MECHANICAL ENGINEERING

Final Year B. Tech.

Effective from A. Y. 2014-15

INDEX

Item **Page No.**

List of Abbreviations

Sr. No.	Abbreviation	Stands for:
1	DEC	Departmental Elective Course
2	PCC	Program Core Course
3	LC	Laboratory Course
4	HSSC	Humanities and Social Science Course
5	MLC	Mandatory Learning Course
6	LLC	Liberal Learning Course
7	OEC	Open Elective Course
8	SEC	Science Elective Course

Program Education Objectives (PEOs):

1. To prepare the students in order to cater the needs of automotive, design, thermal and manufacturing for Indian as well as multinational industries.

2. To develop competence in the students to understand technological concepts, analyze data in order to formulate and undertake industrial problems and obtain viable solutions.

3. To provide students with in depth knowledge in the core subjects such as mathematics and engineering sciences in order to prepare them for higher studies and inculcate research attitude.

4. To make students aware of the importance of lifelong learning and provide opportunity to work on multidisciplinary projects.

5. To inculcate in student effective communication, management skills, professional ethics, codes of professional practice, induce societal awareness and indoctrinate team spirit.

Program Outcomes (POs):

On successful completion Graduates will demonstrate:

a) Proficiently use mathematical methods, basic sciences, engineering analysis, measurement and instrumentation techniques while attempting engineering problems and articulate viable solutions.
b) Graduates will demonstrate the ability to design, develop and analyze mechanical systems and manufacturing process that meets the required specifications.
c) Graduates will be familiar with modern engineering software tools and equipment to analyze mechanical engineering problems.
a) Graduates will demonstrate an aptitude to identify, formulate and solve problems associated with Mechanical Engineering.
b) Graduates will be able to understand the intricacies and impact of engineering solutions.
c) Graduates will be able to communicate effectively in both verbal and written forms.
d) Graduates will identify societal problems and provide viable engineering solution.
e) Graduates would be capable of self-education and clearly understand the value of lifelong learning.
f) Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.
g) Graduates will demonstrate professional and ethical responsibilities.
h) Graduates will adhere to the various important issues such as green house effect, carbon credit retrofit design concept; relevant norms laid down and exhibit maturity while providing engineering solutions.

CURRICULUM STRUCTURE OF Final Year B. Tech (Mechanical)

Effective from 2014-15

Summary – Credits and Contact Hours

Total Credits for B Tech (Mechanical Engineering)									
Program	**Sem I**	**Sem II**	**Sem III**	**Sem IV**	**Sem V**	**Sem VI**	**Sem VII**	**Sem VIII**	**Total**
B. Tech. (Mech. Engg.)	21	21	24	24	22	24	21	23	180
Teaching Hrs	24	23	29	28	24	28	28	34	215

VII-Semester (B Tech – Mech Sem I) W.E.F. 2014 - 15

Sr. No	Course Code	Subject Title	Category of Course	Contact hours L	T	P	Credits
1		Open Elective – II	OEC	3	0	0	3
2	ME- 401	Department Elective – II		3	0	0	3
3	ME -402	CAD/CAM		3	0	0	3
4	ME 403	Refrigeration and Air Conditioning		3	0	0	3
5	ME -404	CAD/CAM Lab	LC	0	0	2	1
6	ME 405	Refrigeration and Air Conditioning lab	LC	0	0	2	1
7	ME 406	Project-I		0	0	8	4
8	ME 407	Seminar		0	0	2	1
10		Liberal Learning Course	LLC	1	0	0	1
11		Intellectual Property Rights	MLC	1	0	0	1
		Total		28 Hrs			21

List of Open Electives-II

- Renewable Sources of Energy
- Steam Engineering
- Modeling and Simulation of Dynamic Systems

List of Department Electives-II, Any one to be chosen by students (B Tech Semester VII)

Sr. No	Course code for Theory	Subject Title
1	ME401-1	Computational Fluid Dynamics and Heat Transfer
2	ME401-2	Integrated Product Design
3	ME401-3	Introduction To Optimum Design
4	ME401-4	Mechanics of Composite Materials
5	ME401-5	Industrial Relations & labour Legislation
6	ME401-6	Analysis and Synthesis of Mechanism

MECHANICAL ENGINEERING DEPARTMENT

VIII-Semester (B Tech – Mech Sem II) W.E.F. 2014 – 15

Sr. No	Course Code	Subject Title	Category of Course	Contact hours L	T	P	Credits
1		Open Elective – III	OEC	3	0	0	3
2	ME 411	Department Elective – III	PCC	3	0	0	3
3	ME 412	Energy Conservation and Management	PCC	3	0	0	3
4	ME 413	Industrial Management	PCC	3			3
5	ME 414	Energy Conservation and Management Lab	LC	0	0	2	1
6	ME 415	Project-II	LC **	0	0	20	10
		Total		34			23

List of Open Electives-III

- Introduction to Nuclear Engineering
- Energy Management

List of Department Electives-III, Any one to be chosen by students

Sr. No	Course code for Theory	Subject Title
1	ME 411- 1	World Class Manufacturing
2	ME 411- 2	Robotics and Automation
3	ME 411- 3	Fracture Mechanics
4	ME 411- 4	Tribology
5	ME 411- 5	Design of Heat Exchanger
6	ME 411- 6	Theory Of Vibration And Acoustic

ME401-1 - Computational Fluid Dynamics and Heat Transfer

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **(6 hrs)**

Introduction to CFD: Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.

Unit 2 **(7 hrs)**

Governing Equations: Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.

Unit 3 **(7 hrs)**

Finite Volume Method: Domain discretization, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach

Unit 4 **(6 hrs)**

Geometry Modeling and Grid Generation: Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance

Unit 5 **(6 hrs)**

Methodology of CFDHT: Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation

Unit 6 **(8 hrs)**

Solution of N-S Equations for Incompressible Flows: Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows

Text Books:

- An Introduction to Computational Fluid Flow (Finite Volume Method), by H.K. Versteeg, W.Malalasekera, Printice Hall
- Computational Fluid Flow & Heat Transfer by Murlidhar and Sundarrajan, Narosa Publication.

Reference Books:

- Computational Fluid Dynamics, The Basic with applications by John A. Anderson, Jr., McGraw Hill International editions, Mechanical Engineering series.
- Numerical Methods in Fluid Flow & Heat Transfer by Dr. Suhas Patankar.
- Computational Methods for Fluid Dynamics by Ferziger and Peric, Springer Publication.
- An Introduction to Computational Fluid Mechanics by Chuen-Yen Chow, Wiley Publication.

Course Outcomes:

After successfully completing this course you will be able:

- To develop an understanding for the major theories, approaches and methodologies used in CFD;
- To build up the skills in the actual implementation of CFD methods (e.g. boundary conditions, methodology etc.) by using programming language;
- To gain experience in the application of CFD analysis to real engineering designs.

ME401-2- Integrated Product Design

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Prerequisites:

1. Machine Design
2. Differential Equations
3. Basic concepts of statistics
4. Basics of CAD

Unit 1 **(12 hrs)**

Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing

Unit 2 **(6 hrs)**

Design for manufacture and assembly, robust design and , design for manufacturing processes such as casting, forging

Unit 3 **(8 hrs)**

Rapid prototyping and reverse engineering

Unit 4 **(6 hrs)**

Statistical considerations in design and Reliability, Strength based reliability, parallel and series systems

Unit 5 **(6 hrs)**

Industrial design: Design for Emotion and experience, Introduction to retrofit and Eco design, Human behavior in design

Reference Books:

- Prashant Kumar, Product Design, Creativity, Concepts and Usability, PHI Learning Pvt. Ltd. New Delhi, 2012
- George E Dieter, "Engineering Design", McGraw Hill Company, 2000.
- Reverse Engineering an Industrial perspective, Editors: Vinesh Raja, Kiran J.Fernandes, Springer , 2008
- Rapid Prototyping: Laser-Based and Other Technologies Patri K. Venuvinod, Weiyin Ma Springer, 30-Nov-2003
- Design of Machine Elements, V. B. Bhandari , Tata McGraw Hill Publications.2003
- Pahl, G.and W.Beitz, *Engineering Design–A Systematic Approach* – Springer, 2nd Ed., 1996.

Course Outcomes:

- Students will be able to identify the needs of the customer while designing a new product or while modifying existing design of a product in the highly competitive, dynamic and customer centered market.
- Students will be able to convert the needs of customers in technical specifications and constraints of a product.
- Students will be able to design the products after realizing the importance of creativity.
- Students will learn various rapid prototyping methods and reverse engineering methods for generating and testing the new product designs.
- Students will understand the importance of design for manufacture and assembly, maintenance, reliability and statistical considerations in design.
- Students will learn the industrial design aspects such as design for emotions, eco design and retrofit design.

ME 401-3 - Introduction To Optimum Design

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,

End - Sem Exam – 60 Marks

Unit 1 **(8 hrs)**

Introduction to optimization, classification of optimization problems, classical optimization techniques

Unit 2 **(6 hrs)**

Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,

Unit 3 **(7 hrs)**

Non-Linear Optimization: - One dimensional minimization, direct and gradient based methods

Unit 4 **(6 hrs)**

Non-Linear Optimization: Constrained optimization, direct and gradient based methods

Unit 5 **(7 hrs)**

Introduction to Genetic Algorithms, operators, applications to engineering optimization problems

Unit 6 **(6 hrs)**

Optimum design of mechanical elements like beams, columns, gears, shafts, etc.

Reference Books:

- R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980.
- J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989.
- Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 2005
- L.C.W. Dixon, "Non-Linear Optimisation - Theory and Algorithms", Birkhauser, Boston, 1980.
- R.J. Duffin, E.L. Peterson and C.Zener "Geometric Programming-Theory and Applications", Willey, New York, 1967.
- G.B. Dantzig "Linear Programming and Extensions Princeton University Press", Princeton, N. J., 1963.
- R. Bellman "Dynamic Programming-Princeton" University Press, Princeton, N.J. 1957.

Course outcomes:
At the end of the course:

- Students will know the principles of optimization.
- Students will be able to formulate an optimization problem
- Students will have knowledge of algorithms for design optimization.
- Students should be able to find the optimum solution of their problems using optimization techniques.

ME401-4- Mechanics of Composite Materials

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Overview:
In pursuit of increasing the efficiency of structures use of composite materials is increased. To understand the role of composite materials for replacement of conventional materials, knowing mechanics of composite materials is essential. After understanding this subject you will be able to start stress and strength analysis of any composite structures using FEA (Finite Element Method) based software. Pre-requisite for this course is basics of Solid Mechanics.

Unit 1 **(3 hrs)**

Introduction
Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus

Unit 2 **(4 hrs)**

Basic Concepts and Characteristics
Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Macromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials

Unit 3 **(5 hrs)**

Elastic Behavior of Unidirectional Lamina
Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters

Unit 4 **(5 hrs)**

Strength of Unidirectional Lamina
Micromechanics of failure; failure mechanisms, Macromechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories

Unit 5 **(8 hrs)**

Elastic Behavior of Laminate

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates Hygrothermal Effects: Hygrothermal effects on mechanical behavior, Hygrothermal stress-strain relations, Hygro-thermoelastic stress analysis of laminates, Residual stresses, Warpage

Unit 6 (5 hrs)

Stress and Failure Analysis of Laminates

Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials

Reference Books:

- Isaac M. Daniels, Ori Ishai, "Engineering Mechaincs of Composite Materials", Oxford University Press, 1994.
- Bhagwan D. Agarwal, Lawrence J. Broutman, "Analysis and Performance of fiber composites", John Wiley and Sons, Inc. 1990.
- Mathews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science", CRC Press, Boca Raton, 2003.
- Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press, 2004.
- Mazumdar S. K., "Composaite Manufacturing – Materials, Product and Processing Engineering", CRC Press, Boca Raton, 2002.
- Robert M. Jones, "Mechanics of Composite Materials", Taylor and Francis, Inc., 1999.

Course Outcome:

The student should be able to

- Student will be able to understand the basic concepts and difference between composite materials with conventional materials.
- Students will be able to understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
- Students will be able to apply knowledge for finding failure envelopes and stress-strain plots of laminates.
- Students will be able to develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.

ME 401-5- Industrial Relations & labour Legislation

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Objectives

- To provide basic knowledge in industrial relations and labour laws.
- To enable the students understand the various provisions of Trade Union.
- To impart knowledge on Labour Laws.

Unit 1 **(7 hrs)**

Industrial relations in historical context

Concepts, Importance, Objectives, Scope, Frame Work of Industrial Relations, Approach to Industrial Relations, Evolution, Conditions for Successful Industrial Relations, Causes of Poor Industrial Relations. Development of IR system in India.

Unit 2 **(7 hrs)**

Labour-management relations:

Trade unionism, collective bargaining, employee grievances, employee discipline, industrial conflict, labour welfare and social security, Workers' participation in management.

Unit 3 **(7 hrs)**

India and international labour standards, Judicial activism, alignment, labour policy and industrialization, strategies, New paradigms of industrial relations.

Unit 4 **(6 hrs)**

Safety

Causes of Accidents, Prevention, Safety Provision, Industrial Health and Hygiene – Importance, Problems, Occupational Hazards, Diseases.

(6 hrs)

Unit 5

Labour Legislation -I

Factories Act, Contract Labour Act, Industrial Disputes Act, Employees State Insurance Act, Maternity Benefit Act.

(7 hrs)

Unit 6

Labour Legislation -II

Minimum Wages Act, Payment of Wages Act, Payment of Bonus Act, Employee Provident Fund Act, Payment of Gratuity Act, Workmen Compensation Act.

Reference Books:

- R.S. Dwivedi, Human Relations & Organizational Behaviour, New Delhi: Macmillan India Ltd, 2007.

- Ratna Sen, Industrial Relations in India, New Delhi: Shifting Paradigms, Macmillan India Ltd, 2007.
- Dynamics of Industrial Relations, Mamoria AND Mamoria, Himalaya Publishing House.
- Industrial Relations, Venkatratnam, Oxford Books.
- Srivastava, Industrial Relations and Labour laws, Noida: Vikas Publishing, 2007.
- C.S. Venkata Ratnam, Globalization and Labour Management Relations, New Delhi: Response Books, 2007.

Course Outcomes:
After this course students will able to know the provisions in various Labour Laws and its application while retendering services as an employer/employee.

ME401-6- Analysis and Synthesis of Mechanism

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Prerequisites:
- Theory of Machines
- Vector Algebra
- Derivatives

Unit 1 **(8 hrs)**

Basic Concepts; Definitions and assumptions; planar and spatial mechanisms; kinematic pairs; degree of freedom; equivalent mechanisms; Kinematic Analysis of Planar Mechanisms.

Unit 2 **(8 hrs)**

Review of graphical and analytical methods of velocity and acceleration analysis of kinematically simple mechanisms, velocity-acceleration, analysis of complex mechanisms by the normal acceleration and auxiliary-point methods,

Unit 3 **(8 hrs)**

Curvature Theory: Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions, cubic of stationary curvature, Ball's point, Applications in dwell mechanisms,.

Unit 4 **(7 hrs)**

Kinematic Synthesis of planar mechanisms, accuracy (precision) points, Chebesychev spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, centre and circle point curves.

Unit 5 **(7 hrs)**

Analytical synthesis of four-bar and slider-crank mechanisms, Freudenstein's equation, synthesis for four and five accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers, three accuracy point synthesis using complex numbers.

Unit 6 **(7 hrs)**

Coupler Curves : Equation of coupler curve, Robert-Chebychev theorem, double points and symmetry, Kinematic Analysis of Spatial Mechanisms, Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms

Reference Books:

- R.S. Hartenberg and J. Denavit, "Kinematic Synthesis of Linkages", McGraw-Hill, New York, 1980.
- Robert L.Nortan ,"Design of Machinery',Tata McGraw Hill Edition
- Hamilton H.Mabie,"Mechanisms and Dynamics of Machinery",John Wiley and sons New York
- S.B.Tuttle,"Mechanisms for Engineering Design" John Wiley and sons New York
- A. Ghosh and A.K. Mallik, "Theory of Machines and Mechanisms", Affiliated East-West Press, New
- Delhi, 1988.
- A.G. Erdman and G.N. Sandor, "Mechanism Design – Analysis and Synthesis", (Vol. 1 and 2), Prentice
- Hall India, 1988.
- A.S. Hall, "Kinematics and Linkage Design", Prentice Hall of India.
- J.E. Shigley and J.J. Uicker, "Theory of Machines and Mechanisms", 2nd Edition, McGraw-Hill, 1995.

Course Outcomes:

- Develop an understanding of basic motion analysis and synthesis application concepts.
- Demonstrate proficiency in kinematics and kinetics, as well as vector mathematics.
- Identify Degrees of Freedom and working condition of various common mechanisms.
- Apply synthesis methods to construct mechanisms to achieve desired motions.
- Utilize analysis techniques to find mechanism positions, velocities, accelerations.
- Apply synthesis and analysis techniques to solve open ended mechanism design problems.
- Communicate experimental findings in appropriate written report form
- Learn to make engineering judgments

ME 402 – CAD/CAM

Teaching Scheme **Examination Scheme**

Lectures : 3 hrs/week
Tutorial : 1 hr/week

100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **(4 hrs)**

Fundamentals of CAD/CAM- Product cycle and CAD/CAM/CIM product cycle, Features of CAD/CAM software, selection of software. CAD workstation configurations.

Geometric Modeling- 2D vs 3D Geometric model, Introduction to Wireframe, surface and solid modeling techniques. Geometry vs Topology, Requirements of Geometric Modeling, Geometric Modeling Methods: Constructive Solid Geometry (CSG), Boundary Representation (B-rep), Feature based Modeling, Direct (History less) Modeling, behavior modeling, 3D scan modeling

Unit 2 **(8 hrs)**

Geometric Transformation- 2D geometric transformations (translation, rotation, scaling, reflection, shear) Homogeneous co-ordinate representation, Inverse transformations, Composite transformations, 2D Geometric mapping, 3D transformations, 3D geometric mapping.

Projective Transformations - Parallel vs perspective projection, One point, two points and three points perspective projection, Orthographic projections: Multiview, Axiometric.

Unit 3 **(8 hrs)**

Mathematical Representation of Curves- Analytic Curves, Line, Circle, Parabolas, Hyperbolas, Ellipses, Conics, Synthetic Curves, Hermite Cubic Spline, Bezier Curv, B-Spline curve..

Mathematical Representation Surface- Analytic Surfaces, Synthetic Surfaces, Introduction to CAD data exchange formats.

Unit 4 **(6 hrs)**

Computer Numerical Control Machines

a)Fundamentals- Introduction to NC/CNC/DNC machines. Classification of NC systems, Axis nomenclature, Interpolation, features of CNC controllers, Advantages of CNC technology.

b) Machine tools - Types of CNC machines- (Turning & Machining centers and their configurations), Construction features of CNC machines- stepper & servo drive motors, Slide ways, Ball screws, Automatic tool changer (ATC), Pallets, Swarf removal systems

Unit 5 **(8 hrs)**

Part Programming for CNC Machines

a)Manual Part Programming - Process planning, NC words, Details of G and M codes. , Programming formats, Part programming for CNC lathe and milling machines.Canned cycles, subroutines and Do loops, Tool radius and length compensations.

b) Computer Aided Part Programming - Introduction, Steps in computer aided part programming, CNC programming using CAM softwares, CNC program verification and simulation.

Unit 6 **(4 hrs)**

Rapid Prototyping and Manufacturing
Introduction to Rapid Prototyping, rapid tooling and rapid manufacturing. Process of rapid prototyping. Different techniques of Rapid prototyping and their applications.

Text Books:

- Bedworth, Wolfe & Henderson -Computer Aided Design & Manufacturing - McGraw Hill
- Groover M. P. & Zimmer E. W.-CAD/CAM – Pearson Education, 2003
- P.N. Rao -CAD/CAM, Principles & Applications-Tata McGraw Hill
- T.K. Kundra- Numerical Control& Computer aided Manufacturing –TMH
- P. Radhakrishnan - CAD/CAM/CIM –New Age International Ltd.Publishers New Delhi
- M.E. Mortenson - Introduction to Computer Graphics - Industrial Press Inc, New york

Reference Books:

- Ibrahim Zeid – Mastering CAD/CAM —– Tata McGraw-Hill Publishing Company Ltd., New Delhi-8.
- David F. Rogers, J. Alan Adams – Mathematical Elements for Computer Graphics, Tata McGraw-Hill Publishing Company Ltd., New Delhi-8.

Course Outcomes:

- Students will demonstrate fundamental knowledge of CAD/CAM
- Students will be able to solve numerical on transformation and modeling of curves.
- Students will be able to generate the tool path for parts.
- Students will be able to write CNC program
- Students will know the terminology of 3D printers and scanners

ME 403 - Refrigeration and Air Conditioning

Teaching Scheme
Lectures :3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-

Tutorial : ----

Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **(5 hrs)**

Application Of Second Law Of Thermodynamics

A Refrigerating Machine – The Second Law Interpretation, Energy Ratios or COP, Power Consumption of a Refrigerating Machine, Best Refrigeration Cycle, vapour as a Refrigerant in Reversed Carnot Cycle Limitations of Carnot Cycle with Gas as a Refrigerant, Reversed Brayton or Joule or Bell Coleman Cycle,Introduction to aeroplane air conditioning cycles (Only Theory)

Vapour Compression System

Limitations of Reversed Carnot Cycle with vapour as a Refrigerant, Dry versus Wet Compression, Throttling versus Isentropic Expansion, Vapour Compression Cycle, Pressure Enthalpy Diagram and Calculations, Suction State for Maximum COP, Standard Rating Cycle and effect of Operating Conditions, effect of Evaporator Pressure Effect of Condenser Pressure, effect of Suction Vapour Superheat, effect of Liquid Sub cooling, Using Liquid- Vapour Regenerative Heat Exchanger, Actual Vapour Compression Cycle (Numerical Treatment)

Unit 2 **(8 hrs)**

Multipressure Systems

Flash Gas Removal, Flash Intercooling, Choice of Intermediate Pressure, Complete Multistage Compression System, Multi-evaporator Systems, Cascade Systems, Solid Carbon Dioxide-Dry Ice, Manufacture of Solid Carbon Dioxide, System Practices for Multistage Systems (Numerical treatment).

Refrigerants

A Survey of Refrigerants, Designation of Refrigerants, Selection of a Refrigerant, Thermodynamic, Chemical, Physical, and safety Requirements, Refrigerant Piping and Design, Lubricants in Refrigeration Systems, Secondary Refrigerants, Ozone depletion, Global warming, green house effect, Environment friendly refrigerant. (Theoretical only)

Unit 3 **(8 hrs)**

Refrigerant Compressors

Types of Compressors, Thermodynamic Processes during Compression, Volumetric Efficiency of Reciprocating Compressors, Effect of Clearance on work, Principal Dimensions of a Reciprocating Compressor, Performance Characteristics of a Reciprocating Compressor, Capacity Control of Reciprocating Compressors, Rotary Compressors, Screw Compressors, Scroll Compressors, Centrifugal Compressors, Calorimetric Testing as per I.S Conditions. (Numerical Treatment)

Condensers, Evaporators And Expansion Devices

Construction and working, Types of condensers, evaporators and expansion devices, Capillary Tube and Its Sizing

Unit 4 **(8 hrs)**

Psychometrics Of Air – Conditioning Processes
Properties of moist Air, Working Substance in Air Conditioning, Psychometric Properties, Psychometric Chart, Mixing Process, Basic Processes in Conditioning of Air Psychometric Processes in Air – conditioning Equipment comfort conditions, (Numerical Treatment),

Unit 5 (10 hrs)

Load Calculation And Applied Psychrometrics
Preliminary Considerations, Internal Heat Gains, System Heat Gains, Break-up of ventilation Load and Effective Sensible Heat Factor, Cooling-load Estimate, Heating – load Estimate, Psychometric Calculations for Cooling, Design of air conditioning equipment, Numerical examples, Introduction to duct design.

Unit 6 (6 hrs)

Vapour Absorption Systems
Introduction, Principle, aqua-ammonia,Lithium-bromide and Electrolux Systems, Performance analysis(Numerical treatment)

Text Book:

- Arora C. P. "Refrigeration and Air Conditioning", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1981.

Reference Books:

- ASHRAE Handbook, Fundamentals, 1993.
- Dossat R.J. "Principles of Refrigeration", Wiley Eastern Limited, New Delhi, 1991.
- Stoecker W.F. "Refrigeration and Air Conditioning", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1958.
- K. C. Koelet and T.B. Gray, "Industrial Refrigeration, Principles, Design and applications", The McMillan Press Ltd, London, 1992.

Course Outcomes:

- Students will demonstrate an understanding of the need and importance of HVAC technology, the typical and some advanced and innovative schematic designs, and the goals of HVAC engineering and HVAC systems.
- Students will demonstrate an understanding thermal comfort conditions with respect to temperature and humidity and human clothing and activities and its impact on human comfort, productivity, and health.
- Students will demonstrate an understanding of psychrometrics and its application in HVAC engineering and design and will practice or observe psychrometric measurements.
- Students will demonstrate an understanding of heat transfer in buildings with a given architectural design and its application to heating and cooling load estimation especially including thermal lag effects by conducting a detailed annual load analysis for a representative building and present the results of this analysis in a formal report possibly including recommendations for energy conservation.
- Students will demonstrate an understanding of the engineering and operation of vapor compression and possibly heat-driven refrigeration systems and evaporative cooling

systems and understand contemporary issues of ozone depletion and global warming potential with respect to refrigeration systems.

ME404 – CAD/CAM – Laboratory

Teaching Scheme
Practical - 2 hrs/week

Examination Scheme
Term work - 50 marks
Practical/Oral- 50 marks

List of experiments (Any Seven):

1. Study of typical CAD/CAM laboratory – Workstation specifications, networking layouts, CNC machines, 3D printer, Scanner specifications. Typical layout of CAD/CAM lab.
2. Use of CAD software to create 3-D models.
3. Use of CAD software to create assembly of components.
4. Create part and Assembly drawings
5. Design automation using CAD programming
6. Manual part programming for CNC lathe machine.
7. Manual part programming for CNC milling machine.
8. Computer aided part programming – (Use of CAM software)
9. Study of 3D printers and scanners.

Course Outcomes:

- Students will be able to use CAD/CAM software.
- Students will be using CNC codes for programming.
- Students will be able to use 3D printers.

ME 405 - Refrigeration and Air Conditioning Laboratory

Teaching Scheme
Practical – 2 hrs/week

Examination Scheme
Term work – 50 marks
Practical/Oral- 50 marks

List Of experiments
The students should perform the following experiments.

1. Trial on Refrigeration unit to determine cooling capacity and COP.
2. Trial on Air Conditioning Unit.
3. Trial on ice-plant
4. Trial on air cooler

5. To study the various expansion devices
6. To study the compressor
7. To study evaporators and condensers
8. Capacity control of compressors
9. Study of Vapour Absorption Systems

ME 406 – Project I

Teaching Scheme
Practical – 8 hrs/week

Examination Scheme
Term work - 50 marks
Practical/Oral- 50 marks

The students in a group of not more than FOUR will work under the guidance of the faculty member on the project work undertaken by them. The completion of work, the submission of the report and assessment should be done at the end of Part I (1st Semester).
The project work may consist of,
1. A comprehensive and up-to-date survey of literature related to study of a phenomenon or product.
2. Design of any equipment and / or its fabrication and testing.
3. Critical Analysis of any design or process for optimizing the same.
4. Experimental verification of principles used in applications related to Production Engineering.
5. Software development for particular applications.
6. A combination of the above.

The objective is to prepare the students to examine any design or process or phenomenon from all angles, to encourage the process of independent thinking and working and to expose them to industry. The students may preferably select the project works from their opted elective subjects.
A synopsis of the selected project work (two to three pages typed on A4 size sheets) certified by the project guide, should be submitted before the month of June of year. The synopsis shall be a part of the final project report.
The students should submit the report in a prescribed format, at the end of 1st semester. The report shall be comprehensive and presented in duplicate, typed on A4 size sheets and bound.
1. Term work will be assessed by the project guide along with one colleague appointed by the Head of Department.
2. The students will be examined orally by the external examiner and the project guide, as the internal examiner. Marks will be awarded on the basis of the work done and performance in the oral examination

ME 407 – Seminar

Teaching Scheme
Practical – 2 hrs/week

Examination Scheme
Term work - 50 marks
Practical/Oral- 50 marks

Before the end of Part I, each student will have to deliver a seminar on a subject mutually decided by candidate and his/her guide. The student should select the topic for his/her seminar other than project work. The seminar topic should be latest and ahead of the scope of curriculum. The student, as a part of the term work, should submit the write-up of the seminar topic in duplicate, typed on A4 size sheet in a prescribed format and bound at the end of semester. The performance of the student will be evaluated on the basis of the contents, the presentation and discussion during the delivery of seminar before the evaluation committee appointed by the Department.

Liberal Learning Course

Intellectual Property Rights

Open Elective –II

OEC - Renewable Sources of Energy

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Objectives:

- On the background of depleting sources of conventional energy, demonstrate significance of renewable Sources of energy and technologies of their Utilization
- Enable the students to estimate the potential of different resources at different numerical exercises
- Understand economics of renewable energy system
- Expose them to conceptualize and design renewable energy appliances and equipment
- Enable them to independently analyze, implement and asses the existing real life systems
- Develop a professional insight about renewable energy technologies so as to motivate all concerned for enhanced employment of renewable energy option

Unit 1 **(6 hrs)**

Introduction: Indian Scenario, Need, Characteristics and challenges in the successful utilization of renewable energy sources**,** Jawaharlal Nehru National Solar Mission (JNNSM)

Solar Energy Resource: Estimation of Potential of the Sun. Solar Extraterrestrial Radiation, Spectral Distribution, Earth sun angles, observer sun angles, Tilt factor, solar radiation intensity incident on tilted surface. Measurement of Solar Radiation

Unit 2 **(6 hrs)**

Low temperature applications of Solar Thermal Energy –Water and air Heating, Flat Plate collectors, losses, Performance evaluation, storage, Testing and standards, Economics, Subsidies and incentives available

Unit 3 **(6 hrs)**

Medium and high temperature applications of Solar Thermal Energy – Concentrating collectors, classification, types and suitability, tracking, Performance evaluation, Industrial Process heating systems, Solar thermal power generation, technologies, Storage issues and challenges in the commercialization.

Unit 4 **(6 hrs)**

Solar Photovoltaic Conversion- Basic Semiconductor Physics, A generic photovoltaic cell, Modules and Arrays, Impact of Temperature and Shading on the performance of a PV module, Stand alone and grid connected Solar Photovoltaic Systems, components, system design and economics

Unit 5 **(6 hrs)**

Wind power systems – Types of Wind turbines, Terminology, Impact of tower height, Maximum Rotor efficiency (Betz Limit), Wind turbine generators, Average power in wind, Estimation of wind availability, performance evaluation.

Unit 6 **(6 hrs)**

Bio-Energy: Biomass as a source of energy, Classification of biomass, Biomass conversion processes, Types of gasifiers, Briquetting, Gasification and combustion of biomass, Bio-methanation, Biogas as a rural energy source, Environmental significance, Biogas production mechanism, Biogas plant and its components, Types of biogas plants, Design and construction features.

Reference Books:

- S. P. Sukhtme, J. K. Nayak, Solar Energy Principles of Thermal Collection and Storage, Tata McGraw Hill
- Duffie John A.and Beckman William A., Solar Engineering of Thermal Processes, John Wiley and Sons,Inc. Second Edition, 1991
- Gilber Masters, Renewable and Efficient Power Systems, Wiley Inter-science, John Wiley and Sons. Inc. ,2004
- Tiwari G. N. and Ghosal M. K. Fundamentals of Renewable Energy Sources, by, Narosa Publishing House

- Garg H.P., Prakash J., Solar energy Fundamentals and Applications, Tata Mc Graw Hill Publishing Company, New-Delhi, Latest Edition
- www.mnre.gov.in for JNNSM document and subsidies
- V.V. N. Kishore, Editor, Renewable Energy Engineering and Technology, A knowledge Compendium, The Energy and Resources Institute, New Delhi, 2008

OEC - Steam Engineering

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Pre requisites for the course: Fundamentals of Thermodynamics, Heat Transfer, Fluid Mechanics, Metallurgy and Fuels and Combustion

Unit 1 **(7 hrs)**

Boilers
Types, Mountings and Accessories, Combustion in boilers, Feed Water and its quality, Blow down; IBR, Boiler standards resent status of energy scenario.

Unit 2 **(8 hrs)**

Piping & Insulation
Water Line, Steam line design and insulation; Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory-types, selection and application of refractory, Heat loss.

Unit 3 **(8 hrs)**

Steam Systems
Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Steam Engineering Practices; Steam Based Equipments / Systems; Identifying opportunities for energy savings.

Unit 4 **(7 hrs)**

Boiler Performance Assessment
Performance Test codes and procedure, Boiler Efficiency, Analysis of losses; performance evaluation of accessories; factors affecting boiler performance.

Unit 5 **(8 hrs)**

Energy Conservation and waste minimization

Energy conservation options in Boiler; waste minimization, methodology; economical viability of waste minimization

Unit 6 **(7 hrs)**

Instrumentation & Control
Process instrumentation; control and monitoring

Text Books:

- T. D. Estop, A. McConkey, Applied Thermodynamics, Parson Publication
- Domkundwar; A Course in Thermal Engineering; Dhanapat Rai and sons
- R.K. Rajput, Applied Thermodynamics, S. Chand & Company Limited
- Yunus A. Cengel and Boles, "Engineering Thermodynamics ",Tata McGraw-Hill Publishing Co. Ltd

Reference Books:

- Book II - Energy Efficiency in Thermal Utilities; Bureau of Energy Efficiency
- Book IV - Energy Performance Assessment for Equipment & Utility Systems; Bureau of Energy Efficiency
- Edited by J. B. Kitto & S C Stultz; Steam: Its Generation and Use; The Babcock and Wilcox Company
- P. Chatopadhyay; Boiler Operation Engineering: Questions and Answes; Tata McGrawHill Education Pvt Ltd, N Delhi

Course Outcomes:

- Students will have the ability to explain working of different boilers and significance of mountings and accessories.
- Students will have the ability to design a steam piping system, its components for a process and also design economical and effective insulation.
- Students will have the ability to use techniques, skills, and modern engineering tools necessary for boiler performance assessment.
- Students will have a theoretical and practical background in thermal systems, and will have a good understanding of energy conservation fundamentals. Students will have the ability to analyze thermal systems for energy conservation.
- Students will have the ability to analyze a thermal system for sources of waste heat design a systems for waste heat recovery.
- Students will have the ability to design and develop controls and instrumentation for effective monitoring of the process.

ME411-1 - World Class Manufacturing

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Objective: To understand the basic concept of manufacturing excellence, to study and understand various manufacturing philosophies, to understand the hurdles in implementation of WCM philosophy.

Unit 1 **(8 hrs)**

Introduction to World Class Manufacturing
Manufacturing excellence and competition frame work of WCM- Hall's, Schonberger's Gunn's, Maskell. WCM and Indian manufacturing scenario.

Unit 2 **(8 hrs)**

Total Quality Management
Quality definition, Contribution of various quality guru, Customer satisfaction, Continuous improvement, Supplier partnership, performance measures of Quality.

Unit 3 **(8 hrs)**

Tools and Techniques of TQM
Matrix diagram, process decision program chart, Management tool- Force field analysis, affinity diagram, Pareto diagram, Histogram, Process flow diagram, why- why analysis, Cause and effect diagram, Benchmarking, Quality function deployment (QFD), ISO 9000, Malcom Baldrig Certificate, European Quality Award certification.

Unit 4 **(8 hrs)**

JIT Philosophy
Just in time, seven waste, Basic element of JIT, KANBAN, PoKaYoKe, 5 S Theory, Implementation of JIT, Value engineering.

Unit 5 **(8 hrs)**

Total Productive Maintenance
Introduction of maintenance, Learning and implementing TPM, Development Autonomous Group, Training pertaining to TPM, Calculation relation with availability of machine.

Unit 6 **(8 hrs)**

Business Process Reengineering
Service Management, Introduction to concurrent engineering, Introduction to ERP and Supply chain management.

Reference Books:

- WCM- A strategic Perspective by B. S. Sahay, K. B. C. Saxena, Macmillan Publication.

- Industrial Engineering and Production Management by Mart and Telsang. S. Chand Publication.
- Total Quality Management by K.C. Arora. S. K. Kataria and Sons Publication.
- Total Quality Management by Barsterfield, Pearson Publication.

ME411-2 - Robotics and Automation

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

OBJECTIVES

- To understand basic terminologies and concepts associated with Robotics and Automation
- To study various Robotic sub-systems and Automation systems
- To study kinematics and dynamics to understand exact working pattern of robots
- To study the associated recent updates in Robotics and Automation

Unit 1 **(5 hrs)**

Introduction:- Basic Concepts such as Definition , three laws, DOF, Misunderstood devices etc. , Elements of Robotic Systems i.e. Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device, ..etc,

Automation :- Concept, Need, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.

Unit 2 **(5 hrs)**

Robot Grippers:- Types of Grippers , Design aspect for gripper, Force analysis for various basic gripper system.
Sensors for Robots:- Characteristics of sensing devices, Selections of sensors, Classification and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot.

Unit 3 **(6 hrs)**

Drives:- Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems,
Control Systems:- Types of Controllers, Introduction to closed loop control

Control Technologies in Automation:- Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process and its Forms. Control System Components such as Sensors, Actuators and others.

Unit 4 **(7 hrs)**

Kinematics :- Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics, solvability, algebraic and geometrical methods.
Velocities and Static forces in manipulators:- Jacobians, singularities, static forces, Jacobian in force domain.
Dynamics:- Introduction to Dynamics , Trajectory generations

Unit 5 **(7 hrs)**

Machine Vision System:- Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation.
Robot Programming :- Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines,
Programming Languages: Introduction to various types such as RAIL and VAL II etc, Features of each type and development of languages for recent robot systems.

Unit 6 **(6 hrs)**

Modeling and Simulation for manufacturing Plant Automation:- Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation.
Artificial Intelligence:- Introduction to Artificial Intelligence, AI techniques, Need and application of AI.
Other Topics in Robotics:- Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and associated mass, New Trends & recent updates in robotics

Text Books:

- John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley, 2nd Edition, 2004
- Mikell P. Groover et. Al., Industrial Robotics: Technology, Programming and Applications, McGraw – Hill International, 1986.
- Shimon Y. Nof , Handbook of Industrial Robotics , John Wiley Co, 2001.
- Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
- Industrial Automation: W.P. David, John Wiley and Sons.

Reference Books:

- Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 2002.
- Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.

ME411-3- Fracture Mechanics

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Prerequisites:

- Design Procedures and Failure Mechanisms
- Basics of Strength of Materials
- Differential Equations and Calculus

Unit 1 **(6 hrs)**

Modes of fracture failure, Brittle and ductile fracture, Energy release rate: crack resistance, stable and unstable crack growth.

Unit 2 **(6 hrs)**

Stress intensity factor: Stress and displacement fields, edge cracks, embedded cracks.

Unit 3 **(6 hrs)**

Crack tip plasticity: Shape and size of plastic zone, effective crack length, effect of plate thickness. Crack tip opening displacement.

Unit 4 **(6 hrs)**

Test methods for determining critical energy release rate, critical stress intensity factor.

Unit 5 **(6 hrs)**

Fatigue failure: Crack propagation, effect of an overload, crack closure, variable amplitude fatigue load.

Unit 6 **(6 hrs)**
Environment-assisted cracking, various crack detection techniques.

Reference Books. :

- Kumar Prashant, Elements of Fracture Mechanics, Tata McGraw-Hill, 2009
- Brook D, "Elementary engineering fracture mechanics".
- Liebowitz H., "Fracture" Volume I to VII.

- A Nadai, W. S. Hemp, "Theory of flow and fracture of solids", McGraw Hill Book Company, 1950.

Course Outcomes:

- Students will understand different modes of failure and understand difference between brittle fracture an ductile fracture.
- Students will be able to determine the damage tolerance of a component with a crack by analyzing the problem by methods of energy release rate and stress intensity factor .
- Students will understand the test methods for determining critical energy release rate , critical stress intensity factor.
- Students will be able to analyse stress and displacement fields at the tip of edge crack and embedded crack.
- Students will able to analyse variable amplitude fatigue in a component when a crack is present in it.
- Students will understand crack propagation, and environment assisted cracking.
- They will also understand various crack detection techniques.

ME411-4- Tribology

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Prerequisites:

- Fluid Mechanics
- Differential equations
- Material Science

Unit 1 **(6 hrs)**

Friction, theories of friction, Friction control,

Unit 2 **(6 hrs)**

Surface texture and measurement,

Unit 3 **(6 hrs)**

Wear, types of wear, theories of wear, wear prevention.

Unit 4 **(6 hrs)**

Tribological properties of bearing materials and lubricants.

Unit 5 **(6 hrs)**

Lubrication Regimes, Hydrodynamic Journal Bearing, Hydrostatic bearings, Their applications

Reference Books:

- S.K. Basu, B. B. Ahuja, S. N. Sengupta , Fundamentals of Tribology. EEE, PHI Pvt. Publications Ltd.
- A. Cameron, "Basic Lubrication Theory", Ellis Horwood Ltd, 1981.
- Principles in Tribology, Edited by J. Halling, 1975

Course Outcomes: At the end of the course:

- The students will understand various theories of friction and wear and will be able to apply them to various practical situations.
- They will understand the various surface measurement techniques and effect of surface texture on Tribological behaviour of a surface.
- They will be able to select materials and lubricants to suggest a tribological solution to a particular situation.
- The students will learn the basics of hydrodynamic bearings and hydrostatic bearings.
- The students will be able to use Raimondi and Boyd charts to design hydrodynamic journal bearing, pivoted pad and slider shoe bearing.

ME411-5- Design of Heat Exchanger

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Objectives:

This course is designed to give students an understanding of the selection of Heat Exchangers, Fouling in Heat Exchangers, Design, analyze and evaluate the heat exchangers.

Unit 1 **(6 hrs)**

Heat Exchangers – Classification according to transfer process, flow arrangement, number of fluids, surface compactness, and construction features. Tubular heat exchanger, plate type heat exchangers, extended surface heat exchangers, heat pipe, Regenerators.

Unit 2 **(6 hrs)**

Heat exchanger design methodology, assumption for heat transfer analysis, problem formulation, e-NTU method, *P*-NTU method, Mean temperature difference method.

Unit 3 **(6 hrs)**

Fouling of heat exchanger, effects of fouling, categories of fouling, fundamental processes of fouling.

Unit 4 **(6 hrs)**

Double Pipe Heat Exchangers: Thermal and Hydraulic design of inner tube, Thermal and hydraulic analysis of Annulus, Total pressure drop
Compact Heat Exchangers: Thermal and Hydraulic design of compact heat exchanger

Unit 5 **(6 hrs)**

Shell and Tube heat exchangers – Tinker's, kern's, and Bell Delaware's methods, for thermal and hydraulic design of Shell and Tube heat exchangers

Unit 6 **(6 hrs)**

Mechanical Design of Heat Exchangers – design standards and codes, key terms in heat exchanger design, and thickness calculation for major components such as tube sheet, shell, tubes.

Reference Books:

- Ramesh K. Shah and Dusan P. Sekulic, "Fundamentals of Heat Exchanger Design" John Wiley & sons Inc., 2003.
- D.C. Kern, "Process Heat Transfer", McGraw Hill, 1950.
- Sadik Kakac and Hongton Liu, "Heat Exchangers: Selection, Rating and Thermal Design" CRC Press, 1998.
- A .P. Frass and M.N. Ozisik, "Heat Exchanger Design", McGraw Hill, 1984
- Afgan N. and Schlinder E.V. "Heat Exchanger Design and Theory Source Book".
- T. Kuppan, "Hand Book of Heat Exchanger Design".
- "T.E.M.A. Standard", New York, 1999.
- G. Walkers, "Industrial Heat Exchangers-A Basic Guide", McGraw Hill, 1982.

Course Outcomes: This course provides students

- Ability to select the appropriate heat exchanger.
- Ability to estimate fouling rates according to design conditions.
- Ability to perform sizing and rating of heat exchangers for complicated designs.
- Ability to design, analyze and evaluate heat exchangers and use of commercial softwares.

ME411-6- Theory of Vibration And Acoustic

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **(6 hrs)**

One degree of freedom systems- harmonic excitation – An Overview; Transient Vibrations, Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function.

Unit 2 **(6 hrs)**

Multi degree of freedom systems, Free, damped and forced vibrations of two degree of freedom systems, Eigen values and Eigen vectors, normal modes and their properties, mode summation method.

Unit 3 **(6 hrs)**

Continuous Systems, Introduction to vibrations of strings, bars, shafts and beams; Mathematical model for vibration of Euler beam and its solution – natural and forced vibration, Mode shapes and natural frequencies, forced vibration of beams carrying concentrated harmonic forces.
Numerical and computer methods in vibrations: Rayleigh, Rayleigh-Ritz and Holzer's method.

Unit 4 **(6 hrs)**

Plane acoustic waves, derivation of plane wave equation, relationships between acoustic pressure, particle displacement and velocity, velocity of plane acoustic waves, specific acoustic impedance, Sound power, sound intensity, sound pressure and sound intensity levels.
Transmission Phenomena, transmission from one fluid medium to another, normal incidence, reflection at the surface of a solid, standing wave patterns. (No analytical treatment to this topic)

Unit 5 **(8 hrs)**

Spherical acoustic waves, Spherical wave equation, Spherical acoustic impedance, Spherical radiation from a simple source, Only description of pressure and sound intensity in case of sources like piston (no analytical treatment) – Near and far field, Beam width and directivity index, Reaction on a vibrating body, Radiation impedance.

Unit 6 **(4 hrs)**

Speech, Hearing and Noise, anatomy of the ear, mechanism of hearing, thresholds of the ear, loudness, pitch and timbre.

Text Books:

- Thomson W.T., "Theory of vibrations with applications", CBS Publishers, Delhi, 2003.
- Rao S.S., "Mechanical Vibrations", Wiley Publishing Co., 1990.
- Inmann Daniel J. Engineering Vibration, 4th Edition, Pearson
- Kinsler Lawrence E. and Frey Austin R. "Fundamentals of Acoustics", Wiley Eastern Ltd., 1987.

Reference Books:

- J .P. Den Hartog, "Mechanical Vibrations", McGraw Hill Book Co. New York, 1958.
- S. Timoshenko, "Vibration problems in Engineering", Wiley, 1974.
- Francis S. Tse, Iran E. Movse, Rolland T.Hinkle, "Mechanical Virbations", CBS Publishers and Distributors, 1983.
- W. Ker Wilson, "Practical Solution of Torsional Vibrations Problems", Chapman and Hall, 1969.
- M. Harris, C.E. Crede "Shock and Vibration Hand Book", McGraw Hill Book Co., 1988.
- J. Hater, "Matrix Computer methods of Vibration Analysis", Butterworths, 1973.
- Thomson W.T., "Theory of Vibrations with applications", George Allen and Unwh Ltd. London, 1981.
- Shriniwasan P., "Mechanical Vibration Analysis", Tata McGraw Hill, 1982.
- Michael Rettinger, "Acoustic Design and Noise Control", Vol. I & II. , Chemical Publishing Co., New York, 1977.
- Leonard Meirovitch, "Fundamentals of vibrations", McGraw Hill International Edition.
- Asok Kumar Mallik, "Principles of Vibration Control", Affiliated East-West Press.
- A.H. Church, "Mechanical Vibrations", John Wiley and Sons, Inc, New York, 1994.

Course Outcomes:

- The students will be able to model a given vibratory system as SDOF or MDOF system, with or without damping. He would also identify the type of given base or force excitation as periodic or aperiodic. He would be able to write, mathematically, the excitations of the types such as impulse, step, ramp, half sinusoidal, or such simple arbitrary excitations.
- Student will be able to obtain natural frequencies and mode shapes of MDOF and continuous systems using computational methods such as Rayleigh-Ritz method, Holzer method, Dunckerley's method, and Stodola's method.
- The student should be able to obtain natural frequencies and mode shapes of MDOF and continuous systems and their response to harmonic excitation using MATLAB.
- Student will know various terminologies used in acoustics and acoustic wave ransmission.
- The student will able to derive plane and spherical wave equations, and will be able to obtain sound pressure level at a given distance from a simple sound source of known strength.
- Students will be able to understand the mechanism of hearing by human and principles of Psychoacoustics and noise control.

ME412 Energy Conservation and Management

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Objectives:

- To inculcate the importance of energy conservation and its management.
- To showcase energy conservation opportunities in various mechanical systems.
- To introduce the intricate phenomenon of Demand Side Management in Electrical systems.
- To induce the knowledge of important phenomenon like Energy auditiong and economic analysis.

Unit 1 **(6 hrs)**

Introduction: Global Energy Scenario and Indian Energy Scenario in various sectors and Indian economy. Concerns of Energy Security in India

Basics – Revision of basics of Electrical and Mechanical Engineering relevant to Energy conservation and Management, Definitions of units, conversions in commercial practices Sankey Diagrams, Specific Energy consumption

Unit 2 **(6 hrs)**

Economic Analysis: Simple Payback Period, Return on Investment, Dynamic value of money, Discount Rate Cash flows, Time value of money, Formulae relating present and future cash flows - single amount, uniform series. Payback period. Return on Investment
(ROI). Life Cycle cost.
Costing of Utilities – specific costs of utilities like, all fuels steam, compressed air, electricity, water etc.

Unit 3 **(8 hrs)**
Energy Auditing: Elements and concepts, Types of energy audits, methodology, Instruments used in energy auditing. Portable and On-line instruments Role of Non-Conventional Energy Sources in Energy Conservation. Need and. Qyoto Protocol, Carbon Credits and Clean Development Mechanism (CDM).

Unit 4 **(8 hrs)**

Fuels – Solid, Liquid and gaseous, Combustion, Excess air requirements, Flue gas monitoring
Boilers –Performance testing, efficiencies, and energy conservation opportunities
Steam Systems – Aspects of steam distribution, Steam Traps, Condensate and Flash-steam utilization, Energy conservation opportunities, Thermal Insulation

Unit 5 **(8 hrs)**

Mechanical Systems: Energy Conservation Opportunities in compressed air systems, Refrigeration and air-conditioning system and water systems, Elementary coverage of Energy conservation in pumps and fans Cogeneration -concept, options (steam/gas, turbine /DCT-based), Selection criteria, Trigeneration.

Unit 6 **(6 hrs)**

Electric System: Demand control, Demand Side Management (DSM), Power Factor Improvement, benefits and ways of improvement, Load scheduling, Electric motors, losses, efficiency, energy-efficient motors, motor speed control, variable speed drive. Lighting: Illumination levels, fixtures, timers, energy- efficient illumination.

Text Books:

- Energy conservation-related booklets Published by National productivity Council (NPC) & Petroleum Conservation Research Assn.(PCRA).
- S Rao and B B Parulekar ," Energy Technology' Khanna Publishers, 1999
- B.G. Desai, M.D.Parmar, R.Paraman and B.S. Vaidya, "Efficient Use of Electricity in Industries" ECQ serries Devki R & D. Engineers, Vadodara

Reference Books:

- P.H. Henderson: India -The energy Sector, Oxford University Press.
- Callaghan: Energy Conservation IGC Dryden, editor ; The efficient use of energy (Butterworths.)
- D.A. Ray: Industrial Energy conservation. Pergamon Press
- W.C. Turner, editor: Energy Management handbook (Willey)
- Patrick Steven R., Patric Dale R. , and Fordo Stephen : Energy conservation Guide book, The Fairmont Press Inc.7.
- F. William Payne and Richard E. Thompson: Efficient Boiler Operation Source Book.
- Albert Thumann: Plant Engineers and managers Guide to Energy conservation

Course Outcomes:

- Able to utilize the technical skills attained in carrying out energy audit.
- Awareness of using renewable energy sources will be induced.
- Able to understand impact of use of non-renewable sources on environment.
- Able to apply practices of energy conservation in various sectors like domestic, Industry and commercial.

ME413 Industrial Management

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Objectives:

- To understand the basic concepts of management and organisation
- To study the function of personal marketing and finance management
- To understand various financial transaction, pertaining to profit making organisation
- To create awareness about globalisation

Unit 1 **(7 hrs)**

Management Concepts
Management, Administration, Its Relationship, Evolution And Development Of Management Thoughts, Scientific Management, Administrative Management, Contribution Of Various Management Guru's, Principle Of Managements, Functions Of Management, Review Of Different School Thoughts.

Unit 2 **(7 hrs)**

Organisation
Concepts, Characteristics, Elements, Theory Of Organisation, Principles Of Organisation, Organisation Structure, Organisation Type, Authority And Responsibility, Span Of Control, Group Dynamics, Industrial Ownership,- Single Ownership, Partnership, Joint Stock Company, Cooperative Society, Public Sector, Private Sectors

Unit 3 **(7 hrs)**

Personal Management
Aims, Objective And Function Of Personal Management, Principles Of Good Personal, Policy, Recruitment And Selection Of Employees, Training, Leadership And Supervision, Worker Participation In Management, Industrial Dispute And Labour Legislation, Job Evaluation And Merit Rating Wage Payment Plan

Unit 4 **(7 hrs)**

Marketing Management
Marketing Management Principles and Function, Market Research, Sales Forecasting, Marketing Segmentation and Marketing Mix, Advertisement Sale Promotion, Channel Of Distribution, Product Pricing

Unit 5 **(7 hrs)**

Financial Management
Budget and Budgetary Control, Investment Criteria, Cost Accounting and Control, Depreciation, Financial Ratios, Financial Book-Keeping

Unit 6 **(7 hrs)**

Globalisation
Globalization Driver, Issue Related With Globalisation, Job Migration Include By Globalisation, Web-based enablers for Engineering Management, Engineering Management In New Millennium.

Reference Books:

- Industrial engineering and management by O. P. Khanna, Dhanpatrai publication
- Engineering management by C. M. Chang, Pearson publication

- Industrial Organisation & Engineering Economics by Banga and Sharma, Khanna publication.

ME 414 - Energy Conservation and Management Laboratory

Teaching Scheme
Practical – 2 hrs/week

Examination Scheme
Term work – 50 marks
Practical/Oral- 50 marks

Course Education Objectives;

- Study of various solar system in comparison with conventional energy systems.
- Study of costing of mechanical and electric systems.
- Study of energy audit.

Term work:

Any two systems for each of the followings:

1. Comparison of economics of use of solar system with various conventional energy systems.
2. Work out the costing of any mechanical systems.
3. Work out the costing of any electric system.
4. Energy audit of any one energy consuming/manufacturing industry.

Course Outcomes:

- Students will be able to do comparison between solar system and conventional energy systems.
- Students will be able to do costing of mechanical as well as electrical systems.
- Students will be doing different types of energy audits.

ME 415 – Project II

Teaching Scheme
Practical – 20 hrs/week

Examination Scheme
Term work - 50 marks
Practical/Oral- 50 marks

The students in a group of not more than FOUR will work under the guidance of the faculty member on the project work undertaken by them. The completion of work, the submission of the report and assessment should be done at the end of Part II (2nd Semester).
The project work may consist of,

1. A comprehensive and up-to-date survey of literature related to study of a phenomenon or product.
2. Design of any equipment and / or its fabrication and testing.
3. Critical Analysis of any design or process for optimizing the same.
4. Experimental verification of principles used in applications related to Production Engineering.
5. Software development for particular applications.
6. A combination of the above.

The objective is to prepare the students to examine any design or process or phenomenon from all angles, to encourage the process of independent thinking and working and to expose them to industry. The students may preferably select the project works from their opted elective subjects.
A synopsis of the selected project work (two to three pages typed on A4 size sheets) certified by the project guide, should be submitted before the month of June of year. The synopsis shall be a part of the final project report.
The students should submit the report in a prescribed format, at the end of 2nd semester. The report shall be comprehensive and presented in duplicate, typed on A4 size sheets and bound.
1. Term work will be assessed by the project guide along with one colleague appointed by the Head of Department.
2. The students will be examined orally by the external examiner and the project guide, as the internal examiner. Marks will be awarded on the basis of the work done and performance in the oral examination

Open Elective –III

OEC - Introduction To Nuclear Reactor Engineering

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Objectives: The course will introduce the subject of Nuclear Reactor Engineering to any Engineering graduate student who has had preliminary exposure to basic mathematics skills. Since nuclear energy is an important part of India's energy security strategy, the course will be useful to understand the processes that take place inside a nuclear reactor and all the associated concepts, such as the reactor power and criticality as a function of reactor dimension and fuel composition, breeding and conversion of fertile to fissile isotopes, role of fission product poison in the operation of the reactor, etc.

It is proposed to introduce this course as both a Department Elective for the final year Mech. Engg. students as well as an Open Elective for other (Non-Mechanical) students. Nuclear Engineering is a truly multidisciplinary science where inputs from all other engineering disciplines, such as Electrical Engg., Mechanical Engg., Metallurgical Engg., Civil Engg., etc.

Only prerequisite for the course is a working knowledge of Advanced Calculus and some Differential Equations, which most Post Graduate students would have acquired.

Unit 1 **(6 hrs)**

Basics of nuclear fission and power from fission

Radioactivity, nuclear reactions, cross sections, nuclear fission, power from fission, conversion and breeding

Unit 2 **(9 hrs)**

Neutron transport and diffusion
Neutron transport equation, diffusion theory approximation, Fick's law, solutions to diffusion equation for point source, planar source, etc., energy loss in elastic collisions, neutron slowing down

Unit 3 **(9 hrs)**

Multigroup, multiregion diffusion equation, concept of criticality
Solution of multigroup diffusion equations in one region and multiregion reactors, concept of criticality of thermal reactors

Unit 4 **(6 hrs)**

Reactor kinetics and control
Derivation of point kinetics equations, inhour equation, solutions for simple cases of reactivity additions, fission product poison, reactivity coefficients

Unit 5 **(3 hrs)**

Heat removal from reactor core
Solution of heat transfer equation in reactor core, temperature distribution, critical heat flux

Unit 6 **(3 hrs)**

Reactor safety, radiation protection
Reactor safety philosophy, defence in depth, units of radioactivity exposure, radiation protection standards

Text Books:

- Introduction to Nuclear Engineering (3rd Edition) by John R. Lamarsh, Anthony J. Barrata, Prentice Hall, (2001)
- Introduction to Nuclear Reactor Theory, by John R. Lamarsh, Addison-Wesley, (1966)

Reference Books:

- Nuclear Reactor Analysis, by James J. Duderstadt and Lewis J. Hamilton, John Wiley (1976)

Outcomes: At the end of the course students will be able to understand

- The basic concepts and processes taking place inside a nuclear reactor, such as nuclear fission, neutron production, scattering, diffusion, slowing down and absorption.
- The student will also be familiar with concepts of reactor criticality, the relationship between the dimension and fissile material concentration in a critical geometry.

- Time dependent (transient) behaviour of power reactor in non-steady state operation and the means to control the reactor.
- It will also familiarize the student with concepts of heat removal from reactor core, reactor safety and radiation protection.

Evaluation Scheme: All tests and End-semester exam will be open book/open notes tests with the evaluation scheme as outlined before, namely, T1-20%; T2-20% and End-Sem-60%

OEC - Energy Management

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

Course Objectives:

- Able to demonstrate concern about energy security of India
- Become capable to interpret energy data and present as per the objective
- Become aware of the National and International Regulations in Energy Management
- Demonstrate proficiency in energy conservation economics
- Model, analyze and evaluate viability of energy conservation project independently
- Demonstrate thorough understanding of energy conservation in Mechanical and Electrical systems

Unit 1 **(6 hrs)**

Introduction: Primary Energy Balance, Global and Indian energy scenario and Concerns of Energy security in Indian and role of Non-Conventional Energy Sources.

Basics – Basics of Electrical and Mechanical Engineering relevant to Energy conservation and Management, Definitions of units conversions in commercial practices Sankey Diagrams, Specific Energy consumption, Demand Side Management (DSM)

Unit 2 **(8 hrs)**

Economic Analysis: Basics of commerce and banking, Raising the Capital, Different economic criteria for evaluating viability of projects such as Simple Payback Period, Return on Investment, Time value of money, Net present Value, Profitability Index, Internal Rate of Return, Cash flows, Life Cycle Costing, Depreciation, Subsidy structures. Sensitivity and risk analysis

Unit 3 **(7 hrs)**

Regulations in Energy Management

Kyoto Protocol - UNFCCC, IPCC, COP, and Latest Status of implementation in the environmental Summits, Indian response, Energy Conservation act 2001, Electricity Act 2003, Energy Conservation in Building Codes, Jawaharlal Nehru National solar Mission

Unit 4 **(6 hrs)**

Energy Auditing: Elements and concepts, Types of energy audits, methodology, Instruments used in energy auditing. Portable and On-line instruments, illustration of concept of preliminary Energy Audit with simple examples

Unit 5 **(6 hrs)**

Preliminary Energy Audits of Boilers, pumps and compressors, refrigeration and air condition, cooling towers

Unit 6 **(7 hrs)**

Energy Conservation in Electrical Systems:, Electric motors, energy-efficient motors, motor speed control, variable speed drive, transformers, Energy Conservation in Lighting

Text and Reference Books:

- Energy Statistics 2013, Central Statistics Office, National Statistics Organization, Ministry of Statistics and Program Implementation, Govt. of India, www.mospi.gov.in
- TEDDY Year book, The Energy and Resources Institute TERI, New-Delhi
- Practical Energy Audit Manuals Published by TERI
- https://unfccc.int, Kyoto Protocol Document
- www.beeindia.in, Energy Conservation Act 2001 Document
- www.powermin.nic.in, Electricity act 2003, Document
- www.mnre.gov.in, Jawaharlal Nehru National Solar Mission Document
- Energy conservation-related booklets Published by National productivity Council (NPC) & Petroleum Conservation Research Assn.(PCRA)
- Energy Management and Conservation Hand Book by Frank Kreith and Yogi D. Goswami, CRC Press, Taylor and Francis Group, Boca Raton,2007
- Energy Management Handbook, Wayne C. Turner and Steve Doty, CRC Press, Taylor and Francis Group, Boca Raton,2006, Sixth Edition
- Optimization of thermal systems by Yogesh Jaluria

OEC Modeling and Simulation of Dynamic Systems

Open Elective for Disciplines with Electrical Engineering background

Teaching Scheme
Lectures : 3 hrs/week
Tutorial : ----

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz- 40 Marks,
End - Sem Exam – 60 Marks

COURSE OBJECTIVES

- To teach basic concepts in numerical integration and computer simulation of mathematical models of systems.
- To teach a basic understanding of behavior of first- and second-order linear time-invariant differential equations.
- To teach students principles of physics as a basis for modeling of mechanical, electrical, fluid, and thermal systems.
- To introduce an appreciation for decision-making skills needed to devise models that adequately represent relevant behaviors yet remain simple.

Unit 1 **(6 hrs)**

Introduction: Need of Modeling, System variables, applications of models and principles of modeling, Energy sources, Energy Stores, Energy Dissipaters
Preparing foundation: Background of MATLAB and Simulink: dealing with array, MATLAB graphics, solution of algebraic equations, simultaneous algebraic equations, differential equations of first and second order time-invariant systems, curve fitting.

Unit 2 **(7 hrs)**

Mechanical Systems: Basic elements such as translational mass, translational spring, rotational mass, rotational spring; Belt driven system; Pulley Cable System; **Electrical Systems:** Basic Elements such as inductance, capacitance, resistance; **Fluid Systems:** Basic elements in fluid systems, pressure and fluid flow rate, fluid reservoir, pressurized tank, fluid flow dissipation; **Magnetic Systems:** Magnetic reluctance and magnetic energy sources; Thermal System involving heat flow rate, heat storage.

Unit 3 **(7 hrs)**

Electrical Mechanical Analogy of Mass Spring Damper System, Modeling of an automobile suspension system, Mass spring damper systems of 2 DoF.

Unit 4 **(5 hrs)**

Modeling Pendulums: Equation of motion of a simple pendulum, linearized model of the system, Model of an inverted pendulum.

Unit 5 **(7 hrs)**

Fluid Flow System Modeling: Modeling of one tank liquid level system and two tank liquid level systems.

Hydraulic System Modeling: Hydraulic Cylinder-connecting rod-Pump servo-system modeling; Example of a two cylinder and four cylinder model.

Unit 6 (6 hrs)

Case Studies: Modeling of a single stage and two stage turbine example, Magnetic ball suspension system example, Ball: Modeling of a Single and double ball system. **Tutorials** form above modeling using SymHydraulics, SymMechanics will be part of exercises.

Text Books:

- Introduction to Physical System Modeling, Peter E. Welstead, Academic Press Limited, London, ISBN: 0-12-744380-0
- Modern Control Engineering, 5th Edition, Kiatsuhiko Ogata, Prentice Hall

COURSE OUTCOMES:

- Given a description of a real-world system, make decisions about how to model it in terms of idealized, lumped elements.
- Given a simple system containing some combination of mechanical, electrical, and/or thermofluid elements, write a differential equation describing its input/output behavior.
- Given a first- or second-order LTI differential equation, predict its step response or free response.
- Given a LTI differential equation and an arbitrary input composed of steps, ramps, and other simple functions, set up the solution using Laplace transforms.
- Given a system composed of mixed mechanical/electrical/thermofluid components, write the transfer function describing input-output behavior.
- Describe how changes in parameter values will affect the performance of the system.
- Implement a mathematical model into commercial simulation software, and exercise the model to make engineering assessments.