MS Mechanical Engineering

Semester-wise Course Plan

Sr. [1]	Code	Course Title	Credit hrs	Status[2]	Prerequisites[3]
		FIRST SEMESTER			
1.	ME-404	Applied Thermal-hydraulics	3	O	Nil
		Equivalent to:			
	ME-401	Heat Transfer	2	O	Nil
	ME-402	Fluid Flow	2	O	Nil
2.	ME-516	Applied Solid Mechanics	3	C	Nil
3.	CME-501	Advanced Engineering Mathematics	3	C	Nil
4.	CME-413	Fundamentals of Radiation Protection	4 (3+1)	IR	Nil
5.	NE-501	Fundamentals of Nuclear Engineering	3	IR	Nil
6.	CMS-501	Professional English	1	C	Nil
		SECOND SEMESTER			
1.	EE-503	Numerical Methods in Engineering	3	C	Nil
2.	ME-503	Finite Element Method	3	O	Nil
3.	ME-504	Classical Thermodynamics	3	C	Nil
4.	ME-505	Mechanical Behaviour of Materials	3 (2+1)	O	Nil
5.	ME-506	Kinematics and Dynamics	3 (2+1)	O	Nil
6.	ME-507	Solar Devices and Renewable Energy	3	O	Nil
7.	ME-508	Advanced Heat Transfer *(Equivalent to "NE-506 Nuclear Heat Transport")*	3	O	ME-404 or ME-401 & ME-402
8.	ME-509	Experimental Stress Analysis	3 (2+1)	O	Nil
9.	ME-501	Mechanical Engineering Design	3	O	Nil
	ME-518	Design of Machine Elements – I	3	C	Nil
10.	ME-601	Theory of Elasticity	3	O	Nil
11.	NE-505	Nuclear Reactor Analysis	3	IR	Nil
12.	CME-504	Mechanical Metallurgy	3	O	Nil
13.	ME-690	Special Topics in Mechanical Engineering – I[4]	3	O	Instructor's Consent
		THIRD SEMSTER			
1.	ME-403	Computer-Aided Design	2	O	Nil
2.	ME-510	Power Plant Systems *(Equivalent to "NE-510 Nuclear Power Plant Systems")*	3	IR	Nil
3.	ME-511	Design of Energy Systems	3	O	ME-518 or ME-501
4.	ME-512	Computer Aided Analysis	3	O	ME-503
5.	ME-513	Mechanical Vibrations	3 (2 +1)	O	Nil
6.	ME-514	Application of Computer Graphics in Engineering	3	O	Nil
7.	ME-515	Measurements and Instrumentations	3 (2 +1)	O	Nil
8.	ME-518	Design of Machine Elements – I	3	O	ME-518
9.	ME-522	Computer-Aided Design and Manufacturing	3 (2+1)	O	Nil
10.	ME-602	Fracture Mechanics	3	O	ME-505
11.	ME-604	Theory of Plasticity	3	O	ME-601
12.	ME-606	Boundary Element Method	3	O	ME-503
13.	ME-609	Theory of Compressible Flow	3	O	ME-402 or ME-404
14.	ME-610	Turbo-machinery Theory	3	O	ME-609 or CME-535, ME-504
15.	ME-691	Special Topics in Mechanical Engineering – II[4]	3	O	Instructor's Consent
		FOURTH SEMESTER			
1.	ME-603	Non-Linear Finite Element Method	3	O	EE-503, ME-503
2.	ME-605	Microelectromechanical Systems (MEMS)	3	O	Nil
3.	ME-607	Finite Element Programming	3	O	ME-503
4.	ME-608	Plates and Shells	3	O	ME-518, ME-601
5.	ME-611	Turbo-machinery Design	3	O	ME-610
6.	CME-614	Computational Fluid Dynamics	3	O	ME-404
7.	CME-618	Turbulence Modelling and Grid Generation	3	O	EE-503, ME-404
8.	NE-529	Project Management	3	O	Nil
9.	NE-612	Boiling Heat Transfer and Two Phase Flow	3	O	ME-404
10.	ME-692	Special Topics in Mechanical Engineering – III[4]	3	O	Instructor's Consent
11.	ME-697	MS Thesis Research	6	C	Nil
		FIFTH SEMESTER			
1.	ME-697	MS Thesis Research	9	C	Nil

Notes:

1. Equivalent courses are mentioned under same serial number.
2. C: Compulsory, O: Optional, IR: Institute Requirement
3. The condition of prerequisites may be relaxed in special cases with the consent of course coordinator and instructor.
4. May be offered in place of a compulsory or an optional course with the consent of the Course coordinator and instructor.

Course Contents

ME-401 Heat Transfer

Compulsory	No
Credits	2
Prerequisite	Nil
Course Format	Two hrs of lectures per week

Steady-state conduction, 1D, 2D conduction, Transient conduction, 1D systems, Semi-infinite geometry, Free Convection, Heat Transfer Correlations, Forced Convection, Surface roughness effects, Heat Exchangers, Radiation Heat Transfer.

References:

- J.P. Holman, Heat Transfer, McGraw Hill, 1988
- Helmut Wolf, Heat Transfer, Harper & Row, 1983

ME-402 Fluid Flow

Compulsory	No
Credits	2
Prerequisite	Nil
Course Format	Two hrs of lectures per week

Fundamental laws of fluid flow; Continuity equation, Bernoulli's equation, Frictional flow and pressure losses; Concept of different types of flow, Laminar and Turbulent flow, Reynolds's number, Pressure and flow measurements.

Reference:

- Sabersky, RH, A J.Acosta and E.G.Hauptmann, Fluid Flow, Macmillan, 1971.
- Streeter, V.L. and E.B.Wylie, Fluid Mechanics, McGraw-Hill, 1975.

ME-403 Computer-Aided Design

Compulsory	No
Credits	2
Prerequisite	Nil
Course Format	Two hrs of lectures per week

Introduction to Drawing and drafting, Hands-on practice on available engineering drawing software, Methods of obtaining design of various components, Wire frame models, Solid modeling. In this course, the students will be required to finally design an assembly of a machine component using available engineering design software.

References:

- User guides and reference manuals of the available engineering softwares.

ME-404 Applied Thermal-hydraulics

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Fundamentals of fluid statics, Integral & differential relations of fluid flow, dimensional analysis, viscous flow, Introduction to compressible flow, boundary layer flow, Conduction, Heat transfer correlations, free & forced convection, radiation, heat exchangers.

References:

- F.M. White, Fluid Mechanics, 6th ed, McGraw Hill, 2006.
- J.P. Holman, Heat Transfer, McGraw Hill. 2001.
- Kern, Process Heat Transfer, Int ed., 2001
- Cengel, Heat Transfer, McGraw Hill, 2001.

ME-501 Mechanical Engineering Design

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Engineering design fundamentals, Material selection in design, Load determination, Static failure, Fatigue failure and failure theories. Design of machine elements such as shafts, keys, couplings, gears, bearings and springs.

References:

- Machine Design, an integrated approach, Robert L. Norton, Prentice Hall.
- Material Selection in Mechanical Design, 2nd ed., Michael F. Ashby., Butterworth-Heinemann.

ME-502 Mechanical Engineering Laboratory

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Nine hrs of laboratory per week

A number of experiments will be offered from the list of experiments given below and students will be required to carry out a minimum of eight experiments.

1. Use of electrical resistance strain gauges in mechanics
2. Fluid circuit friction study
3. Fundamental properties of fluid flow
4. Power plant study
5. Process control
6. Study of characteristics of pumps
7. Study of electrochemical behavior of metals and alloy
8. Study of proportional, derivative and integral response in feedback control loop
9. Study of thermal conduction
10. Tensile, hardness and impact testing
11. Study of creep behavior of materials
12. Study of fatigue behavior of materials
13. Use of transmission photo elasticity
14. Application of electrical resistance strain gauges and its testing
15. Use of reflection polariscope
16. Study of characteristics of turbine
17. Study of feedback control using hydraulic system
18. Study of feedback control using pneumatic system
19. Double pipe heat exchanger
20. Mechanical measurement and use of coordination measurement machine

ME-503 Finite Element Method

Compulsory	No
Credits	3
Prerequisite	NE-401
Course Format	Three hrs of lectures per week

General concepts of FEM, Galerkin / weighted residual method, Rayleigh-Ritz / variational method, Shape functions, Isoparametric elements, 1D problems: trusses, beams and frames, 2D problems: plane stress, plane strain and axisymmetric problems, 3D stress analysis, Heat transfer, Fluid flow problems, Numerical integration: Gaussian quadrature, Reduced integration, The Patch test, Finite element error analysis, Error estimates, Convergence and accuracy of solutions, Infinite and singularity elements, Time Dependant problems, Semi-discrete FEM, Time approximations, Computer implementation.

References:

- The Finite Element Method, Vol. 1: Basics, 5th ed., O. C. Zienkewicz, R. L. Taylor. 2002.
- Applied Finite Element Analysis for Engineers, F. L. Stasa, Int'l Thomson Pub, 1995.
- Finite Element Method in Engineering, 3rd ed., S. S. Rao. Pergamon Press, 1999.
- Programming the Finite Element Method, 3rd ed. I. M. Smith, John Wiley & Sons, 1997.

ME-504 Classical Thermodynamics

Compulsory	Yes
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Basic concepts and definitions, Properties of pure substance, work and Heat, First and second law of thermodynamics, Entropy, Irreversibility and availability, Power and refrigeration cycles. Evaluation of effects of various parameters on thermal efficiency of the system.

References:

- Fundamentals of Classical Thermodynamics , 3rd ed. G. J. Van Wylen, R. E. Sonntag, John Wiley & Sons, 1986.

ME-505 Mechanical Behavior of Materials

Compulsory	No
Credits	3 (Theory: 2, Lab: 1)
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Engineering stresses and strains, True stresses and strains, Methods of obtaining stress-strain curves, Procedures of performing tension, compression and hardness experiments, Types and design of test specimen used in tension and compression experiments, Stress concentration factor, Failure theories, Definition of homologous temperature and its importance in engineering, Creep and relaxation, Monotonic stress strain behavior of materials, Cyclic stress strain behavior of materials, Methods of obtaining stress strain hysteresis loops, Cyclic strain hardening and softening, Coffin-Manson law, Fatigue and its importance in design and

damage analysis, Low cycle fatigue, High cycle fatigue, Effect of different types of wave shapes, environment, temperature, etc. on fatigue, Introduction to Fracture Mechanics, Modes of fracture, Stress intensity factor, Dislocation theory, Deformation of materials under external loads.

References:

- Mechanical Behavior of Materials, Krishan Kumar Chawla, Marc Andre Meyers, Prentice Hall, 1st ed., 1998
- Fundamentals of Metal Fatigue Analysis, J. A. Bannantine, J. J. C. Former, and J. L. Handrock, Prentice Hall publications.
- Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue, 2nd ed., N E Dowling, Prentice Hall, 1998

ME-506 Kinematics & Dynamics

Compulsory	No
Credits	3 (Theory: 2, Lab: 1)
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Kinematics and kinetics of a particle, Analytical treatment, Plane motion of a point, Special cases of plane motion, Kinematics and kinetics of a rigid body in plane motion, Kinematics of machines, Geometric representation of motion, Number synthesis and inversion, Graphical analysis, Velocity and acceleration diagrams, Inertial effects in mechanics, Direct-acting engine mechanisms, Balancing of machines, Governors, Gravity-controlled pendulum governors, Spring controlled governors, Valves and valve gears, Friction, Lubrication and efficiency of machines, Film lubrication, Thrust bearings, Belt friction, Breaks and dynamometers, Propulsion and braking of vehicles, Higher pairing tooth gears, Cams and cam motions, Vibration of mechanical systems, Whirling of circular section shafts, Transient motion in a control system, Motion in three dimensions.

References:

- Theory of Machines, W. G. Green, Blacke & Son Ltd, London and Glasgow, latest ed.
- Kinematics and Dynamics of Machinery (2nd ed.) Charles E. Wilson, J. Peter Sadle, Pearson Education POD, (Jan 1997)
- Machine Elements in Mechanical Design, Fourth Ed., Robert L. Mott, Prentice Hall, 4th ed. (July 16, 2003)
- Computer-Aided Kinematics and Dynamics of Mechanical Systems: Basic Methods, by Edward J. Haug.

ME-507 Solar Devices and Renewable Energy

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Solar irradiation, its nature and measurement, Insulation on tiled surfaces, Application of the principle of heat transfer and thermodynamics to the theoretical and experimental analysis of solar energy components used in the heating and cooling of buildings as well as hot water heating devices. Theoretical consideration of thermal storage devices, solar collectors and solar-augmented heat pumps, Approximate techniques and other research topics.

Reference:

- Solar Engineering of Thermal Processes, 2nd edition, J.A. Duffie, W.A. Beckman, John Wiley & Sons, 1991

ME-508 Advanced Heat Transfer

Compulsory	Yes (for those appointed in Power Plants)
Credits	3
Prerequisite	ME-401, ME-402 or ME-404
Course Format	Three hrs of lectures per week
Equivalent Courses	NE-506 : Nuclear Heat Transport CME-512: Process Heat Transfer

Comprehensive treatment of conduction, convection (including boiling and condensation), and radiation heat transfer. Thermal system design and performance (including heat exchangers), Emphasis is on physical and mathematical modeling of engineering systems for application of modern analytical and computational solution methods.

Reference:

- Advances in Heat Transfer, James Hartnett, Young Cho, George Greene, Academic Press, (Aug. 2003

ME-509 Experimental Stress Analysis

Compulsory	No
Credits	3 (Theory: 2, Lab: 1)
Prerequisite	Nil
Course Format	Two hrs of lectures per week, 42 hrs of Lab work in semester

Fundamental concepts of electrical resistance strain gages, Performance characteristics of strain gage circuits and stain indicators, Gage selecting criteria, Rosette analysis, Some special applications of strain gages, Theory of photoelasticity, Polariscope techniques, Two and three dimensional photoelastic stress analysis, Birefringent coating, Photoelastic materials, Some experiments related to strain gages and photelasticity, Introduction to brittle coating and Moiré method.

References:

- Experimental Stress Analysis, J. W. Dally, and W. F. Riley, McGraw Hill Inc, 1991.
- Handbook on Experimental Mechanics, Kobashi, ASVCH Publishers Inc, 1993.
- Photoelastic Stress Analysis, A. Kuske, G. Robertson, John Wiley & Sons, 1997.

ME-510 Power Plant Systems

Compulsory	Yes
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week
Equivalent Course	NE-510: Nuclear Power Plant Systems

Layout of thermal power plants; Containment buildings; Primary containment vessels; Structure of reactor core; and mechanical stress in various structures. Description and analysis of power plant systems and components including steam generator, steam dryer and separator, pressurizer, reheater, heat exchanger, condenser, demineralizer, pumps, turbine, generator, cooling tower; Auxiliary cooling systems. Fuel handling mechanisms; Control and mechanisms; Radwaste systems; Electrical Systems; Reactor grid interface and load following. Basic considerations in nuclear plant design; Components of nuclear power cost; Economic comparison of nuclear and fossil fueled plants; Dual and multipurpose nuclear power plants; Future trends in nuclear power cost.

References:

- Rust, J. H., Nuclear Power Plant Engineering, Haralson, 1979.
- Pedersen, E.S., Nuclear Power, Ann Arbor Science, 1978.
- El-Wakil, M.M., Power Plant Technology, McGraw-Hill, 1984.
- Lish, K.C., Nuclear Power Plant Systems & Equipment, Industrial Press Inc., 1972.

ME-511 Design of Energy Systems

Compulsory	No
Credits	3
Prerequisite	ME-518
Course Format	Three hrs of lectures per week

This course applies basic concepts of fluid mechanics and heat transfer to a wide variety of energy system components such as heat exchangers, pumps, fans, and bearings. Design and analysis techniques including modeling and simulation methods are developed for energy systems such as piping networks and refrigeration units.

Reference:

- Engineering Design, G. Pahl and W. Beitz, Springer-Verlag, 1996.

ME-512 Computer-Aided Analysis

Compulsory	No
Credits	3
Prerequisite	ME-503
Course Format	Three hrs of lectures per week

Introduction to engineering analysis software, Analysis of solids: Stress and Structural analysis, Thermal stress analysis, Analysis of heat transfer and fluid flow problems.

Reference:

- User guides and reference manuals of the available engineering software.

ME-513 Mechanical Vibrations

Compulsory	No
Credits	3 (Theory: 2, Lab: 1)
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Fundamentals of vibration, Free vibration of single degree of freedom systems, Harmonically excited vibration, Vibration under general forcing conditions, Two degrees of freedom systems, Multi degrees of freedom systems, Determination of natural frequencies and mode shapes, Continuous systems, Vibration control, Vibration measurement and applications.

References:

- Vibration Problems in Engineering, W.Weaver, S.P. Timoshenko, D. H. Young, Interscience, 5^{th} ed. Jan. 1990
- Vibration Analysis of Plates by the Superposition Method, Daniel J. Gorman
- The Vibration Analysis Handbook, James I. Taylor, Published 1994.
- Vibration Simulation Using MATLAB and ANSYS, Michael R. Hatch, 2000.

ME-514 Application of Computer Graphics in Engineering

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Graphics Input / Output devices, Graphic primitives: lines, circles, etc; Transformations (translation, rotation, scaling, etc), windows and clipping; 2D and 3D object representation, 3D transformations, 3D viewing; parallel and perspective projections; Hidden lines and hidden surface removal; Mathematical representations of lines, curves and surfaces; Wire-frame and solid modeling.

References:

- Computer Graphics, D. Hearn, M.P. Baker, Prentice Hall,1986
- Application of Computer Graphics for Engineers, V.B. Anand, John Wiley & Sons, Inc.

ME-515 Measurements and Instrumentation

Compulsory	No
Credits	3 (Theory: 2, Lab: 1)
Prerequisite	Nil
Course Format	Three hrs of lectures per week, three hours of lab work per week

General measurement system, Static and dynamic characteristics of measurements systems, Error analysis, Loading effects and two port network modeling, Signal and noise in measurement systems, Reliability analysis, Transducer elements, Motion measurement and seismic analysis, Force measurement, Pressure measurement, Temperature measurement, Flow measurement, Torque and shaft power measurement, Transducer interfacing.

References:

- Principles of Measurement Systems, 1995, Longmann Scientific & Technical Publishing.
- Measurement System, Application and Design, 1990, Ernest O. Doeblin, McGraw-Hill Publishing International.

ME-516 Applied Solid Mechanics

Compulsory	Yes
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Review of fundamental units. Tensor Analysis. Laws of equilibrium. Free body diagrams. Stress and Strain Tensor. Elastic and plastic behavior of materials. Stress strain and deflection. Generalized hooks law. Energy stored due to deformation. Compatibility equations. Saint-Venant's principle. Stress concentration factors. Principal stresses/directions. Thermal stresses. Stress invariants. Hydrostatic stress. Deviatoric stresses. Mohr circles. Moments of inertia. Shear force and bending moment diagrams. Pure bending of beams. Deflection of beams. Loading of beams. Stresses and strains in beams. Torsion. Hollow and compound shafts. Theory of columns. Thin walled and thick walled cylinders. Material properties used in mechanics. Failure criteria Stress Analysis of pressure vessels.

References:

- Beer Johnston, Mechanics of Materials, 4th ed, 2005
- Benham, Crawford, Mechanics of Engineering Materials, 1996.
- Warnock, Mechanics of Solids & Strength of Materials, 1970
- Timoshenko & Young, Engineering Mechanics, McGraw Hill, 1951.
- Timoshenko & Goodier, Theory of Elasticity, McGraw Hill, 1970.

ME-518 Design of Machine Elements – I

Compulsory	Yes
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Engineering design fundamentals, CAD/CAM, Equilibrium of forces and moments, factor of safety, measurement of material properties, static failure, fatigue failure, fracture, design of tension members, design of compression members, design of members in twisting, design for combined loads, beam applications.

References:

- K.S. Edwards Jr, Fundamentals of Mechanical Component Design, McGraw Hill, 1991.
- R.L. Norton, Machine Design an Integrated Approach, 3rd ed, 2005, Prentice Hall.
- M.F. Ashby, Material Selection in Mechanical Design, 3rd ed, Butterworth-Heinemann, 2005.

ME-519 Design of Machine Elements – II

Compulsory	No
Credits	3
Prerequisite	ME-518
Course Format	Three hrs of lectures per week

Design with composites, bolts nuts and joints, spring design, stresses in springs, compression springs, extension springs, spring washers, design of welded components, bearing selection, sliding-contact bearing, rolling-contact bearings, bearing mountings and lubrication, belt drives; Tribology.

References:

- K.S. Edwards Jr, Fundamentals of Mechanical Component Design, McGraw Hill, 1991.
- R.L. Norton, Machine Design an Integrated Approach, 3rd ed, 2005, Prentice Hall.
- M.F. Ashby, Material Selection in Mechanical Design, 3rd ed, Butterworth-Heinemann, 2005.

ME-522 Computer-Aided Design & Manufacturing

Compulsory	No
Credits	3 (2+1)
Prerequisite	Nil
Course Format	Two hours of lectures and three hours of lab (use of CAD software) per week

Introduction to Drawing & drafting, Hands-on practice on available engineering drawing software, methods of obtaining design of various components, solid modeling, parametric design, introduction to rapid prototyping, virtual engineering, integration of CAD-CAM, product development process.

References:

- A.D. Dimarogonas, Machine Design A CAD Approach, John Wiley, 2001
- P.N. Rao., CAD/CAM, Principles & Applications, 2nd ed., McGraw Hill, 2001
- C. McMahon, J. Browne, CAD/CAM, Principles, Practices & Manufacturing Management, 2nd ed, Pearson Edu. 2005
- User guides and reference materials of the available engineering software

ME-601 Theory of Elasticity

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Review of concepts of stress & strain, Index notation, Plane stress and plane strain, Two dimensional problems in rectangular coordinates and polar coordinates, Two dimensional problems in curvilinear coordinates, Analysis of stress and strain in three dimensions, General theorems, Elementary problems of elasticity in three dimensions, Torsion, Bending of bar, Thermal stress, Application of finite difference equation in elasticity

References:

- Theory of Elasticity, 3rd ed., S. P. Timoshenko and J. N. Goodier, McGraw-Hill Book Company, 1987.
- Foundations for the Nonlinear Theory of Elasticity, V. V. Novozhilov Dover Pubns.
- Fundamentals of Engineering Elasticity, S. F. Borg Stevens Inst. Tech.

ME-602 Fracture Mechanics

Compulsory	No
Credits	3
Prerequisite	ME-505
Course Format	Three hrs of lectures per week

Basic problems and concepts, Mechanisms of fracture and crack growth. The elastic crack-tip stress field, The crack tip plastic zone, The energy principle, Dynamics and crack arrest, Plane strain fracture toughness, Plane stress and transitional behavior, Elastic-plastic fracture, Fatigue crack propagation, Fracture resistance of maltreats, Fail-safety and damage tolerance, Determination of stress intensity factors, Practical problems, Fracture of structures, Stiffened-sheet structures, Prediction of fatigue crack growth.

References:

- Elementary Engineering Fracture Mechanics, David Broek, Martinus Nijhoff Pub, 4th ed.
- Failure Analysis of Engineering Materials C. R. Brooks, A. Choudhury The McGraw-Hill Companies 2001
- Failure Analysis of Brittle Materials, Van Derck FrGechette, The American Ceramic Society, 1990.

ME-603 Non-Linear Finite Element Method

Compulsory	No
Credits	3
Prerequisite	ME-503, EE-503
Course Format	Three hrs of lectures per week

General problems in solid mechanics and non-linearity, Solution of non-linear algebraic equations, Inelastic and non-linear materials, Plate bending approximation, Thin Kirchhoff plates and C^1 continuity requirements, Thick Reissner-Midlin plates, Irreducible and mixed formulations, Shells as an assembly of flat elements, Axisymmetric shells, Shells as a special case of three dimensional analysis, Reissner-Mindlin assumptions, Semi-analytical finite element processes, Use of orthogonal functions and finite strip methods, Geometrically non-linear problems, Finite deformation, Nonlinear structural problems, Large displacement and instability, Pseudo-rigid and rigid flexible bodies, Computer procedures for finite element analysis.

References:

- The Finite Element Method, Vol-2: solid mechanics, 5th ed., O.C. Zienkiewcz, R.L. Taylor, Butterworth and Heinemann, 2002.
- Non-linear Continuum Mechanics for Finite Element Analysis, J. Bonet, R.D. Wood, Cambridge University Press, 1997
- Classical and Computational Solid Mechanics, Y. C. Fung.

- Handbook of Computational Solid Mechanics: Survey and Comparison of Contemporary Methods, Micha Kleiber, Michal Kleiber, Adam Borkowski, Springer Verlag, Oct. 1998

ME-604 Theory of Plasticity

Compulsory	No
Credits	3
Prerequisite	ME-601
Course Format	Three hrs of lectures per week

Stress strain curve, General theorems, Solution of plastic-elastic problems, Plane plastic-strain and theory of the lip-line field, Two-dimensional problems of steady motion, Non-steady motion problems in two dimensions.

Reference:
- The Mathematical Theory of Plasticity, by R. Hill, Oxford at the Clarendon press, 1985

ME-605 Microelectromechanical Systems (MEMS)

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Introduction to MEMS: Fundamentals of MEMS design, analysis and fabrication. Materials and manufacturing of MEMS: Basic IC-processing. Engineering mechanics of microsystem design: Residual stresses, Static bending of thin plates, Mechanical vibration, Thermomechanics, Fracture mechanics, Thin-film mechanics, General material considerations. Scaling laws in MEMS. Sensors: Force and pressure sensors, resonant sensors, Thermofluid sensors. Actuators: Fundamentals of microactuation. Parallel plate electrostatic actuation. Electrostatic pressure, Comb drive actuator. Mathematical modeling: Kinematics and kinetics of MEMS. Determination of force components, Analysis of dynamic effects and frictional effects in MEMS. Design of MEMS: CAD and FEM for MEMS. Hands on practice using available MEMS software. MEMS Packaging. Introduction to Nanotechnology. Future trends in MEMS/NEMS.

References:
- Introduction to Microelectromechanical Systems Engineering, N Maluf, 2000.
- MEMS & Microsystems: Design and Manufacture, T-R Hsu, McGraw Hill, 2002
- Mechanical Microsensors, M Elwenspoek, R Wiegerink, Springer-Verlag, 2001
- Microsystem Design, S D Senturia, Kluwer, 2001
- The MEMS Handbook, M. Gad-El-Hak, CRC Press, 2001

ME-606 Boundary Element Method

Compulsory	No
Credits	3
Prerequisite	ME-503
Course Format	Three hrs of lectures per week

Introduction to boundary solutions, Fundamental solutions, Weighted residual methods, Potential problems, Solution to Laplace, Poisson's and Helmoltz equations, Non-homogeneous solids, Linear elasticity problems, Anisotrpoic elasticity, Coupling of Finite and Boundary elements, Singular elements for fracture mechanics.

References:
- Brebbia, C.A, The Boundary Element Method for Engineers, Pentech, 1984.
- Brebbia, C.A. and J. Dominguez, Boundary Elements, An Introductory Course, McGraw-Hill, 1989.

ME-607 Finite Element Programming

Compulsory	No
Credits	3
Prerequisite	ME-503
Course Format	Three hrs of lectures per week

Implementation of FEM, Development of general geometry-based code, Higher order adaptive techniques, Effective construction of element matrices, Ordering of the unknowns, Automatic mesh generation and refinement, adaptive mesh refinement, Program and database structures, Object oriented FEM.

References:
- Programming the Finite Element Method, 3rd ed., Smith, I.M., Griffith, D.V., J. Wiley & Sons, Chichester, 1998.
- Object Oriented Methods and Finite Element Analysis, Mackie, R.I., Saxe-Coburg Publications, 2001.
- Handbook of Grid Generation, ed. J.F. Thompson, B.K. Soni, N.P. Weathrill, CRC Press, 1999.

ME-608 Plates and Shells

Compulsory	No
Credits	3
Prerequisite	ME-518, ME-601
Course Format	Three hrs of lectures per week

Preliminaries of linear, three-dimensional elasticity theory, Reduction of the elasticity theory to theories of plates and shells, Anisotropy, Nonlinear theories, Effects of discontinuities on the stress distribution in plates and shells, Design construction features of plates and shells, Applications.

References:

- Theory and Design of Modern Pressure Vessels, 3rd ed, J.F. Harvey, Van Nostrand, Reinhold Co., New York.

ME-609 Theory of Compressible Flow

Compulsory	No
Credits	3
Prerequisite	ME-404 or ME-402
Course Format	Three hrs of lectures per week

General equations of compressible flow, Specialization to inviscid flows in 2D, Linearized solution in subsonic and supersonic flow, Characteristic equations for supersonic flow with applications in external and internal flow, 1D nonsteady compressible flow, Introduction to Transonic flow.

References:

- Mathematical and Computational Methods for Compressible Flow, Miloslay Feistauer, Irvan Straskraba, Jiri Felcman, Oxford University Press; (October 2003)
- Compressible Flow, Stephan, Schreier, John Wiley and Sons, Jan 1982

ME-610 Turbo-Machinery Theory

Compulsory	No
Credits	3
Prerequisite	ME-504, CME-535 Or Instructor's consent
Course Format	Three hours of lectures per week

Introduction to turbo-machinery, elementary theory, propulsion, shaft power cycles, ideal cycles, methods of accounting for component losses, design of point performance calculations, comparative performance of practical cycles, combined cycles and cogeneration schemes, closed cycle gas turbine, turbojet, turbofan, turboprop and turboshaft engines, auxiliary power units, thrust augmentation, air breathing engines, simple compressible system, parametric cycle analysis of ideal engines, variation in gas properties, component performance, inlet and outlet pressure recovery, compressor and turbine efficiencies, burner efficiency and pressure loss, exit nozzle loss.

References:

- Saravanamuttoo, Rogers & Cohen, Gas Turbine Theory, 5th ed, Pearson, 2001.
- J.D. Mattingley, Elements of Gas Turbine Propulsion, International edition, McGraw Hill, 2005
- R.S.R. Gorla, A.A. Khan, Turbo-machinery design and theory, Marcell Dekker, 2003.

ME-611 Turbo-Machinery Design

Compulsory	No
Credits	3
Prerequisite	ME-610 or Instructor's consent
Course Format	Three hours of lectures per week

Principle of operation of gas turbines, work done and pressure rise, diffuser, compressibility effects, non-dimensional quantities for plotting compressor characteristics, computerized design procedures, factors affecting stage pressure ratio, degree of reaction, 3D flow, design process, blade design, calculation of stage performance, vortex theory, choice of blade profile, pitch and chord, blade cooling, radial flow turbine, off design performance of single shaft gas turbine, free turbine engine and jet engine, incorporation of variable pressure losses, prediction of performance of turbo-machinery.

References:

- C.A. Norman, R.H. Zimmerman, Introduction to Gas Turbine and Jet Propulsion Design, Harper & Brothers, 1948.
- D.G. Wilson, the Design of high efficiency turbo-machinery and gas turbines, Prentice Hall, 1998
- Boyce, Gas Turbine Engineering Handbook, 3rd ed., GPP. 2006.
- J.D. Mattingley, Aircraft engine design, AIAA Education series. 2002

ME-690 Special Topics in Mechanical Engineering I

Compulsory	No
Credits	3
Prerequisite	Instructor's consent
Course Format	Three hrs of lectures per week

ME-691 Special Topics in Mechanical Engineering II

Compulsory	No
Credits	3
Prerequisite	Instructor's consent
Course Format	Three hrs of lectures per week

ME-692 Special Topics in Mechanical Engineering III

Compulsory	No
Credits	3
Prerequisite	Instructor's consent
Course Format	Three hrs of lectures per week

All of these ***Special*** courses (ME-690 – ME-692) will be designed to accommodate such special topics in the field of mechanical engineering that are not presently covered under other titles described here. The course will be designed and updated to keep pace with the emerging technologies in the field of mechanical engineering. The course will include lectures by visiting faculty on such advanced topics that may not be taught under other titles described here. Courses offered under the title of Special Topics will be approved by either the Board of Studies or three senior faculty members of the department. A same course can be offered at most for two years only, meanwhile it will be approved through the approved channel as a regular course.

ME-697 MS Thesis Research

Compulsory	Yes
Credits	6 + 9
Prerequisite	Nil
Course Format	Thesis work

The thesis will start during the fourth semester with 3 credit hours and will continue in fifth semester with nine credit hours. The student will undertake an in-depth study of some mechanical engineering related problem. This will be done either by joining an on-going research program, or by initiating a new program under the guidance of a PIEAS faculty member. The nature of the thesis may be research, development or design and may involve experimental, theoretical, or computational work or a combination of these. Each student will be assigned a 'Thesis supervisor' from the PIEAS faculty. 'Co-supervisors' may also be assigned, depending on the nature of the work. The supervisor and co-supervisors will guide, instruct and supervise the student in their thesis work. They will also be responsible for reporting the grade of the student based on their evaluation. In this evaluation they may be aided by committee of experts to be appointed by the Department Head. The student shall write a comprehensive report and shall deliver at least one seminar before the end of each semester. The report and the seminar shall also be used in the overall evaluation of the student. Normally, this thesis is to be completed by the end of fifth semester. However, if the supervisor/s feels that more time is needed for the satisfactory completion of the thesis, the duration may be extended beyond the end of the semester.

CME-501 Advanced Engineering Mathematics

Compulsory	Yes
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Matrix Algebra and its application; Partial derivatives of explicit and implicit functions; Maxima and minima of several variables; Double and triple integrals; Solution of linear differential equations, Series solution, Special functions; Laplace and Fourier transforms, Error function; Partial differential equations; Vector algebra, Tensor Calculus.

References:

- Calculus; A New Horizon, Anton, Howard, John Wiley, 1998
- Calculus, Swokowski, E.W. et al., Brooks / Cole Publishing, 2000
- Introduction to Differential Equations, Zill, D.G, Brooks / Cole Publishing, 2000

CME-504 Mechanical Metallurgy

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Elasticity and stress-strain relations, Shear stress and plastic deformation, Critical resolved shear stress for slip, Slip systems, Generation and mutual interactions of dislocations, Tension test, compression and hardness testing, Types of fracture, Impact testing, Cold working, Hot working, Recovery, Recrystallization, Grain Growth, Forging, Rolling, Extrusion, Creep deformation, Primary, secondary and tertiary stages of creep, creep rupture, Grant-Monkman rule, Fatigue failure, Stress cycles and S-N curve, Stages of fatigue. Tribology: Friction, Wear and Lubricants

References:

- Hertzberg, R. W. : Deformation and Fracture Mechanics of Engineering Materials, John Wiley, 1996
- Dieter, G. E.: Mechanical Metallurgy, McGraw-Hill, 1988
- Collins, J.A., 'Failure of Materials in Mechanical Design', John-Wiley, 1981
- Felbeck, D.K. and Atkins, A.G., 'Strength and Fracture of Engineering Solids, Prentice-Hall, 1884

CME-614 Computational Fluid Dynamics

Compulsory	No
Credits	3
Prerequisite	ME-404
Course Format	Three hrs of lectures per week

General Differential Equations; Numerical solution of energy and Navier-Stokes equations; Numerical schemes and algorithms; Methods of obtaining convergence; Transient analysis; Finite difference and finite element methods applied to fluid mechanics; Matrix solving Techniques; Recent developments in CFD; Development if computer programs for CFD.

Reference:

- Patankar, S.V., Numerical Heat Transfer and Fluid Flow, Hemisphere, 1980

CME-618 Turbulence Modeling and Grid Generation

Compulsory	No
Credits	3
Prerequisite	EE-503, ME-404
Course Format	Three hrs of lectures per week

Turbulence Modeling: Turbulent flows; laminar/turbulent transition, turbulent boundary layers, separated flows, Nature of turbulence, Statistical description, Length scales, turbulent transport, Reynolds-averaged Navier-Stokes equations, turbulent closures, Reynolds stress, Kinetic energy balances, turbulence models; Application in CFD; large eddy simulation, Measurements and model evaluation.
Grid generation: Introduction; geometry modeling surface grids; algebraic mesh generation; structured meshes from partial differential equation; automatic generation of unstructured meshes; multi block mesh generation; unstructured grids by default triangulation; mesh adaptation on unstructured grids; unstructured grid for viscous flows.

References:

- Engineering calculation methods fro turbulent flows, Bradshaw, P., Cebecci, T., Whitelaw, J.H., Academic Press.
- Grid generation, Thompson, M., John Wiley, 1988.

EE-503 Numerical Methods

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

System of non-linear algebraic equations; Eigenvalues and eigenvectors; Higher order differential equations and system of first order differential equations; Numerical algorithms for the determinations of the state-transition matrix of the system of differential equations; Partial differential equations. Finite element techniques; Recent developments in Approximate Methods.

References:

- Faires, J.D. and RLBurden, Numerical Methods, Prindle, Weber and Schmidt, 1993.
- Burden, R.L., et al, Numerical Analysis, Prindle, Weber and Schmidt, 1993.
- Brebbia, C.A. and AJ. Ferrante, Computational Methods for Solution of Engineering Problems, Pentech, 1986.

NE-501 Fundamentals of Nuclear Engineering

Compulsory	Yes
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Role and importance of nuclear energy; Nuclear cross-sections, Reaction rates, Nuclear fission and chain reaction, criticality conditions, Conversion and breeding, Reactor components and their characteristics, Classification and design features of research, production and power reactors, Introduction to fast and fusion reactor systems. Different types of fuel cycles, Core and feed-material preparations, Uranium enrichment, Fabrication of fuel, Reprocessing of irradiated fuel, Process waste disposal, Reactor fuel requirements, Burnup studies of nuclear fuels, Fuel cycle performance of commercially available reactors, In-core fuel management and fuel management strategies.

References:

- Introduction to Nuclear Engineering, J. R. Lamarsh, Addison-Wesley, 1983.
- Nuclear Reactor Engineering, S. Glasstone, A. Sesonke, D Van Nostrand, 1981.
- Introduction to Nuclear Engineering, I. U. Rahman, P. S. Sheikh, Krieger, 1981.
- Nuclear Fuel Management, H. W. Graves Jr., John Wiley, 1979.

CME-413 Fundamentals of Radiation Protection

Compulsory	No
Credits	4 (Theory: 3 ; Lab: 1)
Prerequisite	Nil
Course Format	3 hrs of lectures per week + 42 hrs of lab-work in the semester

Radiation sources; interaction of radiation with matter; basic principles of radiation detection; Radiation detectors & their applications; Nuclear Instrumentation; Radiation units, natural & man made radiation sources; Elementary biology & biological effects of radiation; Standards of radiation protection; Calculation of exposure & dose; Attenuation coeff & buildup factors for gamma rays; Shielding of sources with different geometrical shapes; Shields with internal sources; Multi-layered shields; Concept of removal cross-section; Removal-attenuation & removal diffusion calculations; Dispersion of effluents from nuclear facilities; Radiation doses from nuclear plants.

References**:**

- Knoll, G. F, Radiation detection and measurement, John Wiley 1989
- Lamarsh, J. R, Introduction to nuclear engineering, Addison Wesley, 1983.

NE-529 Project Management

Compulsory	No
Credits	3
Prerequisite	Nil
Course Format	Three hrs of lectures per week

Management principles; Management of project planning, financing and implementation; Project evaluation techniques including ratio analysis, break-even analysis, liquidity analysis, and sensitivity analysis; Public sector project approval process; Project cycle; Siting and environmental considerations; Regulatory control and licensing; Safety analysis reports; Regulatory bodies; Public information. Types of contracts; Contract administration and tendering; Technical bid evaluation and award of contracts; Project implementation; Network analysis; Quality assurance, quality control and quality surveillance; Plant acceptance testing; Staffing for plant operation and maintenance.

References:

- Khan, A.Q.: Project Management, CNS, 1993.
- Pederson, E.S.: Nuclear Power, Volume 2, Ann Arbor, 1978.
- Hajek, V.G.: Management of Engineering Projects, McGraw-Hill, 1984.
- Baumgartener, J.S.: Project Management, R.D.Irwin, 1963

NE-612 Boiling Heat Transfer and Two Phase Flow

Compulsory	No
Credits	3
Prerequisite	ME-404
Course Format	Three hrs of lectures per week

Analysis of boiling and condensation phenomena; Heat transfer rates in pool and flow boiling; Two phase flow: basic concepts, void-quality analysis, pressure losses; Flow instability, Critical flow; Instrumentation; Boiling water reactor core analysis.

References:

- Lahey, RT., Jr. The Thermal-hydraulics of a Boiling Water Nuclear Reactor, ANS, 1977.
- Rust, J.H, Nuclear Power Plant Engineering, Haralson, 1979.
- El-Wakil, M.M., Nuclear Heat Transport, International Textbook, 1971.
- Wallis, G.B., One Dimensional Two Phase Flow, McGraw-Hill, 1969.