APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Cluster No.10 for PG Programs

(Engineering Colleges in Kannur, Wayanad & Kasaragod Districts)

Curriculum, Scheme of Examinations and Syllabi for M. Tech. Degree Program with effect from Academic Year 2015 - 2016

Mechanical Engineering

M. Tech.

in

Thermal Engineering

(No. of Credits : 66)

CONTENTS

SEMESTER 1

Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Total Marks	Credits
					Marks	Duration (hours)		
A	10ME6301	Advanced Engineering Mathematics	3-1-0	40	60	3	100	4
B	10ME6303	Advanced Engineering Fluid Dynamics	3-0-0	40	60	3	100	3
C	10ME6305	Advanced Heat Transfer	3-0-0	40	60	3	100	3
D	10ME6307	Advanced Thermodynamics and Combustion	3-0-0	40	60	3	100	3
E	10ME6XX	Elective I	3-0-0	40	60	3	100	3
S	10GN6001	Research Methodology	0-2-0	100			100	2
T	10ME6409	Seminar I	0-0-2	100			100	2
U	10ME6411	Engineering Software Lab	0-0-2	100			100	1
		TOTAL	**15-3-4**	**500**	**300**	**-**	**800**	**21**

Elective I

10ME6313 Refrigeration Engineering
10ME6415 Hydraulic, Pneumatic and Fluid Controls
10ME6317 Thermal Environmental Engineering
10ME6319 Solar Thermal Engineering
10ME6321 Boundary Layer Theory and Turbulence

SEMESTER 2

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Total Marks	Credits
					Marks	Duration (hours)		
A	10ME6402	Internal Combustion Engine	3-1-0	40	60	3	100	4
B	10ME6404	Advanced Power Plant Engineering	3-0-0	40	60	3	100	3
C	10ME6306	Measurements in Thermal Engineering	3-0-0	40	60	3	100	3
D	10ME6xxx	Elective II	3-0-0	40	60	3	100	3
E	10ME6xxx	Elective III	3-0-0	40	60	3	100	3
V	10ME6408	Mini Project	0-0-4	100			100	2
U	10ME6412	Advanced Heat Transfer Lab	0-0-2	100			100	1
		TOTAL	**15-1-6**	**400**	**300**	**-**	**700**	**19**

Elective II

10ME6114	Soft Computing Techniques
10ME6116	Design of Experiments
10ME6118	Management Information System
10ME6122	Quality and Reliability Engineering
10ME6124	Project Engineering and Management

Elective III

10ME6326	Design of Heat Transfer Equipments
10ME6328	Renewable Energy Systems
10ME6432	Industrial refrigeration system
10ME6334	Advanced Gas Dynamics
10ME6436	Computational Fluid Flow and Heat Transfer

SEMESTER 3

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Total Marks	Credits
					Marks	Duration (hours)		
A	10ME7xxx	Elective IV	3-0-0	40	60	3	100	3
B	10ME7xxx	Elective V	3-0-0	40	60	3	100	3
T	10ME7401	Seminar II	0-0-2	100			100	2
V	10ME7403	Project (Phase I)	0-0-12	50			50	6
		TOTAL	**6-0-14**	**230**	**120**	**-**	**350**	**14**

Elective IV

10ME7305	Cryogenic Engineering
10ME7307	Design and Analysis of Turbomachines
10ME7309	Convection and Two-Phase Flow
10ME7411	Gas Turbines
10ME7313	Cogeneration and Waste Heat Recovery Systems

Elective V

10ME7315	Modern Energy Conversion Systems
10ME7417	Steam Turbines
10ME7419	Air Conditioning and Ventilation
10ME7421	Finite Element Analysis for Heat Transfer
10ME7323	Energy Conservation and Heat Recovery Systems

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Total Marks	Credits
					Marks	Duration (hours)		
V	10ME7404	Project (Phase II)	0-0-23	70	30		100	12
		TOTAL	**0-0-23**	**70**	**30**	**-**	**100**	**12**

TOTAL NUMBER OF CREDITS: 66

SEMESTER 1

	Course Name	L-T-P: Credits	Year of Introduction
10ME6301	ADVANCED ENGINEERING MATHEMATICS	3-1-0: 4	2015

Course Prerequisites

Basic knowledge of advanced calculus including methods for solving ODEs and basics of PDEs

Course objectives

The course is designed to teach students various techniques to solve PDEs including boundary value problems and introduce them to the important mathematical tool of Calculus of Variations and its methods.

Syllabus

Methods of solutions of First Order PDEs and important second order PDEs viz. Heat, Wave and Laplace equations.Fourier Transform Methods,Schwarz-Christoffel Transformation,Calculus of Variation,Numerical Methods for PDEs,Finite Difference in polar coordinates etc.

References

1. Mitchel A.R and Griffith D.F .The Finite Difference Method in Partial Differential Equations,John Wiley and sons ,New York (1980)
2. Gupta.A.S. Calculus of Variations with Applications.PHI Pvt. Ltd New Delhi (1997)
3. Introduction to PDE –K..SankaraRao-PHI
4. Advanced Engineering Mathematics-Erwin Kreizig ..
5. Introductory Methods of Numerical Analysis-S.S Sastry PHI
6. Tychonov.A.N and Samarskii.A.A. Partial Differential Equations of Mathematical Physics.Holden-Day,1964
7. Partial Differential Equations-Sneddon.

Expected Outcomes

The students are expected to develop knowledge about a variety of techniques for solving mathematical models in the form of PDEs.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	First order PDEs .Linear Equations,Lagrange method, Cauchy method,Charpits' method, Jacobian method.Second order PDEs,Classifications, Formulations and method of solutions Wave equation, Heat equations and Laplace equation.	9	15
II	Fourier Transform method for solving PDEs,relevant formulae for transform of partial derivatives,one dimensional heat conduction problems in infinite and semi infinite rod,Laplace equation,Poisson Equation.	9	15
	First Internal Examination		
III	Concept of variation and its properties,Euler's equation,Functionals dependent on first and higher order derivatives,Functionals dependent on functions of several independent variables,Problems with moving boundaries,Direct	9	15

	methods,Ritz and Kantorovich methods.		
IV	Schwarz-Christoffel Transformation,Transformation of boundaries in parametric form,Physical applications, Fluid flow problems,Heat flow problems.	7	15
Second Internal Examination			
V	Numerical methods for one dimensional parabolic equation,Explicit and Crank-Nicolson Schemes,Thomas Algorithm,Weighted average approximation,Dirichlet and Neumann conditions,Two dimensional parabolic equations,ADI method.	9	20
VI	Solutions of Laplace and Poisson equations in rectangular region,Finite difference in polar coordinates,Formule for derivatives near curved boundary while using a square mesh.	7	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6303	**ADVANCED ENGINEERING FLUID DYNAMICS**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of Fluid Mechanics and Vector calculus at UG Level

Course Objectives

To understand the basic concept and principles of modeling and analysing thermo-fluid systems, and the applications of the same.

Syllabus

Introduction to fluid dynamics, Differential and integral forms of conservation equations, Navier-Stokes equations, Non-dimensionalisation of N-S equations and order of magnitude analysis, Exact solutions of N-S equations, Boundary layer theory, Prandtl boundary layer equations, von-Karman momentumintegral equations, Introduction to turbulent flow, Reynolds stresses, boundary layer equations, Turbulence modelling,Turbulent flowthrough pipes and ducts, Turbulent jets and wakes.

Expected Outcomes

The students are expected to have a sound understanding of the concept of fluid dynamic principles and capability of applying this in the modeling and analyzing of various thermo-fluid systems in engineering.

References:

1. White, F. M., Viscous Fluid Flow, Third Edition, McGraw-Hill, 2006
2. H. Schlitchting, K.Gersten, Boundary Layer Theory, 8th Edition, Springer, 2004.
3. Papanastasiou, T. C., Georgiou, G. C., and Alexandrou, A. N., Viscous Fluid Flow, CRC Press, 2000.
4. Muralidhar, K. and Biswas, G., Advanced Engineering Fluid Mechanics, Second Edition, Narosa Publishing House, 2005.
5. John F. Douglas, Janusz M. Gasiorek, John A. Swaffield, Lynne B. Jack, Fluid Mechanics, Pearson Education 2009

6. Yunus A. Cengel, John M. Cimbala, Fluid Mechanics, 2nd Edition, Tata McGraw Hill Education Pvt. Ltd., 2010.
7. Pijush K. Kundu, Ira M. Cohen, Fluid Mechanics, Academic Press, 2004.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to fluid dynamics:**Review of fundamental concepts,Reynolds transport equation, Stokes hypothesis,Integral and differential forms of continuity,momentum, and energy equations.	10	15
II	Navier-Stokes equations and boundary conditions, Non-dimensionalisationof N-S equations and order of magnitude analysis, dimensionless parameters and theirsignificance.	7	15
	First Internal Examination		
III	**Exact solutions of incompressible Navier-Stokes equations**: Couette flow, flow between rotating cylinders, Stokes first problem, fullydeveloped flow through ducts, Low Reynolds number flows.	8	15
IV	**Boundary layer theory:**Prandtl boundary layer equations, Blasius solution and other similarity solutions of the laminar boundary layer, Karman momentum integral equations, prediction of boundary layer separations.	9	15
	Second Internal Examination		
V	**Introduction to turbulent flow**:Mean motion and fluctuation, time averaged turbulent flow equations, Reynolds stresses, boundary layer equations, boundary conditions	8	20
VI	**Turbulence modelling:** Shear stress models, mixing length hypothesis, k-Ɛ model, universal velocity distribution laws, flow through pipes and ducts, turbulent jets and wakes	9	20
	Cluster Level End Semester Examination		

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6305	**ADVANCED HEAT TRANSFER**	**3-0-0: 3**	**2015**

Syllabus

Heat transfer characteristics of Fins. Steady state conduction in one and two dimensional systems. Unsteady state conduction. Forced convection equations. Approximate and exact analysis of boundary layers. Free convection.Radiative properties of materials. Radiative exchange between two surfaces.Radiation exchange in an enclosure. Solar and gas radiation

Expected Outcomes

Deepens and broadens the understanding of heat transfer.

References:

1. Yunus A Cengel, Heat and Mass Transfer, A practical approach, Tata McGraw-Hill, 2007.
2. Holman, J. P., Heat Transfer, Ninth Edition, Tata McGraw-Hill, 2002.
3. D. Poulikakos: Conduction Heat Transfer, Prentice Hall, 1994.
4. Fundamentals of Heat and Mass Transfer- Incropera F P and Dewitt D P
5. V.S. Arpaci: Conduction Heat Transfer, AddisionWesly, 1996
6. H.S. Carslaw and J.C. Jaeger: Conduction of Heat in Solids, Oxford University Press, 1959.
7. Bejan: Convection Heat Transfer, J. Wiley, 2007
8. M.F. Modest: Radiative Heat Transfer, McGraw Hill, 1993
9. Siegel and Howell, Thermal radiation Heat transfer, McGraw Hill,
10. Kays and Crawfard., Convective heat and mass transfer, Mc-GrawHil Nations Industrial Development Organization, Vienna.Yoder and Witczak, 'Principles of Pavement Design', John Wiley,1975

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Heat transfer characteristics of straight, annular, and pin fins of uniform and non-uniform cross sections. Steady state conduction with uniform internal heat generation-temperature distribution and heat flux for regular solids with uniform heat generation-temperature dependent and location dependent heat generation	4	15
	steady state conduction in two dimensional systems. Analytical and numerical methods.	4	
II	Unsteady state conduction: unsteady state heating or cooling- Newtonian heating or cooling- Heating or cooling of finite and semi-infinite slabs with negligible surface resistance for different boundary conditions	6	15
	Solutions of heating or cooling of regular solids with comparable internal and external resistance by simple analyticalmethods and use of charts-periodic variation of surface temperature of infinitely thick wallsneglecting and considering surface resistances.	4	
First Internal Examination			
III	Forced convection: Equations of motion of a viscous fluid. General equation of energy transport - 2D boundary layer equation for momentum and energy transport. Laminarflow heat transfer: Exact solutions of the 2D boundary layer momentum and energy equations.	4	15
IV	Approximate calculations of the boundary layer by the momentum and energy integral equations. Turbulent flow heat transfer: Analog methods- Reynolds, Prandtl and von Karman.	6	15
Second Internal Examination			

V	Free convection: Solutions of the boundary layer equations for a vertical plate and a horizontal cylinder – approximate solutions-freeconvection with a turbulent boundary layer.	4	20
	Radiation: Radiative properties of real materials Radiative properties of metals and opaque non-metals-modifications of spectral characteristics. Exchange of radiant energy between black isothermal surfaces. Radiative exchange between two surfaces-	5	
VI	methods for evaluating configuration factors –radiation in a black enclosure, Radiation exchange in an enclosurecomposed of diffuse-gray surfaces Radiation between finite areas-radiation between infinitesimal areas,	4	20
	Solar and gas radiation.	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6307	**ADVANCED THERMODYNAMICS AND COMBUSTION**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of thermodynamics at UG Level.

Course Objectives

To understand the principles of combustion and to get broad knowledge in thermodynamics.

Syllabus

Introduction to thermodynamics, Second law of thermodynamics and concept of chemical equilibrium,Chemistry of Combustion,Physics of Combustion,PremixedFlame,Diffusion Flame, Combustion and Environment.

Expected Outcomes

The students are expected to Have a sound understanding of the principles of combustion and uderstand the complexities of industrial combustion processes

References

1. Thermodynamics – An Engineering Approach, YunusCengel and Michael Boles,7th Ed., Tata McGraw Hill
2. Modern Engineering Thermodynamics, Robert Balmer, Elseveir.
3. Advanced Thermodynamics for Engineers, Winterbone, John Wiley
4. Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw Hill
5. Fundamentals of Engineering Thermodynamics, Michael Moran, Howard Shapiro, John Wiley
6. Fundamental s of Combust ion, D. P. Mishra, Prentice Hall of India, New Del hi, 2008.
7. Principles of Combustion,Kuo K. K., John Wiley and Sons.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to thermodynamics:** Thermodynamics-equation of state, properties of gas mixtures, First law analysis of reacting systems, enthalpy of formation and heat of reaction, stoichometric and equivalence ratio, adiabatic flame temperature.	7	15
II	Second law of thermodynamics and concept of chemical equilibrium, Gibbs free energy and the equilibrium constant of a chemical reaction (VantHofts equation). Calculation of equilibrium Composition of a chemical reaction.	8	15
First Internal Examination			
III	**Chemistry of Combustion:** Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.	5	15
	Physics of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.	5	
IV	**Premixed Flame:** One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame.	8	15
Second Internal Examination			
V	**Diffusion Flame:** Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion.	7	20
VI	**Combustion and Environment:** Atmosphere, Chemical Emission from combustion, Quantification of emission, Emission control methods.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6313	**REFRIGERATION ENGINEERING**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of principles of refrigeration, basic thermodynamics, at UG Level.

Course Objectives

The course is designed to provide a strong background in the concept of refrigeration. Sound

knowledge in vapour compression and vapour absorption system and operations

Syllabus

Vapour Compression refrigeration systems, multi stage refrigeration systems, Cascade systems, Sorption refrigeration, Classification of sorption systems, Absorption and adsorption systems, Dry and wet types; Working principles of sorption refrigeration system, Low temperature refrigeration systems, Air cycle refrigeration, Other methods of refrigeration, Refrigerants, Environmental impact of refrigerants

Expected Outcomes

The students are expected to gain knowledge of advanced refrigeration, sorption refrigeration, and environmentally benign refrigerants. .`

References

1. C.P. Arora, *Refrigeration and Air conditioning,* Tata McGraw Hill, 2000.
2. Wilbert F. Stoecker, *Refrigeration and Air conditioning,* McGraw Hill, Inc 1982.
3. Roy. J Dossat, *Refrigeration and Air conditioning*
4. W.BGosney, Principles of Refrigeration, Cambridge University Press, 1982
5. K.E Herold, R. Radermacher and S. A. Klein, Absorption Chillers and Heat Pumps, CRC Press, 1996
6. Manohar Prasad, *Refrigeration and Air conditioning,* New Age 1999
7. Carriers Handbook system Design of Air

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	Recapitulation of Thermodynamics, Thermodynamics process pertaining to refrigeration and air conditioning. First and Second law applied to refrigerating machines, Carnot principles, COP, EER,Reverse Carnot Cycle, Different methods of refrigeration,	6	15
II	Refrigerants - Classification-designation of refrigerants - selection criterion – Thermodynamic requirements - Chemical-physical requirements - Secondary refrigerants –Environmental impact of Refrigerants Global warming, Ozone depletion, Alternate refrigerants, future refrigerants	8	15
III	Vapour compression systems - Limitations of reversed Carnot cycle with vapour as refrigerant –Vapour compression cycle - Enthalpy pressure diagrams - Suction cycle for maximum COP - Effect of operating conditions - Effect of evaporator pressure - Condenser pressure-suction vapour superheat - Liquid sub cooling -using liquid vapour regenerative heat exchanger - Actual vapour compression system - Complete vapour compression system.	9	15
First Internal Examination			
IV	Advanced vapor compression systems, multi pressure systems, Flash gas removal, Two evaporator and one compressor systems. One evaporator and two compressor systems, other combinations of compressors, evaporators and condensers, Low temperature refrigeration, cascade systems.	8	15
Second Internal Examination			

V	Thermal compression against mechanical compression – Vapour absorption refrigeration systems -Maximum COP - Common refrigerant absorbent systems - Modification to simple vapour absorption systems - Using liquid-liquid heat exchanger - Using analyzer - Actual vapour absorption systems – and its representation on enthalpy composition diagram - Absorption system calculations - Lithium bromide water systems- Triple Fluid systems	9	20
VI	Air Refrigeration Systems: Thermodynamic processes, priority criteria and suitability of air refrigeration system. Types of Air refrigeration system. Lubrication in refrigeration system - Non conventional refrigeration systems – Thermo electric - Pulse tube - Vortex tube refrigeration systems - Ejector compression systems	8	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6415	**HYDRAULIC, PNEUMATIC AND FLUID CONTROLS**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of hydraulics, pneumatics and various fluid control devices in UG level.

Course Objectives

By completing this module, the student should be able to:

- Understand the main components of the hydraulic and pneumatic systems
- Design and understand the electro-hydraulic and electro-pneumatic circuits.
- Design hydraulic and pneumatic circuits.
- Classify various fluidic devices and their area of application.

Syllabus

Introduction to hydraulic/pneumatic devices-Types of hydraulic motors and their characteristics-Hydraulic valves:-JIC symbols of hydraulic/pneumatic components-Typical hydraulic circuits-Design of hydraulic/pneumatic equipment/circuit- Drawing the circuit using standard symbols-Fluidics: Introduction to fluidic devices

Expected Outcomes:

Students will be able to:

Define various concepts of hydraulics. Classify the accessories use in hydraulic system. Identify various valves and auxiliaries. Rectify the problems; Describe the constructional details of pumps and motors. Classify the hydraulic circuits. Develop Hydraulic Circuits. Identify various components of pneumatic system. Differentiate pneumatic and hydraulic system. Ability to identify or predict the flow regime in a given engineering system based on consideration of the governing groups.

References

1. Pippenger , John J &Koff Richard M: Fluid Power Controls

2. Pippenger , John J &Hicks,Tyler G: Industrial Hydraulics
3. Kirshner, Joseph M: Fluid Amplifiers
4. Kirshner, Joseph M & Silas Katz: Design Theory of Fluidic components
5. Dr. Heinz Zoebl, Techn: Fundamentals of Hydraulic circuitry

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction :** Introduction to hydraulic/pneumatic devices, their applications and characteristics, comparison of electric, hydraulic and pneumatic devices. Pumps and motors: principles of working, range of displacement and pressures. Fixed and variable discharge pumps, gear pumps, internal gear pump, serotor pump, vane pump/piston pump, axial piston pump, swash plate pump, bent-axis pump.	12	15
II	**Hydraulic devices and their accessories:** Types of hydraulic motors and their characteristics. Accessories: Hydraulic accumulators, intensifiers, filters, heater, cooler, tank.	6	15
	First Internal Examination		
III	**Types of hydraulic valves and their operation:** Hydraulic valves: Stop valve, non-return valve, relief valve, sequence valve, counter balance valve, pressure reducing valve, flow control valves, direction control valves, their principles of operations and applications. JIC symbols of hydraulic/pneumatic components. Properties of commonly used hydraulic fluids	8	15
IV	**Typical hydraulic circuits**: Examples of practical circuits like those used in machine tools, riveter, pneumatic hammer, hydraulic pressure, power steering.	6	15
	Second Internal Examination		
V	**Designing parameters:** Design of hydraulic/pneumatic equipment/circuit to fulfil a given set of requirements like a sequence of operations, load conditions, speed of operation etc. Specifying the components and their rating. Drawing the circuit using standard symbols.	6	20
VI	**Introduction to fluidics:** Introduction to fluidic devices, principle of working of common fluidic devices like wall attachment devices, proportional amplifiers, turbulent amplifiers, fluidic logic devices. Examples of applications of fluidic devices like edge control of steel plate in rolling mills, tension control.	10	20
	Cluster Level End Semester Examination		

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6317	THERMAL ENVIRONMENTAL ENGINEERING	3-1-0: 4	2015

Course Prerequisites

Basic knowledge of Thermodynamics, Refrigeration, Heat transfer at UG/PG Level.

Course Objectives

The course is designed to provide students a strong background in the Air conditioning practices, theory ,basic principles and design of air conditioning systems.

Syllabus

Air conditioning -Properties of air- Applied psychrometry- Estimation of Air Conditioning Load- Summer Air Conditioning Processes-Winter Air Conditioning Processes-Air Distribution-Air duct design- Air Handling Equipments- Air Conditioning Systems.

Expected Outcomes

This course will provide a gist of the theory behind the Air conditioning and will emphasize direct applications of theory to design of an Air conditioning system. The students are expected to apply the general principles of psychrometry and applied psychometrics in Air conditioning with a knowledge of load estimation,equipment selection, duct design etc.

References

1. Threlkeld, J. L., Thermal Environmental Engineering, Second Edition, Prentice Hall, 1970.
2. Norman C. Harris, N. C., Modern Air Conditioning Practice, Third edition, McGraw-Hill, 1985.
3. Levenhagen, J. L., Spethmann, D. H., Heating Ventilating and Air conditioning Controls and Systems, McGraw Hill1993.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Air conditioning:** Introduction-physiological basis for air conditioning-classification of air conditioning systems-Air conditioning system components.	3	15
	Properties of air: Applied psychrometry - Psychrometric chart- Thermal comfort, effective temperature, comfort chart – Inside design condition, ventilation standards	5	
II	**Estimation of Air Conditioning Loads:** Summer and Winter air conditioning load-load classification- heating and cooling; heat gain/loss through glass, heat gain/loss through structures, internal load, ventilation load, and infiltration load.	8	15
	First Internal Examination		
III	**Summer Air Conditioning Processes:** Room sensible factor, coil sensible factor-ADP-Summer Air Conditioning process.	8	15
IV	**Winter Air Conditioning Processes.**	8	15
	Second Internal Examination		
V	**Air Distribution:** Room air distribution, air diffusion equipments, friction losses and dynamic loss in ducts	4	20
	Air duct design: Ducts-types-fittings-methods of sizing.	5	

VI	**Air Handling Equipments:** Fans – types, performance, and selection; air conditioning apparatus, cooling dehumidifying, humidifying heating and cleaning equipments.	4	20
	Air Conditioning Systems: DX system, all water system, all air system, air water system, central and unitary systems, fan coil system; automatic controls of air conditioning systems, thermostats, dampers, and damper motors; automatic valves piping design- water piping, refrigerant piping, steam piping.	5	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6319	SOLAR THERMAL ENGINEERING	3-0-0: 3	2015

Course Prerequisites

Basic knowledge of solar energy, thermal engineering at UG/PG Level.

Course Objectives

The course is designed to provide students a strong background in the concept of solar engineering, solar energy and alternative energy

Syllabus

Introduction, sun and its energy, solar radiation and its measurement, collection of solar energy, solar ait heater, thermal energy storage, passive solar house, energy storage, latent heat storage.

Expected Outcomes

The students are expected to apply the general principles of solar thermal engineering to design solar energy harnessing devices and make professionals in power and energy industry fields

References

1. F Kreith and J F Kreider: Principles of Solar thermal Engg.
2. J A Diffie and W A Beckman: Solar Engineering of Thermal processes
3. A B Meinel and F P Meinel: Applied Solar Engineering
4. S P Sukhatme: Solar Energy
5. Tiwari, G.N. and SayestaSuneja., Solar Thermal engineering Systems, Narosa Publishing House.
6. Duffie and Backuran, Solar Thermal Engineering.
7. H.P. Gupta.,Solar Engineering

Module	Content	Hours	Semester Exam Marks (%)
I	**Sun and it's Energy**: Solar spectrum, solar constant & solar radiations, Sun earth angles, solar hourly radiations-Radiations on Horizontal and inclined surfaces.,	12	15

II	**Solar radiation**- solar radiation data, solar radiation geometry, empirical equations for predicting solar radiation, solar radiation on tilted surfaces, Measurement of Solar Radiation: Pyrheliometer, Pyranometer, Sunshine- Recorder.	8	15
First Internal Examination			
III	**Collection of Solar Energy** : Flat plate collectors, classification, construction, heat transfer coefficients, optimisation of heat losses - Analysis of flat plate collectors, testing of collectors	6	15
IV	**Solar Air Heater** : Description & classification, conventional air heater, air heater above the collector surface air heaters with flow on both sides of absorbers to pan air heater, air heater with finned absorbers, porous absorber	6	15
Second Internal Examination			
V	**Thermal energy storage**- sensible heat storage, latent heat storage , thermochemical storage. Solar Water heater: Collection cum storage water heater, Natural circulation & forced circulation water heater, shallow solar ponds. Solar Concentrators: Classification, characteristic parameters, types of concentrators materials in concentrators.	6	20
VI	**Passive Solar House**: Thermal gain, Thermal cooling, Ventilation. **Energy Storage**: Sensible heat storage, Liquid, Solid, packed bed, **Latent heat storage**. Solar Distillation, Solar Cookers, Solar Refrigeration	10	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6321	**BOUNDARY LAYER THEORY AND TURBULENCE**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of fluid mechanics, boundary layer at UG/PG Level.

Course Objectives

- To impart knowledge on the governing equations of boundary layer flow.
- To impart knowledge on the Laminar and turbulence flow Boundary Layer Equations
- To understand the theory of turbulent flow and its modeling, structure types and a detailed insight
  about turbulence..

Syllabus

Fundamentals Boundary layer theory, Laminar and turbulent boundary layers, boundary layer separation, turbulence and turbulence models, Statistical Theory of Turbulence, Turbulent flows

Expected Outcomes

On successful completion of this course the student will be able to apply the fundamental concepts related to viscous flows in general, and to boundary layer flows ,apply the concepts of boundarylayer theory and turbulence..

References

1. G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling, Narosa Publishing House, 2002.
2. H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer 2000.
3. R.J. Garde, Turbulent Flow, New Age International (p) Limited, Publishers, 2000.

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Fundamentals Boundary layer theory**-Boundary Layer Concept, Laminar Boundary Layer on a Flat Plate at zero incidences, Turbulent Boundary Layer on a Flat plate at zero incidence,Fully Developed Turbulent Flow in a pipe, Boundary Layer on an airfoil,	10	15
II	**Boundary Layer separation.**	6	15
	First Internal Examination		
III	**Turbulent Boundary layers**Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Law of the wall – Friction law – Fully developed Internal flows – Chennel Flow, Couettee – Poiseuille flows, Pipe Flow	8	15
IV	**Turbulence and Turbulence Models:** Nature of turbulence – Averaging Procedures – Characteristics of Turbulent Flows – Types of Turbulent Flows – Scales of Turbulence, Prandtl's Mixing length, Two-Equation Models, Low – Reynolds – Number Models, Large – Eddy Simulation.	8	15
	Second Internal Examination		
V	**Statistical Theory of Turbulence**: Ensemble Average – Isotropic Turbulence and Homogeneous Turbulence – Kinematics of Isotropic Turbulence – Taylor's Hypothesis – Dynamics of Isotropic Turbulence – Grid Turbulence and decay – Turbulence in Stirred Tanks.	8	20
VI	**Turbulent flows** Wall Turbulent shear flows – Structure of wall flow – Turbulence characteristics of Boundary layer – Free Turbulence shear flows – Jets and wakes – Plane and axi - symmetric flows.	8	20
	Cluster Level End Semester Examination		

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10GN6001	RESEARCH METHODOLOGY	0-2-0: 2	2015

Course Prerequisites

(1) Basic skill of analyzing data earned through the project work at UG level;
(2) Basic knowledge in technical writing and communication skills earned through seminar at UG level.

Course Objectives

(1) To understand the methodology of doing research;
(2) To develop skills related to professional communication and technical report writing.
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

Syllabus

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

Expected Outcomes

The students are expected to :
(1) Be motivated for research through the attainment of a perspective of research methodology;
(2) Analyze and evaluate research works and to formulate a research problem to pursue research;
(3) Develop skills related to professional communication, technical report writing and publishing papers.

References

1. C.R Kothari, *Research Methodology : Methods & Techniques*, New Age International Publishers
2. R. Panneerselvam, *Research Methodology*, Prentice Hall of India, New Delhi, 2012.
3. K. N. Krishnaswamy, AppaIyerSivakumar, and M. Mathirajan, *Management Research Methodology, Integration of Principles*, Pearson Education.
4. Deepak Chawla, and MeenaSondhi, *Research Methodology – Concepts & Cases,* Vikas Publishing House.
5. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
6. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
7. Willktnsion K. L, Bhandarkar P. L, *Formulation of Hypothesis*, Himalaya Publication.
8. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
9. Ranjit Kumar, *Research Methodology : A step by step guide for beginners,* Pearson Education.

10. Donald Cooper, *Business Research Methods*, Tata McGraw Hill, New Delhi.
11. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co
12. Day R A, *How to Write and Publish a Scientific Paper,* Cambridge University Press, 1989
13. Coley S M and Scheinberg C A, *Proposal Writing,* 1990, Newbury Sage Publications.
14. Sople, *Managing Intellectual Property: The Strategic Imperative*, Prentice Hall of India, New Delhi, 2012
15. Manna, Chakraborti, *Values and Ethics in Business Profession*, Prentice Hall of India, New Delhi, 2012.
16. Vesilind, *Engineering, Ethics and the Environment*, Cambridge University Press.
17. Wadehra, B.L. *Law relating to patents, trademarks, copyright designs and geographical indications,* Universal Law Publishing

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**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.	5	15
II	**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	15
First Internal Examination			
III	**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, preparation for presentation in seminars and conferences.	4	15
IV	**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 (IPR), patenting case studies.	5	15
Second Internal Examination			
V	**Research Methods - Modeling and Simulation**: Modeling and simulation, concepts of modeling, mathematical modeling,	5	20

	composite modeling, modeling with ordinary differential equations, partial differential equations (PDE), graphs, heuristics and heuristic optimization, simulation modeling.		
VI	**Research Methods - Measurement, Sampling and Data Acquisition** : 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	20

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6409	**SEMINAR-I**	**0-0-2: 2**	**2015**

Course Prerequisites: None

Course Objectives

- Increasing the breadth of knowledge
- Enhancing the ability of self-study
- Improving presentation and communication skills
- Augmenting the skill of Technical Report Writing..

Syllabus

The student is expected to present a seminar in one of the current topics in the field of specialization and related areas. Students have to register for the seminar and select a topic in consultation with any faculty member offering courses for the programme. Students are required to prepare a seminar report in the prescribed format given by the Department. The seminar shall be of 30minutes duration and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

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

- Identify and choose appropriate topic of relevance.
- Assimilate literature on technical articles of specified topic and develop comprehension.
- Prepare technical report.
- Design, develop and deliver presentation on specified technical topic.

Evaluation

Shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee and The student shall submit typed copy of the paper to the Department. Grades will be awarded on the basis of contents of the paper and the presentation

1. Evaluation by the supervisor/s : 30 %
2. Presentation & evaluation by the Committee: 40 %
3. Evaluation of the Report: 20%
4. Regular Attendance : 10 %

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6411	ENGINEERING SOFTWARE LAB	0-0-2: 1	2015

Course Prerequisites: None

Course Objectives

- To impart fundamental knowledge on using various analytical tools like fluent for engineering simulations
- To know various fields of engineeringwhere these tools can be effectively used to improve the output of a product
- To impart knowledge on how these tools are used in industries by solving some real time problems using these tools

List of Experiments

- Solving basic mathematical problems such as curve fitting, numerical differentiation and
- integration and numerical solution of differential equation using
- C/C++/FORTRAN/JAVA/MATLAB
- Modeling and analysis of Fluid dynamics and Heat transfer problems using software such as
- FLUENT / CFX / PHOENIX / ANSYS
- Solving governing equation of fluid flow and heat transfer using numerical methods (By
- using C/C++/FORTRAN/JAVA/MATLAB.

Expected Outcomes.

After completion if this course

- Student will be able to appreciate the utility of tools like fluent in solving real time problems and day to day problems
- Students will become versatile in using these tools for any engineering and real time applications
- Students will also acquire knowledge on utilizing these tools for a better project un their curriculum

SEMESTER 1I

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10ME6402	INTERNAL COMBUSTION ENGINE	3-0-0- 3	2015

Course Prerequisites

Basic knowledge of thermodynamics, thermochemistry, processes, pollution at UG/PG Level.

Course Objectives

The course helps the students to impart an awareness regarding the chemistry of fuel air mixtures and their combustion, how the combustion mechanism takes place in the engine cylinder of an IC engine. Also to convey information regarding various alternate fuels, their performances and engine emission and their control

Syllabus

Thermochemistry of Fuel-Air Mixtures – first & second laws of thermodynamics applied to Combustion- Properties of working fluids – Unburned Mixture Composition- Thermodynamic Relations for Engine Processes- Combustion in S.I. Engines-Combustion in C.I. Engines- Mixing Controlled Combustion- Pollutant formation in S.I. and C.I. Engines and its Control

Expected Outcomes

The students will be able to understand the basic concepts of fuel air mixing and combustion. They will be able to explore alternate fuels that are sustainable and emission free

References

1. Heywood J.B. , Internal Combustion Engine Fundamentals, McGraw Hill Book Co., 1989
2. Ferguson C.R. and Kirkpatrick A.T., Internal Combustion Engines, John Wiley & Sons Inc, 2001
3. Taylor C.F., The Internal Combustion Engine Theory & Practice, Vol I & II, The MIT Press, Cambridge, 1985
4. Obert E.F., Internal Combustion Engines & Air Pollution, Harper & Row Publication Inc., 1973
5. Chambell A.S., Thermodynamic Analysis of Combustion Engines, John Wiley & Sons Inc., 1986 Current Literature

Module	Content	Hours	Semester Exam Marks (%)
I	**Thermochemistry of Fuel**, Air Mixtures – Characterization of flames, Ideal Gas Model, Composition of Air & Fuels, **Combustion Stoichiometry** first & second laws of thermodynamics applied to Combustion, Chemical Equilibrium, Chemical Reaction rates.	8	15
II	**Properties of working fluids** – Unburned Mixture Composition, Burned and Unburned Mixture Charts, Relation between Unburned & Burned Mixture Charts, Transport Properties, Exhaust Gas Composition	8	15
First Internal Examination			

III	**Thermodynamic Relations for Engine Processes** - Cycle Analysis with Ideal Gas Working Fluid, Fuel – Air Cycle Analysis, Over Expanded Engine **Cycles**, Availability Analysis of Engine Processes, Comparison with Real Engine Cycles.	8	15
IV	**Combustion in IC Engines** Combustion in S.I.Engines – Essential Features, Thermodynamic Analysis, Flame Structure & Speed, Cyclic Variations in Combustion, Partial Burning & Misfire, Spark Ignition, Abnormal Combustion – Knock & Surface Ignition, S.I. Engine Combustion Chamber Design. Combustion in C.I. Engines – Essential Features, Types of Diesel Combustion Systems	10	15
Second Internal Examination			
V	Phenomenological Model, Analysis of Cylinder Pressure Data, Fuel Spray Behaviour, Ignition delay, Mixing Controlled Combustion, Variables that affect C.I. Engine Performance. I.C.Engine Fuels –conventional and alternative fuels, characteristics, fuel rating. Supercharging & Turbocharging – Performance of 2 stroke & 4 stroke S.I. & C.I. Engines	8	20
VI	**Pollutant formation in S.I. and C.I. Engines and its Control** – Pollutants – NOx, CO, Unburned HC, Particulate Emissions, Exhaust Gas Treatment – Thermal & catalytic Converters, Particulate Traps, Emission Standards & Instrumentation to measure Pollution	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10ME6404	**ADVANCED POWERPLANT ENGINEERING**	**3-0-0-3**	**2015**

Course Prerequisites

Fundamentals of thermodynamics, knowledge of thermodynamic cycles, Heat exchangers and gas turbine UG Level.

Course Objectives

- To make the students to understand the energy scenario and the environmental issues related to the power plants
- Creating awareness to the students on the various utilities in the power plants and the avenues for optimizing them.

Syllabus

Introduction to engineering seismology, General Principles of seismic design, Static and Dynamic analysis, Design spectrums, Building Configurations, Reduction of Earthquake effects, Behaivour

of Masonry Buildings and RC buildings to earthquake, Ductile detailing for seismic design, Irregularities in buildings, Base Isolation technique, Seismic dampers.

Expected Outcomes

On successful completion this course a student gets a sound knowledge in

- Indian Power sector
- Different types of power plant
- Environmental Impact of power plants

References

1. M.M.EI Wakil : Power Plant Technology, Tata McGraw-Hill
2. Nag: Power Plant Engineering, Tata McGraw-Hill
3. Vapat&Scrotski : Power station Engineering and Economy, Tata McGraw-Hill
4. Nagpal : Power Plant Engineering, Khanna Publications
5. R K Rajput : Power Plant Engineering, Laxmi Publications

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to power plants** ,Overview of the Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection	6	10
II	**Steam Power plants**, Rankine Cycle – Performance – thermodynamic analysis of cycles. Cycle improvements. Superheaters, reheaters – condenser and feed water heaters – operation and performance – layouts..	10	20
	First Internal Examination		
III	**Gas turbines**– optimization – thermodynamic analysis of cycles – cycle improvements – multi spool arrangement. Intercoolers, reheaters, regenerators – operation and performance – layouts	8	20
IV	Binary and combined cycle – coupled cycles – comparative analysis of combined heat and power cycles – IGCC – AFBC/PFBC cycles – Thermionic steam power plant. .	8	15
	Second Internal Examination		
V	**Overview of Nuclear power plants** – radioactivity – fission process – reaction rates – diffusion theory, elastic scattering and slowing down – criticality calculations – critical heat flux – power reactors – nuclear safety. MHD and MHD – steam power plants.	8	20
VI	**Environmental impacts and its control**-Air and water pollution – acid rains – thermal pollution – radioactive pollution – standardization – methods of control. Environmental legislations / Government policies. Economics of power plants.	8	15
	Cluster Level End Semester Examination		

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6306	MEASUREMENTS IN THERMAL ENGINEERING	3-0-0: 3	2015

Course Prerequisites

Basic knowledge of mechanical measurements at UG Level.

Course Objectives

To enhance the knowledge of the students about various measuring instruments, techniques and importance of error and uncertainty analysis.

Syllabus

Generalized configuration and functional description of measuring instruments, generalized performancecharacteristics of instruments - static characteristics, dynamic characteristics, Uncertainty analysis, pressuremeasurement, flow measurement, temperature and heat flux measurement,Thermal Analysis Techniques, Data Acquisition and Processing.

Expected Outcomes

After the completion of the course, one should be able to understand the flow properties and basic principles related to measuring systems, measurement uncertainty, signal conditioning and analysis, background for optical experimentation, fluid mechanical apparatus, measurement of flow pressure, measurement of flow rate, flow visualization techniques, measurement of local flow velocity, measurement of temperature.

References

1. J P Holman : Experimental methods for Engineers
2. Ernest O Doeblin : Measurement Systems - Application & Design
3. Donald P Eckman : Industrial Instrumentation
4. Willard, Mertt, Dean,Settle : Instrumental Methods of analysis
5. D. Patranabis : Principles of Industrial Instrumentation
6. Beckwith & Buck : Mechanical Measurements
7. Nakra&Chaudary : Industrial Instrumentation
8. Physical Measurements in Gas Dynamics and Combustion : High Speed Aerodynamics and JetPropulsion Vol. IX

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Characteristics of Measurement Systems** - Elements of Measuring Instruments Performancecharacteristics - static and dynamic characteristics.	6	15
	Analysis of experimental data - Causes andtypes of experimental errors - Error & uncertainty analysis- statistical & graphical methods -probability distributions.	6	15
II	**Temperature measurements** -Theory, Thermal expansion methods, Thermoelectric sensors, Resistancethermometry, Junction semiconductor sensors, Pyrometry, Temperature measuring problems in flowingfluids, Dynamic Response & Dynamic compensation of Temperature sensors.Heat Flux measurements	8	15

First Internal Examination			
III	**Fluid pressure measurement** - Mechanical & Electrical types, High pressure & Low pressure measurements, Differential Pressure Transmitters.	6	15
IV	**Laminar & Turbulent flow measurements** - Determination of Reynolds stresses – Flow visualization techniques - Gross Volume flow measurements - Measurement of Liquid level, Density, Viscosity, Humidity & Moisture, Compressible flow measurements.	6	15
Second Internal Examination			
V	**Thermal Analysis Techniques** - Measurements in combustion: Species concentration, Reaction rates, Flame visualization, charged species diagnostics, Particulate size measurements.	6	20
VI	**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	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6114	**SOFT COMPUTING TECHNIQUES**	**3-0-0 : 3**	**2015**

Course Prerequisites

Basic knowledge of operations research and computer programming.

Course Objectives

To understand and appreciate the application of various soft computing techniques in engineering systems.

Syllabus

Combinatorial optimization – Evolutionary methods – Genetic algorithm – single and multi-objective applications -Simulated annealing-Fuzzy logic – Artificial neural networks.

Expected Outcomes

On successful completion of the course, the students are expected to solve combinatorial optimisation problems using the following tools-

- Genetic Algorithm for single objective and multiobjective optimisation
- Simulated Annealing
- Fuzzy Logic
- Artificial Neural Network

References

1. Deb, Kalyanmoy, *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd., 2012.
2. Deb, Kalyanmoy, *Multi-objective optimization using evolutionary algorithms*. John Wiley

& Sons, 2001.
3. Goldberg, D.E., *Genetic Algorithms in Search, Optimization, and Machine Learning*, Addison-Wesley, 1989.
4. Schalkoff ,R.J., *Artificial Neural Networks*, McGraw-Hill Companies Inc., 1997.
5. Sundareswaran, K.*, A Learner's Guide to Fuzzy Logic Systems*, Jaico Publishing House, 2005.
6. Yegnanarayanan, B., *Artificial Neural Networks*, Prentice Hall of India, 1999

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to combinatorial optimization – Meta heuristics- Genetic algorithm -Terminology of GA – Strings - Coding - Fitness function - GA operators - Algorithm	8	15
II	Multi-objective genetic algorithm – Weighted sum approach – Algorithm for non-dominated solutions – Diversity preserving mechanism	8	15
First Internal Examination			
III	Simulated Annealing: Introduction - Algorithm - Applications	6	15
IV	Fuzzy Logic: The concept of uncertainty and associated solutions - Fuzzy sets - Basic properties and characteristics of fuzzy sets - Fuzzy set operations - Fuzzy reasoning - Major components of a fuzzy logic system - Design aspects of fuzzy systems - Applications of fuzzy logic	10	15
Second Internal Examination			
V	Artificial Neural Networks (ANN): Characteristics of ANN - Terminology -Models of neuron – Topology - Basic learning laws - Overview of neural computing - Neural approaches to computing - Engineering approaches to computing	8	20
VI	ANN's learning approches - Training set and test set - Generalization - Learning curves - Applications of ANN in optimization - Simple examples	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6116	DESIGN OF EXPERIMENTS	3-0-0 : 3	2015

Prerequisites
Fundamentals of statistics at the UG level

Objectives
This course exposes the students to the basic statistical concepts, sampling techniques, principles and applications of Design of Experiments.

Syllabus

History of design of experiment; strategy, principle and application of DOE-A rationale for randomization Restricted randomization- Testing significance of effects in a 2^k factorial experiment-Developing a mathematical model - Experiments with single factorial design and application of ANOVA- 2k and 3k factorial design

Expected Outcomes

On completion of this course, the students will able to

- Conduct the experiments using factorial designs.
- Get the basic idea of Factorial design, 2k and 3k factorial design; blocking and confounding techniques in 2k factorial design.
- Get familiarized with the purpose of randomization.
- Interpret experimental results

References

1. Lawson, J. & Erjavec, J., "Modern Statistics for Engineering and Quality Improvement ", Thomson Duxbury, Indian EPZ edition
2. Nibtginertm Diygkas C, "Design and Analysis of Experiments". Fifth ed,-John Wiley & Sons
3. Box, George E P, Hunter William G, Hunter Sturat J : "Statistics for Experimenters" John Wiley & Sons
4. Douglas C. Montgomery, "Design and Analysis of Experiments", 8th Edition, , John Wiley

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	History of design of experiment; strategy, principle and application of DOE; basic statistical concepts, sampling techniques and distributions; inferences about means and standard deviations and considerations of different hypothesis; Experiments with single factorial design and application of ANOVA; randomized blocking and Latin squares.	6	15
II	An Introduction to Design of Experiments; The problem of interpreting experimental results; The purpose of randomization; A rationale for randomization, Restricted randomization.	6	15
First Internal Examination			
III	Hypothesis Testing rationale; Comparing two methods experimentally; Introduction to Factorial Experiments and DOE Terminology; Yate's algorithm for calculation of effects in a 2^k design; Testing significance of effects in a 2^k factorial experiment; Normal Probability Plot on ordinary graph paper.	8	15
IV	Developing a mathematical model; Residual Analysis, testing for model adequacy; Finding the Alias Structure of a Fractional Factorial; strategy, principle and application of DOE; basic statistical concepts, sampling techniques and distributions	8	15
Second Internal Examination			
V	Inferences about means and standard deviations and considerations of different hypothesis; Factorial design, 2k and 3k factorial	8	20

	design; blocking and confounding techniques in 2k factorial design;		
VI	Concept of fractioning of factorial design; Response surface method; Introduction to robust design, robust parameter design for single response system; Experiments with non-normal data.	8	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6118	**MANAGEMENT INFORMATION SYSTEM**	**3-0-0 : 3**	**2015**

Course Prerequisite:
Basic knowledge on computer programming and management at UG level

Course Objective:
This course comprises an introduction to the foundations, technology and applications of Management Information Systems (MIS). It is intended to provide a critical understanding of the context within which IS professionals perform specific technical tasks.

Syllabus:
Introduction to Management Information Systems – Information Systems Development Life Cycle – System Requirements Specification documents – Data Flow Diagrams – Decision Tools and Models - Introduction to data structures and relational database – Modern Software Design Techniques - Introduction to Capability Maturity Model(CMM) and Quality Management in software organizations – Software Testing – Software Reliability - System implementation issues and solution procedures - Multimedia technology, Distributed data management, Data mining and warehousing

Expected Outcomes:
On completion of the course, the students are expected to have the ability to

- Understand the basic components of a management information systems
- Gather and document the system requirements
- Design and develop an Information System
- Test, Implement and maintain a management information system

Reference Books:

1. Burch and Gruditski, Information Systems-Theory and Practice, Fifth edition, John Wiley & Sons, New York, 1989.
2. Hawryszkiewycz, I.T., Introduction to Systems Analysis and Design, Prentice Hall of India, 1989.
3. Ian Sommerville, Software Engineering, 6th. Edition, Pearson Education Asia, 2001.
4. Lucas, Henry C., Analysis, Design, and Implementation of Information Systems, 4th Edition, McGraw Hill, New York, 1992.
5. O'Brien J.A., Management Information Systems, 4/e, Tata McGraw Hill, 1999

Course Plan			
Module	**Contents**	**Contract hours**	**Semester Exam marks %**
I	Management Information Systems- Building blocks in information systems-input, output, model, technology, database, and control blocks, System view of business and information system design forces, Information systems development life cycle, Information systems for strategic planning	8	15
II	System Investigation and requirements engineering, System requirements specification documents, Feasibility studies, System analysis and general system design, Charting tools in data base design, Data flow diagrams and E-R diagrams, Decision tools and models, Prototyping, Detailed system design, Form design, Code design, Database normalisation, Introduction to data structures and relational database.	8	15
First Internal Examination			
III	Modern software design techniques, Verification and validation methods, Performance of software systems, Software metric and models, Software standards, Introduction to Capability Maturity Model(CMM) and Quality Management in software organizations.	10	15
IV	Software testing, Review, walkthrough and inspection, Testing approaches, Software reliability, Errors, faults, repair and availability, Reliability and maintenance.	6	15
Second Internal Examination			
V	System implementation issues and solution procedures, training and post implementation audit, System fine-tuning, Monitoring and updating.	8	20
VI	Multimedia technology, Distributed data management, Data mining and warehousing, Security features in global information systems.	8	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6122	**QUALITY AND RELIABILITY ENGINEERING**	**3-0-0 : 3**	**2015**
Course Prerequisites Fundamental knowledge in probability theory and statistics is desirable.			
Course Objectives			

To learn in depth the quality and reliability aspects with emphasis on an industrial organizational environment.

Syllabus

Traditional Quality Control-Total Quality management-QMS-ISO9000 standards- Taguchi methods-Six sigma concepts- Design of experiments- Reliability- Total Productive Maintenance-Reliability management.

Expected Outcomes

After completing the course, the students will be able to

- Identify and describe various areas in the quality control and reliability engineering fields.
- Plan and design a quality control program in an industry/organization.
- Estimate the reliability of complex engineering systems
- Gain good understanding of the principles of total productive maintenance

References

1. Dale H; Besterfield, Total quality Mangement,Pearson Education Inc
2. Caplen, Practical Approach to Quality Control, Random House
3. O'Connor, Practical Reliability Engineering, John Wiley and Sons
4. Ryan, Statistical Methods for Quality Improvement, John Wiley and Sons
5. Ross, Taguchi Techniques for Quality Engineering, McGraw Hill Publishers
6. Douglas C. Montgomery. Design and Analysis of Experiments, John Wiley and Sons
7. Balaguruswami E. , Reliability Engineering, Tata Mc Graw Hill Publishing Co. Pvt Ltd

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Basic concepts and definition, Traditional Quality Control,Total Quality management, Deming's principles, Customer focus, Employee involvement, Continuous process improvement, PDCA cycle	8	15
II	Seven step process, Kaizen, Quality measurements, Quality costs, QFD, QMS-ISO9000 standards-requirements and documentation, Taguchi methods, quality loss function, Parameter design and Tolerance design concepts	8	15
	First Internal Examination		
III	Six sigma concepts –define and measure phase, flow charting, basic tools, probability and hazard plotting, Six sigma measurements, basic control charts and process performance matrices, Measurement systems analysis.	8	15
IV	Design of experiments-basics, single factor, two factor experiments. ANOVA, Taguchi approach to design of experiments, orthogonal arrays, Signal to noise ratio, RSM-concepts and methods.	8	15
	Second Internal Examination		
V	Fundamental aspects of reliability, Reliability mathematics, Reliability testing and evaluation methods. FMEA, Failure data analysis.	8	20

VI	Total Productive Maintenance, maintainability and Availability Concepts, Reliability management.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6124	**PROJECT ENGINEERING AND MANAGEMENT**	**3-0-0 : 3**	**2015**

Course Prerequisites
Basic knowledge of Industrial Engineering or Management at the UG Level

Course Objectives
This course examines project management in theory and practice and the roles and responsibilities of the project manager. The course offers a practical approach to managing projects, focusing on organizing, planning, and controlling the efforts of the project.

Syllabus
Overview of Project Management - Project Management Concepts and Techniques - Project Cost Estimation - Project Planning and Scheduling- Resource Constrained Scheduling - Project Monitoring and Control - Management of Special Projects.

Expected Outcomes
On completion of the course, the students are expected to have

- A thorough understanding of the principles of project management;
- The ability to lead a project team;
- The ability to accomplish projects on schedule without cost and time overruns;
- The knowledge on the procedure for implementing big and special projects.

Reference Books

1. Shtub, Bard and Globerson Project Management: Processes, Methodologies, and Economics, 2/E, Prentice Hall Inc, 2005.
2. Lock, Project Management Handbook, Gover Publishing Ltd, 1981.
3. Cleland and King, Project Management Handbook 2nd Edition, Wiley, 1988.
4. Wiest and Levy, A Management Guide to PERT/CPM Prentice Hall of India New Delhi.
5. Horald Kerzner, Project Management: A Systemic Approach to Planning, Scheduling and Controlling, CBS Publishers, 2002.
6. S. Choudhury, Project Scheduling and Monitoring in Practice, South Asian Publishers, Delhi, 1983.

Course Plan

Module	Content	Contract hours	Semester Exam Marks %
I	Introduction to Project management, Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing	6	15

	Project organization, role of Project Manager-.		
II	Project screening and Selection Techniques - Structuring concepts and Tools - Work Breakdown Structure, Organisation Breakdown Structure, and Linear Responsibility Chart - Project Planning Tools- Bar charts, Line of Balance – Critical Path Method, and Project Evaluation and Review Technique- Risk Analysis and Management	10	15
First Internal Examination			
III	Types of Estimates and Estimating Methods- Capital Cost Estimation - Project Budgeting - Project cash flow analysis	6	15
IV	Project Scheduling with Resource Constraints- Resource Leveling- Resource constrained scheduling with multiple resources- linear programming formulation – Introduction to staff scheduling and rostering	10	15
Second Internal Examination			
V	Monitoring Techniques and time control System- Project Cost Control -Time cost Tradeoff procedure, lowest cost schedule- Computer applications in project management	8	20
VI	Management of Software Engineering Projects, New Product Development Projects, R&D Projects and Large Scale Construction Projects -Case Studies	8	20
End Semester Cluster Level Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6326	**DESIGN OF HEAT TRANSFER EQUIPMENTS**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of Heat transfer, Thermodynamics, Psychrometry, Material science and Manufacturing process at UG/PG Level.

Course Objectives

The course is designed to provide a complete design knowledge of various heat transfer equipments which are invariably used in most of the chemical process industries.

Syllabus

Thermal performance analysis of heat exchangers - Design calculation of double pipe heat exchanger, LMTD ,NTU and P-NTU Methods; Shell and tube heat exchangers- classification of shell and tube exchangers-The Circulating Water System-Introduction-System Classification-Wet Cooling Towers-Dry cooling towers- Heat Pipes Types and Applications-Capillary Limitation and Temperature Characteristics - Sonic, Entrainment, and Boiling Limitations- Heat pipe design – Fluid, Wick and Material Selection- Heat Pipe Design Procedure-Design Problems.

Expected Outcomes

This subject exposes students to the practical applications of the fundamental laws using Thermodynamics, Heat transfer, Material sciences and Manufacturing processes. This course will provide a gist of the theory behind the heat transfer equipments and will emphasize direct

applications of theory to design.

References

1. R K Shah, *Fundamentals of Heat Exchanger Design*, John Wiley & Sons.
2. Chi, S. W., *Heat Pipe Theory and Practice- A Source Book*, McGraw-Hill, 1976
3. Reay, D.A., Kew, P.A., *Heat pipes*, fifth edition, Butterworth-Heinemann publications, 2006.
4. Fraas, A. P., *Heat Exchanger Design*, Second Edition, John Wiley & Sons, 1989.
5. Dunn, P. D. and Reay, D. A., *Heat Pipes*, Fourth Edition, Pergamon Press, 1994.
6. El Wakil., *Power Plant Technology*, McGraw Hill.
7. Das, S.K., Prosess heat transfer, Narosa publishing house.2005

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Heat Exchangers:** Meaning, Classification, Significance, Applications and Selection	4	15
	Thermal Performance Analysis of Heat Exchangers : compact, cross flow, liquid to gas, and double pipe heat exchangers, film coefficients for tubes and annuli, equivalent diameter of annuli, fouling factors, caloric or average fluid temperature, true temperature difference.	4	
II	**Design calculation of double pipe heat exchanger**: LMTD ,NTU and P-NTU Methods.	8	15
First Internal Examination			
III	**Shell and tube heat exchangers:** classification of shell and tube exchangers.	8	15
IV	**The Circulating Water System:** Introduction-System Classification-The Circulation System-Wet Cooling Towers-Wet Cooling Tower Calculations-Dry cooling towers.	8	15
Second Internal Examination			
V	**Heat Pipe Types and Applications:** Heat pipe invention and Operating principles-Working fluids-Wick structures-Control Techniques-Applications.	4	20
	Capillary Limitation and Temperature Characteristics: Pressure balance- Maximum capillary pressure-Liquid and Vapor pressure drops- Effective thermal conductivity of wick structures- Capillary limitation on heat transport capability-Heat Pipe Temperature Characteristics.	5	
VI	**Sonic, Entrainment and Boiling Limitations:** Introduction-Sonic Limitation-Entrainment Limitation-Boiling Limitation.	3	20
	Heat Pipe Design – Fluid selection- Wick selection- Material selection- Preliminary Design Considerations.	3	
	Heat Pipe Design Procedure: Introduction- Heat Pipe Diameter- Design of Heat Pipe Containers- Wick design-Entertainment and Boiling limitations-Design Problems.	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6328	RENEWABLE ENERGY SYSTEMS	3-0-0: 3	2015

Course Prerequisites

Basic knowledge of Solar energy, Biomass and other renewable energy UG Level.

Course Objectives

The course is designed

- To provide students a strong background in the concept of renewable energy such as solar energy, wind energy, biomass, etc.
- To develop ability for designing renewable/hybrid energy systems that meet specific energy demands, are economically feasible and have a minimal impact on the environment

Syllabus

Renewable energy sources in India, Solar energy, Utilization ,Measurement and collection, Thermal energy storage, Wind energy, Biofuels, Biogas production, Geothermal energy, OTEC, Tidal energy, Wave energy.

Expected Outcomes

The students are expected to understand the concept and application of renewable energy and usage.

References

1. G.D Rai :Non conventional Energy Sources. Khanna Publishers, New Delhi
2. S.P Sukhatme : Solar Energy. Tata McGraw Hill Publishing company Ltd, New Delhi
3. Godfrey Boyle : Renewable energy, Power for a sustainable future. Oxford University Press U.K
4. Twidell J W & Weir A : Renewable energy sources. 2nd edition,Taylor & Francis London, UK
5. Tiwary :Solar Energy: Fundamentals, Design, Modeling and Applications, . Narosa Publishing House, New Delhi
6. Ibrahim Dincer :Thermal Energy Storage: Systems and Applications, John Willey, UK.

Module	Content	Hours	Semester Exam Marks (%)
I	World energy use – Reserves of energy resources – Environmental aspects of energy utilisation – Renewable energy scenario in India – Potentials – Achievements – Applications	12	15
II	Solar energy, Measurement and collection flat plate collectors, concentrating collectors, solar ponds, photovoltaic conversion	8	15
	First Internal Examination		
III	Thermal Energy storage Thermal energy storage methods, Sensible heat storage, Latent energy storage, Phase change storage Case studies	6	15

IV	Wind energy, principle, potential and status, Wind characteristics, National wind atlas, Theory of wind turbine wind blades, Types of wind turbines, and charecteristics	6	15
Second Internal Examination			
V	Bio fuels Sources, potential, Properties and characterization, Bio gas generation through Aerobic and Anaeorobic digestion, Thermo-chemical methods biofuel utilisation, Combustion and gasification	6	20
VI	Tidal energy – Wave energy – Open and closed OTEC Cycles – Small hydro –Geothermal energy – Fuel cell systemsWind data and energy estimation – Types of wind energy systems – Performance – Details of wind turbine generator – Safety and Environmental Aspects. Biomass direct combustion – Biomass gasifier – Biogas plant – Ethanol production – Bio diesel – Cogeneration – Biomass applications	10	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME6432	**INDUSTRIAL REFRIGERATION SYSTEM**	**3-0-0: 3**	**2015**

Course Prerequisites

Should be able to evaluate thermodynamic and fluid parameters of refrigeration systems, Establish the thermodynamic parameters of refrigeration and air conditioning systems.

Course Objectives

- To understand the key issues in Industrial Refrigeration systems.
- To understand the operational features of compressors in large systems.
- To understand the operational features of Evaporators & Condensers in Industrial Refrigeration System.
- To understand the energy conservation aspects of Industrial Refrigeration System.

Syllabus

Introduction to industrial refrigeration, types of compressors and applications, evaporators and liquid circulation methods, lubricating oils and its properties, vessels in industrial refrigeration, energy conservation and design considerations.

Expected Outcomes

The students will be able to demonstrate knowledge of industrial refrigeration systems, investigate and select components for industrial refrigeration systems.

References

1. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998.
2. ASHRAE Hand Book: Fundamentals, 1997.
3. ASHRAE Hand Book: Refrigeration, 1998.

4. ASHRAE Hand Book: HVAC Systems and Equipment, 1996.
5. Transport properties of SUVA Refrigerants, Du-Pont Chemicals, 1993

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to industrial refrigeration** - difference from conventional system - applications - industrial and comfort air - conditioning - conditions for high COP.	6	15
II	**Industrial Compressors:** Reciprocating and screw compressor, Multistage industrial applications, cylinder arrangement, cool methods - oil injection and refrigeration injection, capacity regulations - Economizers.	10	15
First Internal Examination			
III	**Liquid circulation & feeding systems** Liquid circulation: Mechanical pumping and gas pumping - advantage and disadvantage of liquid re-circulation - circulation ratio - top feed and bottom feed refrigerant - Net Positive Suction Head (NPSH) - two pumping vessel system - suction risers – design - piping loses.	8	15
IV	**Industrial Condensers & Evaporators** Different Industrial Condensers arrangement, Evaporators-Types and arrangement, liquid circulation, type of feed, refrigerant piping design, functional aspects. Lubricating oil: types - physical properties, types of circulation and oil separator.	8	15
Second Internal Examination			
V	**Vessels in industrial refrigeration**: High pressure receiver - flash tank - liquid and vapour separator - separation enhancers - low pressure receivers - surge drum - surge line accumulator – thermo syphon receiver - oil pots.	8	20
VI	**Energy conservation & aspects:** Energy conservation and design considerations - source of losses - energy efficient components - heat reclaim - thermal storage: ice builder and ice harvester. Insulation: critical thickness - insulation cost and energy cost - vapor barriers – construction methods of refrigerated spaces	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6334	ADVANCED GAS DYNAMICS	3-0-0: 3	2015

Course Prerequisites

An introduction to undergraduate level thermodynamics and gas dynamics.

Course Objectives

- To understand the compressible flow fundamentals
- To study the compressible flow with friction and heat transfer.
- To know the application of normal shock & their governing equations.

Syllabus

Introduction to Shocks, Governing equations ,Generalized One-Dimensional Flow , Flow in Constant Area Duct , general principles and characteristics, interaction and reflection of shocks, Boundary layer flow ,various flow visualization techniques

Expected Outcomes

To distinguish between various flow regimes.
To analyse the flow under different flow conditions.
To assess the flow behavior and consequent loads due to flow.

References

1. E. Rathakrishnan, Gas Dynamics , Prentice-Hall of India, New Delhi, 2002.
2. M.A. Saad, Compressible Fluid Flow , Prentice-Hall, New Jersey, 1985.
3.A. H. Shapiro, The Dynamics and Thermodynamics of Compressible Fluid Flow (2 volumes),The Ronald Press, New York, 1953.
4. Pope, Wind Tunnel Design

Module	Content	Contact Hours	Semester Exam Marks (%)
I	**Supersonic Flow:** Normal Shocks - Governing equations, Rankine Huguenot, Prandtl and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent divergent nozzle with shocks, moving shock waves, shock problems in one dimensional supersonic diffuser, supersonic pitot tube.	12	15
II	**Flow in Constant Area Duct under different conditions:** Flow in Constant Area Duct with Friction: Governing equations, working formulas and tables, choking due to friction, performance of long ducts, Isothermal flow in long ducts. Flow in Constant Area Duct with Heating and Cooling: Governing equations, working formula and tables, choice of end states, choking effects, shock waves with changes in stagnation temperature.	8	15
First Internal Examination			
III	**Generalized One-Dimensional Flow:** Working equations, general method of solution, example of	6	15

	combined friction and area change, Example of combined friction and heat transfer. .		
IV	**Oblique shock:** Governing physical equations and general relations, shock polar diagram and auxiliary diagrams, strong and weak shocks, detached shock, interaction and reflection of shocks.	6	15
Second Internal Examination			
V	**Method of characteristics flows & its applications:** General principle of integration using method of characteristics, application to one dimensional isentropic progressive waves, application to steady two dimensional irrotational isentropic supersonic flows, Prandtl-Meyer expansion	6	20
VI	**Boundary layer flow and various flow techniques:** Boundary layer flow with Prandtl number unity and arbitrary Prandtl number, Integral equations of Laminar boundary layer, Differential and integral equations of Boundary layer, flow past a flat plate with turbulent Prandtl number of Unity. Elementary idea of boundary layer in tubes and in the presence of shock waves. Study of various flow visualization techniques. Study of different types of wind tunnels, their design criteria.	10	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10ME6436	**COMPUTATIONAL FLUID FLOW AND HEAT TRANSFER**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of Numerical methods, Fluid mechanics and Heat transfer.

Course Objectives:

- To study the mechanism of computational fluid dynamics and significance of computational fluid dynamics in engineering application.
- To impart knowledge in discretization approach of computational fluid dynamics and its influence on the computation result.
- Understand the numerical algorithm of computational fluid dynamics and its influence on the convergence of the computation

Syllabus

Basic equations of fluid dynamics and heat transfer, wave equations for stability, One dimensional steady state, Discretization , Finite volume method for diffusion and convection diffusion problems Algorithms, Higher order schemes.

Expected Outcomes

The students will be able to

- Understand the mechanism of computational fluid dynamics and significance of computational fluid dynamics in engineering application, such as turbine engineering and nuclear engineering.
- Understand the discretization approach of computational fluid dynamics and its influence on the computation result.
- Understand the numerical algorithm of computational fluid dynamics and its influence on the convergence of the computation.

References

1. Numerical Heat Transfer and Fluid Flow- S V Patankar
2. Computational Fluid Mechanics and Heat Transfer- D A Anderson, Tannehill J C &Pletcher.
3. Computational Fluid Dynamics in Practice-Rhodes
4. Muraleedhar, K. and Sundararajan, T. (eds.), Computational Fluid Flow and Heat Transfer, Second Edition, Narosa Publishing House, 2003.
5. Versteeg, H. K. and W. Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Addison Wesley – Longman, 1995

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction:** Basic equations of fluid dynamics and heat transfer-nature of terms-physical and mathematical classification- boundary and initial conditions-Taylor series representation finite difference approximation for space and time-forward, central and backward differences	8	15
II	Analysis of 1D heat and wave equations for stability- Courant-Friedrich-Lewy criterion-Laplace and Poisson's equations in curvilinear coordinates-Grid generation: Elliptical and hyperbolic grids.	8	15
	First Internal Examination		
III	**Numerical Heat Conduction:** One dimensional steady state problem-governing equation boundary condition(prescribed, convective and radiative). Method of solution: Gauss elimination, Gauss Seidel-Tridiagonal Matrix algorithm. Jacobi-over and under relaxation. Two dimensional steady state problem	8	15
IV	**Diffusion problems:** Method of solution-line by line method-Three dimensional problem-plane by plane method-transient 1D problem-Discretization: explicit, Crank-Nicholson and implicit methods-Two and Three dimensional transient conduction problems- grid independence test- axisymmetric problem-conduction through composite media-variable thermal conductivity-irregular geometries.	8	20

Second Internal Examination			
V	**Convective Heat Transfer:** Finite volume method for diffusion and convection diffusion problems- steady one dimensional convection and diffusion equation-upwind, hybrid and power-law schemes-Discretization equation for 1,2 and 3 dimensions- false diffusion calculation of flow field	6	15
VI	**Flow field calculation:** Algorithms for pressure velocity coupling- semi implicit method for pressure linked equation-its variants such as SIMPER, SIMPLEC and SIMPLEST. Higher order schemes-quick solution of 2D flow problems in rectangular and cylindrical coordinate systems-treatment for natural convection-Natural convective flow in rectangular and cylindrical enclosures- evaluation of Nusselt's number.	10	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L - T - P - Credits**	**Year of Introduction**
10ME6408	**MINI PROJECT**	**0 - 0 - 2 - 2**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Skills in hardware/software implementation techniques earned through UG studies.
(3) Seminar I

Course Objectives

(1) To support the problem based learning approach and to enhance the reading habit among students;
(2) To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 3rd& 4th semesters. The mini project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of mini project the student can suggest possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or hardware based one. Mini project is envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university

encourages *interdisciplinary projects* and *problem based learning strategy*. References cited shall be authentic.

Expected Outcomes

The students are expected to :

(1) Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution;

(2) Be motivated and successful in the selection of the topic for the main project.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Abstract Submission	2 Week	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME6412	**ADVANCED HEAT TRANSFER LAB**	**0-0-2: 1**	**2015**

Course Prerequisites: None

Course Objectives

- Practical training for conducting experiments related to advanced heat transfer.
- Applying scientific and engineering principles to analyze and design thermo fluid aspects of systems
- To investigate heat and mass transport phenomenon
- To Interpret results of investigations related to heat transfer, fluid flow and thermal design

List of Experiments

Experimental Analysis of Heat Transfer Problems – Use of Data Acquisition System.

Experiments shall include

i) Forced convection

ii) Natural convection

iii) Heat pipe heat transfer

iv) Drop wise / Film wise condensation

v) Extended surface heat transfer

vi) Shell and tube heat exchanger vii) Wall solar chimney
Expected Outcomes. After completion if this course • The students will have a deep and broad understanding of heat transfer and fluid flow
Assessment : i) Practical Records /outputs 40% ii) Regular Class Viva-Voce 20% iii) Final Test (Objective) 40%

SEMESTER 1II

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7305	CRYOGENIC ENGINEERING	3-0-0: 3	2015

Course Prerequisites

Basic knowledge of Thermodynamics, Heat Transfer, Fluid Flow and Mechanics of Solids at UG/PG Level.

Course Objectives

The course is designed to provide students an introduction to the engineering aspects and challenges of cryogenics, design and analysis of the systems used to produce, maintain and utilize low temperature.

Syllabus

Introduction to cryogenic systems- Low temperature properties of engineering materials- Gas liquefaction systems: Production of low temperatures- liquefaction system for gases other than Neon, hydrogen and helium- Liquefaction system for Neon, Hydrogen and Helium- Gas separation and purification system - Cryogenic Refrigeration systems- cryogenic fluid storage and transfer systems- storage vessels and insulation- Introduction to vacuum technology- Applications of Cryogenic Systems.

Expected Outcomes

The students are expected to apply the general principles of design and analysis of systems used to produce, maintain and utilize low temperature.

References

1. Cryogenic Systems – Randall Barron
2. Cryogenic Engineering- R.B.Scott
3. Cryogenic Engineering – J.H.Bell Jr.
4. Timmerhaus, K. D. and Flynn, T. M., Cryogenic Process Engineering, Plenum Press, 1989.
5. Vance, R. W. and Duke, W. M., Applied Cryogenic Engineering, John Wiley, 1962.
6. Sitting, M., Cryogenics, D' Van-Nostrand, 1963

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to Cryogenic Systems:** Historical development- Present areas involving cryogenic engineering.	3	15
	Low Temperature Properties of Engineering Materials: Mechanical properties-Thermal properties - Electric and magnetic properties-Properties of cryogenic fluids.	5	
II	**Gas Liquefaction Systems:** Introduction-System performance parameters- Thermodynamically ideal system-Production of low temperatures- Joule Thomson effect, Adiabatic expansion	3	15
	Liquefaction system for gases other than Neon, Hydrogen and Helium:simplelindehampson, precooled lindehampson,	5	

	linde dual pressure system-cascade system-claude system-kapitza system-heylandtz system-**Liquefaction system for Neon, Hydrogen and Helium:**precooledlindehampson system, claudesystemorthopara hydrogen conversion in the liquifier, collins helium liquifiersystem.		
First Internal Examination			
III	**Gas Separation and Purification:** Thermodynamically ideal separation system-principles of rectfication-Air seperationsystem:Linde single column and double column system.	8	15
IV	**Cryogenic Refrigeration Systems:** Ideal Refrigeration systems-Refrigerators using liquids and gases as refrigerants:Joule Thomson, cascade, expansin engine Refrigeration system-philips refrigerators-A.D.Little single volume and double volume refrigerator-Refrigerators using solids as working media:Magnetic refrigeration system.	8	15
Second Internal Examination			
V	**Cryogenic Fluid Storage and Transfer Systems:** Fluid storage vessels-Basic storage vessel-Inner vessel design-Outer vessel design-Suspension system-Safety devices.	4	20
	Insulation: Expanded foam-gas filled powder and fibrous-vacuum insulation-Evacuated powder and fibrous-o pacified powder and multilayer insulation-Comparison of insulation performance.	5	
VI	**Cryogenic Fluid Transfer Systems:**Uninsulated lines-porous insulated lines-Vacuum insulated lines-Two phase flow in cryogenic fluid transfer system-Cool down process.	3	20
	Introduction to Vacuum Technology in Cryogenics: Importance of vacuum technology in cryogenics-Calculation of pump down time-Cryo pumping.	3	
	Application of Cryogenic Systems: Superconductive devices, Cryogenics in Space technology, Bilogy and Medicine.	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7307	**DESIGN AND ANALYSIS OF TURBOMACHINES**	**3-0-0: 3**	**2015**

Course Prerequisites

Knowledge of Fluid Mechanics and machineries at UG/PG Level.

Course Objectives

To impart knowledge on various types of turbo machines and their operation, flow mechanism through the impeller, methods of their performance evaluation under various operation

conditions.

Syllabus

Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations, Centrifugal and axial flow compressors, configuration , working , velocity diagrams, Combustion and Combustion chamber, Axial and radial flow turbines, Gas turbines, Jet engine cycles

Expected Outcomes

By undergoing the course, one will be able to understand the working of various turbomachines under different operating conditions and will be able to design a system for the required output at the given conditions.

References

1. Ganesan, V., Gas Turbines, Tata McGrawHill, 2011.
2. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, DhanpatRai Publications, 2003
3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiely, 5th Edition 2001.
4. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction** Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations – area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachines - velocity diagrams. Euler's equation for turbomachines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and poly tropic	12	15
II	**Centrifugal and axial flow compressors** Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio. Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses	11	15
First Internal Examination			
III	**Combustion and Combustion chamber** Basics of combustion. Structure and working of combustion chamber – combustion chamber arrangements - flame stability – fuel injection nozzles. Flame stabilization - cooling of combustion chamber	7	15
IV	**Axial and radial flow turbines** Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients. Degree of reaction -	8	15

	stage temperature and pressure ratios – single and twin spool arrangements – performance. Matching of components. Blade Cooling. Radial flow turbines		
Second Internal Examination			
V	**Gas turbine** Gas turbine cycle analysis – simple and actual. Reheated, regenerative and intercooled cycles for power plants.	6	20
VI	**Jet engine cycles** Working of turbojet, turbofan, turboprop, ramjet, scramjet and pulsejet engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.	7	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME7309	**CONVECTION & TWO PHASE FLOW**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of thermodynamics, heat and mass transfer at UG/PG Level.

Course Objectives

The course aims at imparting theoretical knowledge about the physics of forced convection in wall bounded flows and two phase flow, and thereby, enable them to tackle two phase flow and forced convection heat transfer problems..

Syllabus

Differential equation of boundary layer, momentum, mass diffusion and energy, Convective hear transfer, Forced convection in turbulent flow, free convection, Methods of Analysis of flow patterns, Basic Flow Models:

Expected Outcomes

By the end of this course, students should be able to:

- Apply the principles of thermodynamics, fluid mechanics and heat transfer to analyze forced convective heat transfer and two phase flow problems.
- Develop analytical models and solution methods to solve practical engineering problems. Develop confidence to undertake challenging research problems and.
- Make them to work with practiced professional or researcher groups confident

References

1. H.Schlitching : Boundary Layer Theory
2. W M Kays& M E Crawford : Convective Heat and Mass Transfer
3. Eckert and Drake; Analysis of Heat and Mass Transfer
4. Bejan. A, Convective Heat Transfer

Module	Content	Hours	Semester Exam Marks (%)
I	**Convectionheat transfer Equations:** Conservation principles, differential equations of the boundary layer, Momentum, Mass diffusion and energy equations, simplified equations for velocity boundary layer and thermal boundary layer, integral equation of boundary layer, equations for turbulent boundary layer. Turbulent flow over a flat plate and a circular pipe universal velocity distribution	12	20
II	**Convective heat transfer**-Forced convection in laminar flow-flow inside smooth tubes-energy differential equations. Fully developed velocity and temperature profiles. Thermal entry length solutions for circular tubes-effect of axial variations of the surface temperature and heat flux-combined hydrodynamic and thermal entry length, the flat plate in Laminar flowsimilaritysolution-flow over bodies with boundary layer separation	10	15
First Internal Examination			
III	**Forced convection in Turbulent flow**. Analogy between momentum and heat transfer. Reynold's analogy, Karman-BoelteMartinelli analogy- circular tubes with fully developed flow, constant heat rate, modararePrandtl Numbers. The eddy diffusivity near the centre line of a pipe-Fully developed profiles with constant surface temperature-fully turbulent flow between parallel planes-Thermal entry length in circular tubes-Effect of axial variation of surface temperature and heat flux. Influence of surface roughness- The plane plate in longitudinal flow.	10	15
IV	**Free Convection:** Boundary layer equations-vertical semi infinite plate, constant and variable temperature, effect of wall suction and blowing and variable properties. Approximate Integral solutions for free convection, free convection flow regimes, free convection between heated plates, solution for other geometry, combined free and forced convection.	8	15
Second Internal Examination			
V	**Methods of Analysis of flow patterns** Vertical and horizontal channels – flow pattern maps and transitions. Void fraction – definitions of multiphase flow parameters – one dimensional continuity, momentum and energy equation- Pressure gradient components: frictional, acceleration and gravitational	8	20
VI	**Basic Flow Models:** Homogeneous flow model-Pressure gradient-Two phase friction factor for laminar and turbulent flow-two phase viscosity-friction	6	20

	multiplier. Separated flow model-pressure gradient relationship-Lokhart-Martinelli correlation – Parameter X and its evaluation		
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7411	**GAS TURBINES**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of thermodynamics, turbo machinery at UG/PG Level.

Course Objectives

- To impart a basic concept of various types of gas turbines and its applications
- To make the student capable of designing different types of gas turbines.

Syllabus

Introduction to gas turbines, gas turbine plants. Reheat and regeneration, Application of gas turbines, Design of turbines, salient feature of combustion chambers.

Expected Outcomes

- The students are expected to gain ability to perform detail analysis about gas turbines, on both thermodynamic and machinery level.
- The student will be able to design, operate and maintain various types of gas turbines

References

1. Horlock J H: Axial flow turbines.
2. Shepherd D G : Principles of Turbomachinery.
3. S M Yahya -Turbines, Compressors and Fans
4. Cohen, Rogers and Saravanamuttoo- Gas Turbine Theory

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Gas Turbine Plants** Open and closed circuit plants- gas turbine power cycles-improvements in the constant pressure cycle-open gas turbine cycle with inter cooling.	8	15
II	Reheat and regeneration-effect of regeneration, reheating and inter-cooling on efficiency-effect of operating variables on thermal efficiency, air rate and work ratio- advantages and disadvantages of closed cycle gas turbine- semi-closed type gas turbine..	8	15
First Internal Examination			
III	**Applications of gas turbines** Gas turbine applications in aircrafts, surface vehicles, electric	8	15

	power generation, petrochemical industries, cryogenics. Two dimensional cascade		
IV	**Design of turbines** The theory for the design of a turbine stage. Irreversibility's-losses in turbine stage-various efficiency for turbines- off design Performance. Three dimensional flows in axial turbo machines. Design of turbines	10	15
Second Internal Examination			
V	High temperature turbine stages-effect of high gas temperature-methods of cooling-high temperature materials-heat exchange in a cooled blade- ideal cooled stage –actual cooled stage	7	20
VI	**Salient features of various types of combustion chambers** for gas turbine engines. Principles of combustion chamber design. Compressor turbine matching- general and simplified methods for equilibrium operations	8	15
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME7313	**CO GENERATION AND WASTE HEAT RECOVERY SYSTEMS**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of engineering thermodynamics at UG Level.

Course Objectives

To analyze the basic energy generation cycles. To detail about the concept of cogeneration its types and probable areas of applications. To study the significance

Syllabus

Introduction to waste heat recovery systems, cogeneration technologies - Issues and applications, waste heat recovery systems, economic analysis.

Expected Outcomes

Ability to analyze the basic energy generation cycles, Understands the significance of waste heat recovery systems and the concept of cogeneration, its types and probable areas of applications, carryout its economic analysis.

References

1. Charles H Butler : Cogeneration. McGraw Hill Book Co.
2. EDUCOGEN : The European Educational tool for Cogeneration.
3. Horlock J H : Cogeneration-Heat and Power, Thermodynamics and Economics. Oxford
4. Institute of Fuel ,London. Waste heat recovery, Chapman and Hal Publishers.
5.SenguptaSubrata, Lee SS EDS, Waste heat utilisation and management. Hemisphere Washington

Course Plan			
Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	**Introduction** Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – organic ranking cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.	8	15
II	**Cogeneration technologies** Configuration and thermodynamic performance – steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc	10	15
First Internal Examination			
III	**Issues and applications of cogeneration technologies** Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment.	10	15
IV	**Waste heat recovery systems** Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems.	8	15
Second Internal Examination			
V	**Economics of analysis** Investment cost - economic concept - measure of economic performance – procedure for economic analysis – examples –	6	20
VI	Procedure for optimized system selection and design load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7315	MODERN ENERGY CONVERSION SYSTEMS	3-0-0: 3	2015

Course Prerequisites

Basic knowledge of Thermodynamic principles and renewable energy resources at UG/PG Level.

Course Objectives

To provide an understanding of the thermo physical principles that govern energy conversion processes of different type

Syllabus

Direct Energy conversion systems, Principles of Fuel cells, Principle for energy conversion, Principles for MHD, Nuclear energy sources, Conventional& Renewable Energy sources, Biomass, Wind and Ocean power

Expected Outcomes

Course will provide a foundation for design analysis of energy conversion systems encountered in a variety of applications.

References

1. R.A.Coombe: An introduction to Direct Energy Conversion
2. George Sutton: Direct Energy Conversion
3. Duffie and Beckmann: Solar Energy Thermal Processes
4. Meinel&Meinel: Solar Energy
5. MaheshwarDayal: Energy-Today & Tomorrow

Course Plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Direct Energy conversion systems**: Basic principles of Thermoelectric generation and Thermionic generation-Seebeck effect, Peltier effect and Thomson effect. The Diode-selection of materials-elementary principles of design- applications of electrochemical series-Thermionic generations	8	15
II	**Principles of Fuel cells**- Thermodynamics of the Fuel cells-Selection of fuel and operating conditions-constructional features-practical problems-state of the art and prospects. Photoelectric conversion conceptual description of photo-voltaic effect-the solar cell-the state of art of solar cells materials and prospects. V-I characteristics of solar cell-applications –SODIS Method	8	15
	First Internal Examination		
III	**Principle of MHD** generation-the Faraday and Hall generators-choice of generator parameters-Magnetic field requirements-conductivity and ionization-effect of seeding-Recent developments in MHD power systems. requirements of MHD-drawbacks of MHD systems-open cycle and closed cycle.-MHD loop-generator configurations-seeding-MHD waves	8	15
IV	**Nuclear energy**: Fission Reactors:- Classification and Vbasic	6	15

	principles-fuels, moderators and reactor materials-constructional features, safety and waste disposal. Nuclear Fusion;-Fuels and Reactions-sustained fusion reaction-practical aspects-containment-production of plasma-state of the art of fusion power. evolution of nuclear energy in India		
Second Internal Examination			
V	**Renewable Energy sources**: Solar energy:-Installation data-collectors and concentrators design, fabrication and performance of flat plate collectors-solar thermal devices (stills, water heaters, furnaces, solar cookers, solar refrigerators)-solar thermal power generation systems thermal storage. Biomass: Methods of beneficiation and utilization – pyrolysis, wood distillation, briquetting, gasifiers – energy plantations and fast growing varieties. working of P-V systems.	10	20
VI	**Bio-Gas:** Socio-economic relevance – technical data-recent developments in designs. **Ocean power:** Principles of ducts and OWC converters-evaluation of the potential in India of wave and tidal power- principle of OTEC system. **Wind power**: Survey of wind energy conversion systems-the wind map of India- wind turbine- pump coupled systems- **wind turbine**-generator systems.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7417	**STEAM TURBINES**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of hydraulic machines at UG Level.

Course Objectives

The course is designed to provide a strong background in the concept of design of steam engine in detail with design of flow passes, nozzles, and blade profiles

Syllabus

Types of steam turbines, working cycle and efficiency, Design of nozzles, Design of turbine flow passage, performance of steam engines and control of steam turbines.

Expected Outcomes

The students will be able to demonstrate and understanding of the main factors and design limitation that influence energy generation using steam turbines

References

1. Theory and design of Steam and Gas Turbines-John Flee
2. Steam Turbine Theory and Practice- W J Kearton
3. Steam & Gas Turbines- R Yadav

Course Plan			
Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	**Steam turbines types , working cycle and efficiency** Steam turbine types and working cycles- classification. Steam turbine cycles- Carnot cycle, rankine cycle, Reheat cycle, regenerative cycle-Effect of temperature and pressure on cycle efficiency- Thermal efficiency-Heat rate and Steam rate-Mechanical efficiency-Engine efficiency	12	15
II	**Design of nozzles**-nozzle construction-critical pressure ratio-nozzle losses-divergence and position angles-wet steam-super saturated steam-shock waves in nozzles-nozzle discharge coefficients-nozzle calculations. Compounding of steam turbines	8	15
First Internal Examination			
III	**Design of Turbine Flow passages**-isentropic velocity ratio-energy distribution in turbines effect of carry over velocity and energy distribution. Impulse flow turbine passages- Impulse blade profiles- Blade pitch and width. Blade height-blade entrance and exit angles-angle of efflux-geometry of blades	6	15
IV	**Blade profiles.** Reaction turbine flow passages-reaction blade profiles, blade angles, blade pitch, -losses in reaction blade passages. Flow passages with radial equilibrium-steam turbine control and performance.	6	15
Second Internal Examination			
V	**Control of steam turbines**: control and supervisory instruments-principles of governing-direct acting speed responsive governors-characteristics of the simple speed responsive governor-speed responsive governors with servomotors- hydraulic speed-responsive governors with servomotors-pressure regulators-speed regulation and parallel operation. Emergency governors	6	20
VI	**Performance of steam turbines**: Effect of throttle governing, effect of initial pressure and temperature changes, effect of nozzle governing-Parsons number and quality factor-performance of automatic extraction turbines-performance of mixed pressure turbine AC generator.	10	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7419	AIR CONDITIONING AND VENTILATION	3-0-0: 3	2015

Course Prerequisites

Basic knowledge of Psychrometry, refrigeration and air-conditioning at UG Level.

Course Objectives

- The course is designed to provide an understanding of air properties and comfort conditions
- To impart a strong background in the HAVC systems, design and applications.
- To study various types of AC systems

Syllabus

Psychrometry, General Principles of air-conditioning, design and applications of HVAC systems.

Expected Outcomes

- The students will acquire ability to perform Psychrometric analysis and design application specific HVAC system.
- The student will be able to design an AC system for the required comfort condition and also they will be in a position to minimize the total energy use

References

1. Harris NC : Air conditioning practice
2. Gunther R C : Air conditioning and cold storage
3. Stoeker W F : Refrigeration and Air conditioning and Ventilation of Buildings
4. ASHRAE guide and Data Book

Module	Content	Hours	Semester Exam Marks (%)
I	**Psychometry** Properties of moist air-Psychrometry, Psychrometric chart on enthalpy concentration and temperature concentration scales	8	15
II	**Analysis of Psychrometric processes**; sensible heating and cooling, Humidification and Dehumidification, sensible heat ratio	8	15
	First Internal Examination		
III	Summer winter cycles. Air Heating and cooling, Air washers-humidification. Air filtering equipments and unitary equipment.	10	15
IV	**Air Conditioning systems:** DX system, all water systems, all air systems-air water systems, heat pump system, central and unitary systems, fan coil systems. Air movement in rooms, Air distribution devices, Air curtains.	10	15
	Second Internal Examination		
V	**Estimation of cooling load and duct design** Estimation of cooling load, duct design; Special purpose Air Conditioning such as theatres, computer room, school, libraries, rail cars, aircraft and ships	10	20

VI	**Automatic controls** Automatic controls of air conditioning systems, thermostats, dampers and damper motors, automatic valves. Noise control and acoustic problems.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P: Credits	Year of Introduction
10ME7421	**FINITE ELEMENT ANALYSIS FOR HEAT TRANSFER**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of heat transfer at UG/PG Level.

Course Objectives

- To equip the students with the Finite Element Analysis fundamentals.
- To enable the students to formulate the heat transfer and fluid flow problems into FEA.

Syllabus

Review of the fundamentals of the three modes of heat transfer. Governing differential equations, Basic concepts of Finite Element method, Finite element equations and element characteristic matrices, Steps involved in a thermal analysis, Effects of convection and radiation in heat transfer, Computer programming and implementation of FEM.

Expected Outcomes

Upon completing this course, the students will be able to:

1. Identify mathematical model for solution of common engineering problems.
2. Formulate simple problems into finite elements.
3. Solve heat transfer and fluid flow problems using professional-level finite element software's

References

1. R W Lewis, K Morgan, H R Thomas and K Seetharamu: The Finite Element Method in Heat Transfer Analysis
2. H C Huang and A Usmani: Finite Element Analysis for Heat Transfer
3. L J Segerland: Applied Finite Element Analysis
4. O C Zeinkewicz: The Finite Element Method 1997

Module	Content	Hours	Semester Exam Marks (%)
I	Review of the fundamentals of the three modes of heat transfer. Governing differential equations. Initial and boundary conditions. Review of the numerical techniques for the solution of matrix equations	6	15

II	**Basic concepts of Finite Element method**. Mesh generation- Types of elements, Node numbering scheme. Interpolation polynomials	8	15
First Internal Examination			
III	**Finite element equations and element characteristic matrices**. Variational approach, Galerkin approach. Assembly of element matrices. Solution of finite element system of equations.	8	15
IV	**Steps involved in a thermal analysis**. Analysis of linear and nonlinear conduction problems in steady and transient hea t transfer. 1D, 2D and 3D analysis with simple examples. Axisymmetric heat transfer. Finite element solution in the time domain	9	15
Second Internal Examination			
V	**Convection and Radiation heat transfer**: Effects of convection in heat transfer- advection-diffusion. Analysis of heat transfer problems with radiation. Concepts of adaptive heat transfer analysis. Implementation of the adaptive procedure	10	20
VI	**Computer programming and implementation of FEM**. Introduction to general purpose FEM packages.	8	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P: Credits**	**Year of Introduction**
10ME7323	**ENERGY CONSERVATION & HEAT RECOVERY SYSTEMS**	**3-0-0: 3**	**2015**

Course Prerequisites

Basic knowledge of thermodynamic principles at UG Level.

Course Objectives

- To make the awareness about the need of conserving energy an minimization of wastage of energy
- To impart knowledge of various energy recovery, storage and transfer techniques
- To make the students understand about various energy conversion systems

Syllabus

Potential for energy conservation, Energy consumption, Waste heat recovery systems, heat to mechanical energy, energy management, Energy auditing,

Expected Outcomes

The students are expected to apply their knowledge to improve thermal efficiency of various systems and ability to select suitable application specific heat recovery systems.

References

1. Kenney W F- Energy conservation in the Process industries
2. Chiogioji M H- Industrial energy conservation

3. Bernhardt G A. Sjritsju&Vopat W A – Power station engineering & economy
4. Thumann, Albert PE- Plant Engineers and Managers Guide Energy Conservation
5. Dubin F B-Energy conservation standards
6. A.P.E. Thummann: Fundamentals of Energy Engineering, Prentice Hall, 1984
7. M.H. Chiogioji: Industrial Energy Conservation, Marcel Dekker, 1979
8. W. R. Murphy and G. McKay: Energy Management, Butterworth-Heinemann, 2001

Module	Content	Hours	Semester Exam Marks (%)
I	**Potential for energy conservation** Energy consumption and potential for energy conservation in industry-thermodynamics of energy conservation-energy flows-energy auditing-technologies for energy conservation-thermal insulation.	9	15
II	**Waste Hear recovery systems** Waste heat recovery systems, thermal energy storage, heat exchanger, heat pumps, heat pipes,	8	15
	First Internal Examination		
III	**Waste heat to mechanical energy conversion systems.** Different sources of heat energy. Design for conversion of energy, simulation and modelling. Applications and case studies-	8	15
IV	**Energy management** Definition of energy management - Energy conservation schemes - Optimizing steam usage - Waste heat management - Insulation	6	15
	Second Internal Examination		
V	**Energy auditing** Energy auditing - Thermodynamic availability analysis – Thermodynamic efficiencies - Available energy and fuel.	7	20
VI	**Thermodynamic analysis of common unit operations** - Heat exchange - Expansion – Pressure let down - Mixing- Distillation - Combustion air pre-heating	7	20
	Cluster Level End Semester Examination		

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10ME7401	**SEMINAR II**	**0 - 0 - 2**	**2015**

Course Prerequisites

1. The habit of reading technical magazines, conference proceedings, journals etc.

2. Knowledge in technical writing and communication skills earned through seminar at UG level and in first semester
3. The course Seminar I in first semester

Course Objectives

- To enhance the reading ability required for identification of the thesis area and its literature review
- To develop skills regarding professional communication and technical report writing.
- To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
- To arrive at a conclusion for doing Project Phase 1;
- To learn how to prepare and publish technical papers.

Guidelines

Students have to present a second seminar in 3rd semester. It is highly recommended that seminar-2 may report the literature survey being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized at the end of the second semester/ in the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress Evaluation Committee (PEC) formed in the second semester itself, may be the panel of evaluators for Seminar-2 also. The presentation of seminar-2 shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for seminar-2 may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community. The references cited in the report shall be *authentic*.

Expected Outcomes

The students are expected to

- Be motivated in reading which equip them in identification of thesis area and its literature review;
- Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction;
- Develop skills regarding professional communication and technical report writing;
- Arrive at a conclusion for doing Project Phase 1;
- Learn the methodology of publishing technical papers.

References

1.M. Ashraf Rizvi, *Effective Technical Communication*, Tata McGraw Hill, New Delhi, 2005
2.Day R A, *How to Write and Publish a Scientific Paper,* Cambridge University Press, 1989
3.Coley S M and Scheinberg C A, *Proposal Writing,* 1990, Newbury Sage Publications.

Course plan

Item	Description	Time	
1	Abstract Submission 3 Weeks	3 Weeks	
2	Allotment of Topic and Scheduling Seminars	1 Weeks	
3	Literature Review and Presentation Sessions	6 Weeks	

4	Report Submission	3 Weeks	
5	Publishing Grades	1 Weeks	

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10ME7403	**PROJECT** (PHASEI)	**0 - 0 - 12**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest solving in socially relevant or research problems
(3) Skills in hardware/software implementation techniques earned from UG and mini project in semester 1
(4) Course Mini project, Seminar II &b Research Methodology

Course Objectives

(1). The student is expected to finalise the thesis topic from the areas identified during seminar II. Background studies towards the project have to be done through literature survey in relevant fields.
(2). (S)he will work on the topic, familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work.
(3) To develop the skill of identifying research problems/socially relevant projects
(4) To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to identify the topic project (phase I) related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 4th semester also. This project phase is conceptualized in such a way that, some the outcomes of the work may be continued for thesis work. Hence on completion of thisproject phase, (S)he will make a presentation based on the work and suggest future plan for his thesis work. The implementation of this phase of project can be software and/or hardware based one. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*.References cited shall be authentic.The following guidelines also have to be followed.

1. The student will submit a detailed project (phase I)report
2. The student will present at least two seminars
3. The first seminar will highlight the topic, objectives and methodology
4. A progress seminar can be conducted in the middle of the semester
5. The third seminar will be a presentation of the work they have completed till the end of third semester and the scope of the work which is to be accomplished in the fourth semester, mentioning the expected results

Expected Outcomes

The students are expected to :

- Develop the skill of identifying industrial/ research problems/socially relevant projects
- Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution.
- Hands on experience in design and analysis tools required for the project work
- Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning
- To enhance the skills regarding the implementation aspects of hardware/software projects.
- Acquire documentation and problem solving skills.
- Develop professionalism.
- Communicate technical information by means of written and oral reports.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Abstract Submission	2 Week	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

SEMESTER 1V

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10ME7404	**PROJECT** (PHASE II)	**0 - 0 - 24**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest solving in socially relevant or research problems
(3) Skills in hardware/software implementation techniques earned from UG and mini project in semester 1
(4) Course Seminar II&b Research Methodology
(5) Course PROJECT(Phase I)

Course Objectives

- It is expected to complete the thesis work, which is normally based on Project (phase I)
- To work on the topic, and get the result.
- To develop the skill of achieving specific research target in a limited time
- To implement/completethe thesis work

Guidelines

Each student has to complete project (phase II) under the guidance of a faculty member, as specified in Phase I. It has to be approved by a committee constituted by the institute concerned. Hence on completion of this project phase, (S)he will make a presentation based on the work and suggest future possibilities. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. References cited shall be authentic.

The following guidelines also have to be followed.

1. The student will submit a detailed project (phase II)report
2. The student will present at least three seminars
3. The first seminar will highlight the topic, objectives and methodology
4. A progress seminar can be conducted in the middle of the semester
5. The third seminar (pre submission seminar) will be a presentation of the work they have completed till the end of forth semester and scope for future work also has to be mentioned.The pre-Submission seminar has to be presented before the Evaluation Committee for assessing the quality and quantum of work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of Thesis.

Expected Outcomes

The students are expected to :

- Develop the skill of identifying industrial/research problems/socially relevant projects
- Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution.
- Hands on experience in design and analysis tools required for the project work

- Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning
- Enhance the skills regarding the implementation aspects of hardware/software projects.
- Acquire documentation and problem solving skills.
- Develop professionalism.
- Communicate technical information by means of written and oral reports.

References

1.J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2.Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3.Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4.Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
(1)	Implementation Phase	10 Weeks	
(2)	Thesis Preparation	3 Weeks	
(3)	Final Internal Presentation-cum Demonstration	1 Week	
(4)	Evaluation by the External expert	4 Weeks	

ASSESSMENT CRITERIA

A. Evaluation of Theory Courses

KTU follows a continuous academic evaluation procedure. This includes two internal examinations and one end semester cluster level University examination. Besides, students should be given proper assignments / course seminars which are essential aspects of a student-centric teaching approach. The continuous assessment procedure and corresponding weights for awarding 100 marks for a theory subject are as follows.

1. Two internal tests, each having 15 marks summing to a total of 30 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
3. Cluster level end-semester examination having 60 marks

B. Evaluation of Research Methodology

The course Research Methodology should be a common one for all specializations, which is envisaged to provide a research orientation for PG students. The teaching - learning process for this course should be a student-centric one in which the faculty-in-charge would take the role of a facilitator in the system. Students should be given proper guidelines for practicing the various methodologies which aims at the overall improvement of their skills required for pursuing research. The continuous assessment procedure and corresponding weights for awarding 100 marks (fully internal) for Research Methodology are as follows.

1. Three internal tests, each having 20 marks summing to a total of 60 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 40 marks

C. Evaluation of Practical Courses

The continuous assessment procedure and corresponding weights for awarding 100 marks for a practical subject are as follows.

1. Practical Records / Results summing to a total of 40 Marks
2. Regular Class Viva-Voce summing to a total of 20 Marks
3. Final Test (Internal & Objective Type) having 40 Marks

D. Guidelines for Seminar-1

Students have to select a topic and present a seminar in first semester on any current topic related to the branch of specialization under the guidance of a faculty member. It is recommended that the same faculty member may serve as his/her supervisor for the mini-project in 2nd semester and also for the main project during 3rd& 4th semesters. Hence it is also recommended that a topic, possibly relevant to his mini-cum-main project may be selected as the topic for seminar-1, after the consultation with the guide. The student will undertake a detailed study of the subject based on current published papers, journals, and books and present it before a committee with the Head of the Department as the chairman and two faculty members (Faculty advisor + Guide) from the department as members. The presentation shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, coverage of the topic, adequacy of references, depth of

knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution.
The weights for awarding 100 marks (totally internal) for the seminar-1 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the topic (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report in the prescribed format given by the Institution : 30 marks

E. Guidelines for the Mini Project

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 3rd& 4th semesters. The mini project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of mini project the student can suggest possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or hardware based one. Mini project is envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning* strategy.
There should be a Progress Evaluation Committee (PEC) for each student which is constituted by three faculty members : (1) HoD as chairman, (2) Faculty advisor, and (3) Guide. This committee should evaluate the mini project through 2 presentations - (i) a preliminary presentation which is to be held soon after finalizing the topic, and (ii) a final presentation towards the end of the semester. In between, the Guide and /or the Co-guide is entrusted for the continuous evaluation of the work progress.
The weights for awarding 100 marks (totally internal) is as follows.

(1) Preliminary Presentation (PEC) : 20 Marks
(2) Progress Evaluation (Guide and/or Co-guide) : 30 Marks
(3) Final Presentation-cum-demonstration (PEC): 30 Marks
(4) Report (Mandatory) : 20 Marks

F. Guidelines for Seminar-2

Students have to present a second seminar in 3rd semester. It is highly recommended that seminar-2 may report the *literature survey* being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized in the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress evaluation Committee (PEC) formed in the second semester itself, will be the panel of evaluators for Seminar-2 also. The presentation of seminar-2 shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended

that the report for seminar-2 may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community.

The weights for awarding 100 marks (totally internal) for the seminar-2 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the literature review (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report / Paper in the prescribed format given by the Institution : 30 marks

G. Guidelines for the Project Work

Project work is to be carried out in the 3rd and 4th semesters and also to be evaluated in both semesters. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in the 4th semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work. Project evaluation committee should study the feasibility of each project work before giving consent. The project work is also to be evaluated continuously, during 3rd & 4th semesters through presentation sessions. Based on these evaluations the grade is finalized in the fourth semester. The internal committee (PEC) and an External Expert shall evaluate the project based on *four* presentations by the student during these semesters. The *first* presentation in 3rd semester should be held in the beginning of the semester which would highlight the topic, objectives, and the methodology. The *second* presentation in the same semester should bring out the work progress through the preliminary results and is to be conducted towards the end of the semester. These are evaluated totally internally by the PEC.

The Project Phase - II will be an extension of the Project Phase - I. A student has to prepare a project report, namely the thesis, towards the end of the 4th semester. Both the presentation and the thesis will be evaluated by the Committee and the External expert. The *third* presentation on project is to be made towards the end of 4th semester as a final internal presentation. At least one technical paper is to be published in Journals / Conferences so as to meet the requirements for final external submission. The *fourth* presentation is a *repetition* of the third one, but before an *External Expert*, appointed through the process of submitting the M. Tech. Thesis to the University (Cluster). The external expert will assess the quality and quantity of the work done by the student in the final (fourth) presentation. The comments of the examiners during this presentation should be incorporated in the work and report and is to be submitted as hard bound copies before the program exit by the student.

The weights for awarding 150 marks for Project shall be as follows.

A. 3rd Semester - Marks : 50 for Project Progress Evaluation
    1. Preliminary Presentation, evaluated by PEC : 15 Marks
    2. Progress evaluation by the Project Supervisor/s : 20 Marks
    3. End-semester presentation, evaluated by PEC : 15 Marks
B. 4th Semester - Marks : 100 for Final Evaluation
    1. Project evaluation by the supervisor/s : 30 Marks
    2. Final internal evaluation by PEC : 40 Marks
    3. Evaluation of the thesis presentation by an External Expert : 30 Marks