurements , Addison-wesley ,1969
9. B.C Nakra& K K Chaudhry : Instrumentation measurement and analysis
   Mc Graw hill - 3rd edition
10. R W Ladenburg:Physical Measurements in Gas Dynamics and Combustion : High Speed Aerodynamics and Jet Propulsion Vol. IX

**COURSE PLAN**

| **COURSE TITLE: MEASUREMENTS IN THERMAL SYSTEM**<br>**COURSE NO: 07 ME 7141** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Characteristics of Measurement Systems, Elements of Measuring Instruments Performance characteristics, static and dynamic characteristics, Analysis of experimental data, Causes and types of experimental errors, Error & uncertainity analysis- statistical & graphical methods, probability distributions | 8 | 9 (15 %) |
| MODULE : 2<br>Temperature measurements, Theory, Thermal expansion methods, Thermoelectric sensors, Resistance thermometry, Junction semiconductor sensors, Pyrometry, Temperature measuring problems in flowing fluids, Dynamic Response & Dynamic compensation of Temperature sensors, Heat Flux measurements | 6 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Pressure Measurements, Mechanical & Electrical types, High pressure & Low pressure measurements, Differential Pressure Transmitters. | 6 | 9 (15 %) |
| MODULE :4<br>Laminar & Turbulent flow measurements, Determination of Reynolds stresses, Flow visualization techniques, Gross Volume Flow measurements, Measurement of Liquid level, Density, Viscosity, Humidity & Moisture. | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Measurements in combustion: Species concentration, Reaction rates, Flame visualization, charged species diagnostics, Particulate size measurements. | 8 | 12 (20 %) |
| MODULE: 6<br>Data Acquisition and Processing, General Data Acquisition system, Signal conditioning, Data transmission, A/D & D/A conversion, Data storage and Display, Computer aided experimentation | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |

**COURSE TITLE: AUTOMOTIVE ENGINE SYSTEM**

**COURSE NO: 07ME 7151 CREDITS: 3-0-0:3 YEAR:2015**

**Pre-requisites:** IC engines, fuels and combustion, Automobile Engineering

**Course Objectives:**

To give the student:-

- To impart knowledge on various automotive engine types and its performance characteristics**.**
- To impart knowledge on fuel and fuel systems.
- To impart knowledge on current trends in engine technology.

**Syllabus**

Automotive Engine types, characteristics, performance, emissions, fuels, current trends, multi-valving, fuel injection systems- CRDI, GDI, combustion and knock, supercharging, EGR, Hybrid electric vehicles, certification and testing of IC engines, current materials and production processes.

**Course Outcome**

The students will be aware of the latest trends in automotive systems, and other technologies in fuel injection, valve timing etc.

**References**


1. Robert Bosch, GmbH, Automotive Hand Book, Germany, 2000.
2. Tom Denton, Automobile Electrical and Electronic Systems, SAE International USA, 2000.
3. Eric Chowanietz, Automobile Electronics, SAE International, 1995.
4. SAE Inc., Advanced Power Plant Concepts, SP – 1325, 1998.
5. Michael Plintand Anthony Martyr, Engine testing Theory and Practice (Second Edition) SAE International, 1999.
6. SAE Inc, Advancements in Electric and Hybrid Electric Vehicle Technology, SP – 1023, 994.

**COURSE PLAN**

| **COURSE TITLE: AUTOMOTIVE ENGINE SYSTEM**<br>**COURSE NO: 07ME 7151** | **(L-T-P: 3-0-0) CREDITS: 3** |
|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Automotive Engine Types, On-highway, Off-highway, Gasoline, Diesel and Alternate Fueled. Characteristics of Automotive Engines, Power, Torque, Fuel Consumption, Pollutant Emissions, Thermal Efficiency, Life Cycle Cost | 6 | 9 (15 %) |
| MODULE : 2<br>Duality of matter, Thermoelectric Vs photoelectric phenomena, Basic thermoelectric engine, Thermoelectric materials, Applications. Fuel systems-Carburetion, fixed venturi and variable venturi and constant vacuum types, Gasoline Injection, TBI, MPFI, GDI and Air-assisted Injection, Engine Management System, Catalytic Conversion of Engine Pollutants | 8 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Electrical Catalyst Heaters, Common rail injection, Diesel Particulate Trapping and Trap Regeneration, Gaseous Fuel Injection, Lean NOx catalysts, SCR systems, Dual and Bifueling and Controls | 6 | 9 (15 %) |
| MODULE :4<br>Combustion chambers and Emissions-Fuel – Quality standards for Automotive Engines – Lead free gasoline, low and ultra – low sulphur diesels, LPG, CNG, Alcohols, Biodiesels, FT diesels, hydrogen.Ignition, Combustion and knock in SI and CI engines, Control of combustion in SI and CI engines | 8 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Control of combustion in SI and CI engines, Importance of control of parameters. Combustion chambers. Emission formation in SI and CI engines. Lean burn, GDI and HCCI systems, Development trends-Current trends in engine technology - Multi-valving, Tuned manifolding, camless valve gearing, variable valve timing, Turbo and supercharging. EGR, Part-load charge stratification in GDI systems, | 8 | 12 (20 %) |
| MODULE: 6<br>Current materials and production processes for engine components, TS 16949 Certification, performance testing of automotive engines, parasitic losses, standard codes of testing automotive engine components and assemblies, Hybrid electric vehicular piston engines and their characteristics. | 6 | 12 (20 %) |

| **Internal Continuous Assessment *(Maximum Marks: 40)*** | |
|---|---|
| Assessment procedure: | |
| Two internal tests: | 30 marks each |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks |

**COURSE TITLE: OPTIMIZATION TECHNIQUES**

**COURSE NO: 07ME 7161 CREDITS: 3-0-0:3 YEAR: 2015**

**Pre-requisites:** Operations research, operations management

**Course Objectives:**

To give the student:-

- To understand the theory of simplex method, non-linear programming, algorithms for unconstrained optimization and sequential decision making

**Syllabus**

Simplex method, Duality theory, parametric programming, Integer programming, minimal planning tree problems, general and non-linear programming problems, Lagrangian optimization, Fibonacci search method, constrained optimization, multi-objective decision models, stochastic process, simulated annealing, pareto optimality concept.

**Course Outcome**

The student will be able to explain the importance and basic principles of optimization, apply the theory to formulate design problems as mathematical optimization problems, solve optimization problems using different methods or algorithms, learn different methods of solving unconstrained and constrained optimization problems

**References**


1. Hillier, F.S. and Liberman, G.J., Introduction to Operations Research, McGraw-Hill International edition, Eighth Edition 2009.
2 Rao, S.S, Optimization: Theory and Applications, Second edition, Wiley eastern, 1994.
3 Ravindran, A., Philips, D.T., and Solberg, J.J., Operations Research: Principles and Practice, Second Edition, John Wiley & Sons, 1987.
4 Taha, H.A., Operations Research: An Introduction, Sixth Edition, Prentice-Hall of India, New Delhi, 1999.
5 Deb, K., Optimization in Engineering Design, Prentice-Hall of India, New Delhi, 1994.
6 Papadimitriou, C.H., and Steghtz, K., Combinatorial Optimization: Algorithms and Complexity, Prentice-Hall, New Jersey, 1982.
7 Simmons, D.M., Ravindran, A., Non-linear Programming for Operations Research, Prentice-Hall, New Jersey, 1975.
8 Reklatis, G.V., Ravindran, A., and Ragsdell, K.M., Engineering Optimization: Methods and applications, Wiley Interscience, New York, 1983.
9 Budnick F.S., McLeavey and R. Mojena, Principles of Operations Research for Management, 2/e, Richard D. Irwin Inc., Homewood, Illinois, 1991.

**COURSE PLAN**

| **COURSE TITLE: OPTIMIZATION TECHNIQUES**<br>**COURSE NO: 07ME 7161** **(L-T-P: 3-0-0) CREDITS: 3** | | |
|---|---|---|
| **MODULES** | **Contact Hours** | **Sem. Exam Marks; %** |
| MODULE : 1<br>Theory of Simplex Method, Duality Theory, Duality theorems, Dual simplex method, Revised simplex method, Bounded variables algorithm, Sensitivity analysis, Parametric programming. Integer Programming: Cutting plane method, Branch and bound method.<br>Network Models and Solutions: Shortest Route problems, Minimal spanning tree problems, Maximal flow problems. | 9 | 9 (15 %) |
| MODULE : 2<br>Non-linear Programming Problems: General non-linear programming problems; convex, quasi-convex, concave and unimodal functions, Theory of unconstrained optimization-Necessary and sufficient conditions for extrema, Theory of constrained optimization-Lagrange multipliers and Lagrangian optimization, Inequality constraints, Kuhn-Tucker conditions. | 9 | 9 (15 %) |
| **FIRST INTERNAL TEST** | | |
| MODULE: 3<br>Algorithms for Unconstrained Optimization: Fibonacci search method, Golden section search method Cauchy's (Steepest descent) method Algorithms for Constrained Optimization: Quadratic programming, Separable convex programming. | 6 | 9 (15 %) |
| MODULE :4<br>Multi-objective Decision Models: Introduction to multi-objective decision making, Concept of pareto-optimality, Goal programming formulation, the weighting method of solution, Analytic hierarchy process. | 6 | 9 (15 %) |
| **SECOND INTERNAL TEST** | | |
| MODULE: 5<br>Sequential Decision Making (Stochastic Case): Stochastic processes, Markov processes, Markov chains, Markov decision problems, Algorithms for solving Markov decision problems, finite-stage models and infinite stage models. | 6 | 12 (20 %) |
| MODULE: 6<br>Metaheuristics: Nature of metaheuristics, Tabu search, Simulated Annealing, Genetic Algorithm. Complexity of algorithms: Complexity of algorithms for combinatorial optimization problems. | 6 | 12 (20 %) |
| **Internal Continuous Assessment *(Maximum Marks: 40)*** | | |
| Assessment procedure: | | |
| Two internal tests: | 30 marks each | |
| Tutorials/Assignments (In the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher.) | 10 marks | |