CURRICULUM FOR B.SC. MECHANICAL ENGINEERING
(SESSION 2018 ONWARD)

Course No. and Title		Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
1.	**Knowledge Area-Humanities (10 Credit Hours)**					
IS 101	Islamic Studies	3	0	3	0	None
HU 101	Languages	0	0	0	0	None
IS 201	Pakistan Studies	3	0	3	0	None
HU 111	Communication Skills	0	3	0	1	None
HU 221	Technical Writing & Presentation Skills	3	0	3	0	None
2.	**Knowledge Area-Management (8 Credit Hours)**					
MGT 315	Professional Ethics & Engineering Entrepreneurship	2	0	2	0	None
MGT 316	Project Management and Engineering Economics	2	0	2	0	None
ME 371	Production & Operation Management	2	0	2	0	None
ME 381	Health Safety and Industrial Environment	2	0	2	0	None
3.	**Knowledge Area-Natural Sciences (17 Credit Hours)**					
Phy 119 & Phy 119L	Engineering Physics	2	3	2	1	None
MA 113	Calculus and Analytic Geometry	3	0	3	0	None
MA 129	Vector and Complex Analysis	3	0	3	0	None
MA 225	Differential Equations and Transforms	3	0	3	0	None
MA 242	Engineering Statistics	2	0	2	0	None
MA 345 & MA 345L	Numerical Methods	2	3	2	1	None
4.	**Knowledge Area-Computing (3 Credit Hours)**					
CS 101 & CS 101L	Computing Fundamentals	2	3	2	1	None
5.	**Knowledge Area-Engineering Foundation (37 Credit Hours)**					
ME 100L	Workshop Practice	0	3	0	1	None
ME 111 & ME 111L	Thermodynamics-I	3	3	3	1	None
ME 121	Engineering Statics	2	0	2	0	None
ME 122	Engineering Graphics	2	0	2	0	None
ME 122L	Engineering Drawing	0	3	0	1	None
ME 123 & ME 123L	Engineering Dynamics	3	3	3	1	ME 121
ME 131	Industrial Materials	2	0	2	0	None
ME 211	Fluid Mechanics-I	2	0	2	0	None
ME 212 & ME 212L	Thermodynamics-II	3	3	3	1	ME 111
ME 213	Fluid Mechanics-II	3	0	3	0	ME 211

ME 221 & ME 221L	Mechanics of Materials-I	3	3	3	1	ME 123
ME 222 & ME 222L	Mechanics of Machines	3	3	3	1	ME 123
ME 231 & ME231L	Manufacturing Processes	2	1	3	3	None
ME 214L	Fluid Mechanics Lab	0	3	0	1	ME 213
6.	**Knowledge Area-Major Based Core (52 Credit Hours)**					
ME 311 & ME 311L	HVAC	3	3	3	1	ME 212
ME 361 & ME 361L	Energy Resources & Utilization	3	1	3	1	None
ME 321	Mechanics of Materials -II	3	3	3	1	ME 221
ME 223 & ME 223L	Machine Design and CAD-I	3	3	3	1	ME 122L
ME 322 & ME 322L	Machine Design and CAD-II	3	3	3	1	ME 223
ME 331 & ME 331L	Machine Tools and Machining	2	3	2	1	ME 100L
ME 332 & ME 332L	Metrology and Quality Assurance	2	3	2	1	MA 242
ME 411 & ME 411L	Power Plants	2	3	2	1	ME 212
ME 412 & ME 412 L	Heat & mass Transfer	3	1	3	1	ME 212
ME 413 & ME 413L	IC Engines	2	3	2	1	ME 212
ME 461	Energy Conservation & Management	2	0	2	0	ME 361
ME 421 & ME421L	Mechanical Vibrations	2	1	2	1	ME 222
ME 341 & ME 341L	Control System	2	3	2	1	EE 201
ME 451 & ME 451L	Finite Element Analysis	2	3	2	1	None
ME 4 - -	Elective-I	2	0	2	0	None
ME 4 - -	Elective-II	3	0	2	0	None
7.	**Interdisciplinary Engineering Breadth (3 Credit Hours)**					
EE 201 & EE 201L	Electrical Engineering and Electronics	2	3	2	1	None
8.	**Senior Design Project (6 Credit Hours)**					
ME 498L	Project I	0	9	0	3	
ME 499L	Project II	0	9	0	3	ME 498L

PROPOSED SEMESTER WISE SCHEME OF STUDIES FOR B.SC. MECHANICAL ENGINEERING (SESSION 2018 ONWARD)

1st Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
HU 111	Communication Skills	0	1	0	3	
MA 113	Calculus and Analytic Geometry	3	0	3	0	
Phy 119 & Phy 119L	Engineering Physics	2	1	2	3	
CS 101 & CS 101L	Computing Fundamentals	2	1	2	3	
ME 111 & ME 111L	Thermodynamics-I	3	1	3	3	
ME 121	Engineering Statics	2	0	2	0	
ME 131	Industrial Materials	2	0	2	0	
	Total:	**14**	**4**	**14**	**12**	

2nd Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
IS 101	Islamic Studies	3	0	3	0	
MA 129	Vector and Complex Analysis	3	0	3	0	
ME 100L	Workshop Practice	0	1	0	3	
ME 122	Engineering Graphics	2	0	2	0	
ME 122L	Engineering Drawing	0	1	0	3	
ME 123 & ME 123L	Engineering Dynamics	3	1	3	3	ME 121
HU 121	Technical Writing & Presentation Skills	3	0	3	0	
	Total:	**14**	**3**	**14**	**9**	

3rd Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
EE 201 & EE 201L	Electrical Engineering and Electronics	2	1	2	3	
IS 201	Pakistan Studies	3	0	3	0	
MA 225	Differential Equations and Transforms	3	0	3	0	
ME 211	Fluid Mechanics-I	2	0	2	0	
ME 221 & ME 221L	Mechanics of Materials-I	3	1	3	3	ME 123
ME 231 & ME231L	Manufacturing Processes	2	1	3	3	
	Total:	**15**	**3**	**15**	**9**	

4th Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
MA 242	Engineering Statistics	2	0	2	0	
ME 212 & ME 212L	Thermodynamics-II	3	1	3	3	ME 111
ME 213	Fluid Mechanics-II	3	0	3	0	ME 211
ME 222 & ME 222L	Mechanics of Machines	3	1	3	3	ME 123
ME 223 & ME 223L	Machine Design and CAD-I	3	1	3	3	ME 122L
ME 214L	Fluid Mechanics Lab	0	1	0	3	ME 211
	Total:	**14**	**4**	**14**	**12**	

5th Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
ME 381	Health Safety & Industrial Environment	2	0	2	0	
ME 311 & ME 311L	HVAC	3	1	3	3	ME 212
ME 361	Energy Resources and Utilization	3	0	3	0	
ME 321	Mechanics of Materials-II	3	1	3	3	ME 221
ME 331 & ME 331L	Machine Tools and Machining	2	1	2	3	ME 100L
MGT-315	Professional Ethics & Engineering Entrepreneurship	2	0	2	0	
	Total:	**15**	**3**	**15**	**9**	

6th Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
MGT 316	Project Management & Engineering Economics	2	0	2	0	
MA 345 & MA 345L	Numerical Methods for Engineers	2	1	2	3	
ME 322 & ME 322L	Machine Design and CAD-II	3	1	3	3	ME 223
ME 332 & ME 332L	Metrology and Quality Assurance	2	1	2	3	MA 242
ME 341 & ME 341L	Control Systems	2	1	2	3	EE 201
ME 361L	Energy Resources and Utilization Lab	0	1	0	3	
	Total:	**11**	**5**	**11**	**15**	

7th Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
ME 411 & ME 411L	Power Plants	2	1	2	3	ME 212
ME 412 & ME 412L	Heat and mass Transfer	3	1	3	3	ME 212
ME 471	Production and Operations Management	2	0	2	0	
ME 451 & ME 451 L	Finite Element Analysis	2	1	2	3	
ME 498L	Project I	0	3	0	9	
ME 4 - -	Elective-1	2	0	2	0	
	Total:	**11**	**6**	**11**	**18**	

8th Semester

Course No.	Title	Contact Hrs		Credit Hrs		Pre-requisite
		Th	Lab	Th	Lab	
ME 413 & ME 413L	IC Engines	2	1	2	3	ME 212
ME 461	Energy Conservation and Management	2	0	3	0	ME 361
ME 421 & ME 421L	Mechanical Vibration	2	1	2	3	ME 222
ME 499L	Project II	0	3	0	9	ME 498L
ME 4 - -	Elective-II	3	0	3	0	
	Total:	**9**	**5**	**9**	**15**	
	Grand Total:	**104**	**32**	**104**	**96**	
		136		**200**		

DETAIL OF COURSES FOR B.SC. MECHANICAL ENGINEERING
(SESSION 2018 ONWARD)

IS 101 Islamic Studies 3(3,0)

It is a university level course. The contents are designed by the Department of Islamic Studies.

IS 201 Pakistan Studies 3(3,0)
It is a university level course. The contents are designed by the Department of Islamic Studies.

HU 101 Languages 0 (0, 0)
It is a university level course. The contents are designed by the Department of Humanities.

HU 111 Communication Skills 1(0,1)

It is a university level course. The contents are designed by the Department of Humanities.

HU 121 Technical Writing & Presentation Skills 3(3,0)

It is a university level course. The contents are designed by the Department of Humanities.

Phy 119 & Phy 119L Engineering Physics 3(2,1)

Introduction: Scientific notation and significant figures. Units in different systems. Vectors: Review of vectors, Vector derivatives, Line and surface integrals, Gradient of scalar. Mechanics: Coordinate systems. Motion under constant acceleration, Newton laws and their applications, Uniform circular motion. Vortex Motion, Frictional forces. Work and energy. Potential energy, energy conservation, energy and our environment.
Electrostatic and magnetism: Coulomb's law, Gauss's law, Electric field around conductors, Dielectrics. Magnetic fields. Magnetic force on current. Semiconductor Physics: Energy levels in a semiconductor, Hole concept, Intrinsic and extrinsic regions, Law of mass action, P-N junction, Transistor.
Waves and Oscillation: Free oscillation of systems with one degree of freedom, Classical wave equation. Transverse modes for continuous string. Standing waves. Dispersion relation for waves. Optics and Laser: Basic introduction to Optics and Laser. Diffraction grating. Lasers, Population inversion. Resonant cavities. Quantum efficiency. He-Ne, Ruby and CO_2 lasers.
Modern Physics: Photoelectric effect, Compton Effect, Bohr theory of hydrogen atom, atomic spectra, reduce mass, De-Broglie hypothesis Braggs law, Electron microscope, Zeeman effect, Atomic nucleus, Mass energy relation, Binding energy, Nuclear forces and fundamental forces, Exponential decay and half-life.

Recommended Books:

1. Fundamentals of Physics, Halliday, Resnick and Walkers.
2. Applied Physics (University Physics), Zears, Zemansky and Young
3. Physics for scientist and Engineers with Modren Physics, Dougles C. Giancol,

MA 113 Calculus and Analytic Geometry 3(3,0)

Pre-requisite: Derivative of a function; Differentiation; Rules of differentiation; Differentiation of algebraic, trigonometric, inverse trigonometric, exponential and logarithmic functions; Differentiation of implicit functions; Anti-derivatives; Integration; Basic techniques of integration; Algebra of vectors; Scalar and vector products; Determinants and their properties.

Contents: A review of differentiation: Geometrical interpretation of a derivative; Infinitesimal; Differential coefficient; Derivatives of higher order; Indeterminate forms and L. Hopital's rule; Asymptotes; Curvature; Increasing and decreasing functions; Maxima and minima of a function. Approximation and error estimates.
Further techniques of Integration; Integration by reduction formula; Fundamental Theorem of Integral Calculus; Definite integral and its properties; Area enclosed between curves; Arc length; Volume of a solid; Volume of a solid of revolution; Area of surface of revolution; Moments; Centroids.
Cartesian, cylindrical and spherical coordinates; The ratio formula; Equations of a straight line in R^3; Direction ratios and direction cosines; Angle between two straight lines, Distance of a point from a line; Equations of a plane; Angle between two planes; Shortest distance between two skew lines; The sphere; Directional derivatives.
The concept of limit, continuity and differentiation in functions of several variables; Geometric interpretation of partial derivatives; Total differential; Chain rule; Implicit differentiation; Maxima and minima of functions of two independent variables. Taylor's and Maclaurin's series for functions of two variables.
Double Integration; Fubini's Theorems; Change of order; Geometrical Interpretation of double integral; Applications to find volumes and areas.

Recommended Books:

1. "Calculus" Thomas & Finny published by Addison Wesley
2. "Mathematics for Engineers and Scientists" Muhammad Iqbal Bhatti and Muhammad Nasir Ch., published by Allied Book Centre, Urdu Bazar Lahore.
3. "Advanced Engineering Mathematics" E. Kreyszig, published by John Wiley & Sons,
4. "Calculus" Howard Anton.
5. "Calculus" Swokowski.

MA 129 Vector and Complex Analysis 3(3,0)

Pre-requisite: Algebra of vectors; Scalar and vector products, Complex numbers and their conjugates, Absolute value of a complex number and properties, Algebra of complex numbers; Polar form of a complex number.

Contents: A review of vector algebra, scalar and vector products: Scalar triple product, Vector triple product; Scalar and vector point functions; Differentiation and integration of vector point functions; Gradient of a function; Divergence, curl and their physical interpretations; Green's theorem in the plane; Gauss' divergence theorem and Stock's theorem; Cartesian tensors.
Polar and exponential forms of complex numbers; Product and quotient of complex numbers in polar form; Properties of complex numbers; Logarithm of a complex number; De Moivres Theorem, The nth roots of a number; Solution of equations; Circular and hyperbolic functions; Inverse hyperbolic functions; Limit, continuity and differentiability of complex functions; Analytic functions, Harmonic functions; Cauchy fundamental theorem and its consequences; Cauchy Integral formula; Derivatives of an analytic function; Singularities and calculus of residues; Contour integration.

Recommended Books:

1. "Advanced Engineering Mathematics" E. Kreyszig, published by John Wiley & Sons,

2. "Vector Analysis" M.R. Spiegel, McGraw – Hill Book Company.
3. "Elements of Complex Variables" Pennisi, L. L. Holt, Rinehart and Winston, U.S.A.
4. "Vector and Tensor Analysis" N.A. Shah, A–One Publishers, Urdu Bazar, Lahore.
5. "Mathematics for Engineers and Scientists" Muhammad Iqbal Bhatti and Muhammad Nasir Ch, published by Allied Book Centre, Urdu Bazar Lahore.

MA 225 Differential Equations and Transforms 3(3,0)

Pre-requisite: Rules and formulas of differentiation and integration,

Contents: Formation of differential equations; Solution of several types of first order differential equations; Orthogonal trajectories, Application in physical problems. Linear differential equations of second order, Complementary function and integral. Solution of non-homogeneous linear differential equations of second order and higher by (i) the method of undetermined coefficients (ii) the method of variation of parameters and (iii) the method of power series; Application of second order differential equations; System of differential equations.

Formation of partial differential equations; Equations reducible to ordinary differential equations; Equations of the form $Pp + Qq = R$; Solution by the method of separation of variables. Wave, heat and Laplace equations.

Introduction to Laplace transform: Laplace transform of elementary functions, Laplace transform theorems, Inverse Laplace transform, applications to the solutions of initial value problems, Convolution theorem and applications.

Periodic functions. Even and odd functions. Fourier series of functions of period 2π and arbitrary period; Half range series; Complex Fourier series, Fourier transform and applications

Recommended Books:

1. "Mathematics for Engineers and Scientists" Muhammad Iqbal Bhatti and Muhammad Nasir Ch, published by Allied Book Centre, Urdu Bazar Lahore.
2. "Advanced Engineering Mathematics" E. Kreyszig, published by John Wiley & Sons,
3. Elementary Differential Equations and Boundary Value Problems, Boyce and Diprima, , Wiley,
4. "Advanced Engineering Mathematics" H.K. Dass, published by S. Chand & Company, New Dehli.
5. "Ordinary Differential Equations" N.A. Shah, A-one publishers, Urdu Bazar, Lahore.

MA 242 Engineering Statistics 3(3,0)

Introduction & role of statistics in engineering. Population & samples, Variables, Methods of displaying data sets, Stem & leaf display, Histogram, Histogram shapes, Boxplot, Bar chart, Pareto diagram, Dot diagram, Frequency distributions & their graphs, Outlier. Mean, Median, Quartile, Percentile, Range, Deviation from mean, Sample variance, Sample standard deviation, Coefficient of variation.

Probability, Concepts & definitions, Basic theorems of probability, Law of total probability, Bayes theorem, Discrete and continuous random variables and their probability distributions, Density and distribution functions; Expectation.

Mean & variance of discrete & continuous random variables, Binomial distribution, Poisson distribution, Normal distribution, t-distribution, Chi- square distribution, F-distribution.

Sampling techniques and sampling distribution; Point estimation and interval estimation of parameters, Least square linear & polynomial regression, Linearization of nonlinear models, Correlation, Design of experiments, Analysis of variance.

Recommended Books:

1. Applied Statistics for Engineers & Scientists by Devore/Farnum. Thomas.
2. Probability and Statistics for Engineers and Scientists, Ronald E. Walpole. Pearson Educational International.
3. Probability and Statistics for Engineering and Sciences. CENGAGE Learning.
4. Advanced Engineering Mathematics by Erwin Kreyszig. John and Viley and Sons.
5. Applied Statistics and Probability for Engineers by Montgomery, Runger, John and Viley and Sons.
6. Probability and Random Variables and Stochastic Processes, Papoulis Athanasios, McGraw-Hill Inc.
7. Introduction to Statistical Theory by Muhammad Shehzad and Sher Muhammad, Ilmi Kitab Khana Urdu Bazar Lahore.

MA 345 & MA 345L Numerical Methods in Computing 4(3,1)

Basic concepts: round-off errors, floating point arithmetic, Convergence, Solution of non-linear equations: Open methods, bracketing methods for locating roots, initial approximation and convergence criteria, Newton Raphson and Secant methods. Solution of linear simultaneous equations: Jacobi's method; Gauss-Seidle method.
Finite differences: Difference operators and tables; Differences of polynomials; Interpolation and polynomial approximation: Taylor series approximation, introduction to interpolation, Newton's polynomials, Newton's divided difference table and interpolation, Lagrange's interpolation, Chebyshev polynomials. Curve fitting: Least squares line, curve fitting, Interpolation by spline functions.
Numerical differentiation: approximating the derivative. Numerical integration: Introduction to quadrature, trapezoidal, composite trapezoidal and Simpson's rules. Solution of differential equations:Taylor series method, Euler's method, Runge Kutta methods.
Solution of partial differential equations: Hyperbolic Equations, Parabolic Equations, Elliptic equations. Computations: Numerical techniques in context of engineering applications and solutions of problems by using Matlab.

Recommended Books:

1. "Numerical Methods for Engineers" S. C Chapra & R. P Canale, McGraw-Hill.
2. "Numerical Methods using MATLAB" John H. Mathews, Pearson Education.
3. "Applied Numerical Methods for Engineers using MATLAB" Robert J. Schilling & Sandra L. Harris, Brooks/Cole.
4. "Numerical Methods for Engineers and Scientists" D. Joe Hoffman.
5. "A First Course in Numerical Analysis with FORTRAN and C." Saeed Akhtar Bhatti.

CS 101 & CS 101L Computing Fundamentals 3(2,1)

Introduction to Computer, Categories of Computer, Internet and world wide web, System Unit, Ports and Connections, Gates and Flip-Flops, Input & Output Devices, Storage System, Bit and Byte system, Binary, Decimal, Hexadecimal and Octa-decimal, System, Binary Operation, Applications Software, Communications & Networks, Steps in Program Development, Algorithms, Problem solving techniques, Pseudo code, Flow charts, Data analysis, Reports and Presentation with MS Office,
Introduction to MATLAB, MATLAB Applications in Mechanical Engineering, Class Project: Solving Specific Engineering Problems using MATLAB.
Bibliographic programs for citation and references (End Note, Latex, Mandalay)

Recommended Books

1. Computer Science and Overview, J. Glenn Brook Shear
2. Simple Program Design, Lesley Anne Robertson
3. Schaum Series, Visual Basic and Tutorials
4. Discovering Computers, Shelly Vermaat

EE 201 & EE 201L Electrical Engineering and Electronics 3(2,1)

Introduction to DC circuits, series and parallel circuits and analysis, AC current, resistance, inductance and capacitance in AC circuits, power factor, single and polyphase circuits, power and power factor measurement, current and voltage relationship in phase and line circuits, introduction to AC/DC motors and generators, transformers, losses and efficiency, introduction to semiconductors, diode, power amplifiers, transistors, relays, signal conditioning, operational amplifier.

Recommended books

1. Electrical Power Technology, Theodore Wildi
2. Electric Machinery Fundamentals, S. Chapman
3. Electric Circuits, Basic Electricity, Schaum's Series
4. Electronic Devices, Floyd, Prentice Hall
5. Electronic Principles , Malvino, A.Paul McGraw Hill

ME 100L Workshop Practice 1(0,1)

Machine Shop: Detailed study of center lathe and accessories. Plain and Taper turning. Basic lath operations including turning, facing, simple screw cutting/treading, knurling, Grooving (Drilling and Boring), cutting tools and their grinding. Brief Introduction of shaper, milling Sharing and Surface Grinding Machine. Assigning of Practical Jobs.
Fitting and Fabrication Shop: The use and care of fitter's tools. Marking out of job. Practice in Metal filing. Sawing, Drilling, dieing, Tapping and reaming. Brief introduction and use of power Hack Saw, Arbor Press, Sheet Sharing Machine, Sheet Rolling Machine, Punching Machine and Drilling Machine. Assigning of practical Jobs.
Carpentry Shop: The use and care of tools. Type of Timber, its defects and preservation methods practice in planning and sawing. Different types of wood joints. Study of sawing, planning, turning mortise and tenon machines. Assigning of Practical Jobs.
Electrical Shop: Electric shocks and treatment. The use and care of tools used by Electrician. Types and uses of cable and electrical accessories for house wiring, practice in simple house wiring, testing methods. Switch gear used on domestic installation and DB system. Earthing System. Assigning of Wiring arrangements practical.

Books recommended:

1. Workshop Technology part-1, W.A.J Chapman.
2. Electrical Wring , Richter and Schwan
3. Wiring Manual , Pak Cables Limited.

ME 111 & ME 111L Thermodynamics-I 4(3, 1)

Thermodynamics, system, continuum, properties, state, thermodynamic equilibrium, state postulate and its conclusions, process, cycle, zeroth law of thermodynamics, forms of energy, energy transfer by heat, energy transfer by work, moving boundary work and other forms of work, properties of pure substances, phase change processes of pure substance, critical and triple point, property diagrams for phase change processes, use of property tables, ideal gas equation, specific heats, Joule's law, internal energy, enthalpy and specific heats of perfect gases, liquids and solids, first law of thermodynamics, first law of thermodynamics applied to

non – flow processes, continuity equation, first law of thermodynamics applied to flow processes, steady flow energy equation and steady flow engineering devices, uniform state and uniform flow processes, second law of thermodynamics, statements, corollaries, thermodynamic temperature scale, reversible and irreversible processes, entropy and its application to non-flow and flow processes, temperature-entropy and enthalpy-entropy diagrams, generation of steam through boilers, classification, configurations and applications of boilers, boiler efficiencies, energy analysis of boilers, boiler Draughts, concept of steam condenser and its types, thermodynamic cycles, Carnot cycle, gas power cycles, vapor power cycles, vapor compression cycle

Recommended Books

1. Thermodynamics, An Engineering Approach, Y. A. Cengel and M. A. Boles
2. Applied Thermodynamics for Engineering Technologists, T.D. Eastop, A. McConkey
3. Basic Engineering Thermodynamic, Rayner Joel
4. Fundamentals of Engineering Thermodynamics, Moran, Shapiro

ME 121 Engineering Statics 2(2, 0)

Force System, force, rectangular components, moment, couples, resultant of forces, moments and couples (two and three-dimensional systems), equilibrium, mechanical systems, isolation and equilibrium equations for two and three-dimensional systems. Free body diagram, two forces and three force members, plane trusses, method of joints, method of sections, frames and machine analysis, distributed forces, flexible cables, friction, types of friction, dry friction, applications of friction.

Recommended Books:

1. Engineering Mechanics, Dynamics, R.C. Hibbeler and S.C. Fan, 14th Edition, Pearson,
2 Engineering Mechanics, Statics, J.L. Meriam and L.G. Kraig, , John Wiley & Sons,
3 Vector Mechanics for Engineers, Statics, Ferdinand P. Beer and E.Russell Johnston McGraw-Hill,

ME 122 Engineering Graphics 2(2, 0)

Introduction, types of lines, projections, types of projections, orthographic projections, plane of projections, four quadrants, projection of points, projection of straight lines, examples with different quadrants, traces of a line, true length of a line, inclination to both the planes, projection of oblique and auxiliary planes, loci of points and generated curves, Loci of points and straight lines, cycloid, epicycloid, involute, Archimedean spiral, development of solids, types of solids, poly-hedra, solids of revolution, prism, pyramid, cylinder, cone, sphere, intersection of surfaces, Intersection of cylinder and cylinder, cone and cylinder, cone and cone, cone and prism, projection of solids, projection of various solids in simple position and inclined positions, section of solids, true shape of section on auxiliary plane of various solids.

Recommended Books

1. Engineering Drawing and Graphics , N.D Bhatt and V.M.Panchal
2. Technical Graphics Communication, Bertoline Wiebe, Miller Mohler, Irwin
3. Practical Geometry and Engineering Graphics , Abbot.
4. Engineering Graphics , Craft, Meyers and Boyer

ME 122L Engineering Drawing 1(0, 1)

Introduction, types of lines, lettering, dimensioning, use of pencil and drawing instruments, planning of drawing sheet, projections, types of projections, orthographic projections, plane of projections, four quadrants, Isometric and pictorial projections of solids/machine parts, making of freehand sketches from solid objects and from orthographic projections, sections of joints, screw thread systems, nuts and bolts, keys and cotter, coupling and simple bearings,

Recommended Book

1. Engineering Drawing, A. C. Parkinson
2. Engineering Drawing from Beginning, M.F. Cousins
3. Engineering Drawing, N.D. Bhatt
4. Machine Drawing, K.L. Narayana
5. Engineering Drawing, A.W.Boundy

ME 123 & ME 123L Engineering Dynamics 4(3, 1)

Prerequisite: ME 121: Engineering Statics

Kinematics of Particles: Introduction to dynamics and kinematic quantities, rectilinear kinematics (continuous and erratic motion), curvilinear motion (using rectangular and normal & tangential coordinates components), motion of a projective (in vector form analysis), Relative motion of two particles using translating axis,

Kinetics of particles: Force, mass and acceleration, Newton's second law of motion, Equation of motion for a particle (using rectangular coordinates and normal & tangential coordinates). Work of a force, Principle of work and energy, Power and efficiency. Principle of linear impulse and momentum. Angular momentum and its relationship with moment of force.

Planer kinematics of rigid bodies: Planer rigid body motion, Rotation about a fixed axis, Absolute motion analysis, Relative motion analysis (velocity and acceleration) using translating and rotating axis.

Planer kinetics of rigid bodies:

Mass moment of inertia, Planer kinetic equation of motion using force acceleration method (for translation, rotation and general plane motion). Planer kinetics using work and energy method, kinetic energy (for rotational and general plane motion), work of a force and couple moment, Principle of work and energy, Planer kinetics using impulse and momentum method.

Recommended Books

1. Engineering Mechanics, Dynamics by R.C. Hibbeler and S.C. Fan, Pearson,
2 Engineering Mechanics, Statics, J.L. Meriam and L.G. Kraig, John Wiley & Sons,
3 Vector Mechanics for Engineers, Statics, Ferdinand P. Beer and E.Russell Johnston Jr. McGraw-Hill,

ME 131 Industrial Materials 2(2, 0)

Metals and their structure, crystalline, polymorphism or allotropy. crystallographic planes, mechanisms in metals, slip and slip systems, types of dislocation, twinning, yield phenomenon and strain aging, metals and alloy systems, production of iron, wrought iron, cast iron, production of steel and its classification, ferrite, austenite, S-iron, cementite, pearlite, martensite, bainite, etc., iron-iron carbide phase diagram, alloying elements and their effect on the properties of alloy steel, refining of copper, aluminum and zinc, aluminum alloys, structure, properties, applications and selection of aluminum alloys, zinc alloys, structure, properties, applications and selection of zinc alloys, copper alloys, structure, properties, applications and selection of copper alloys, brass and bronzes, metals and alloys

for special application, corrosion of metals anti-corrosive coatings and paints, material forms and designation, heat treatment critical temperature transformation on heating/cooling, annealing, normalizing, tempering, quenching, tempering, hardening, rolling processes and production of various steel sections such a billet, bar, rod, channel, Roll pressure calculation, British standards and ASTM standard specification on iron / steel, Non Metals: Properties, Composition, structure of plastics, rubber, ceramic, fiberglass and composite materials. Polymers: Molecular structure, properties, bonding and classification of polymers Compounding, forming of thermosetting or thermoplastic polymer. Ceramics and Refractory: Mechanical and thermal properties of Ceramics, Ceramic materials, structure, properties, applications and selection of ceramics, introduction to composite materials

Recommended books

1. Material Sciences and Engineering, William D. Callister
2. Introduction to Physical Metallurgy, Avner
3. Process and Materials of Manufacturing, Lindberg
4. Materials and Processes in Manufacturing, E.P Degarmo

ME 211 Fluid Mechanics-I 2(2, 0)

Introduction, continuum concept of fluid, properties of fluids, no-slip condition, no-temperature jump condition, 6. Classification of fluid flows: Viscous versus Inviscid Regions of Flow, Internal versus External Flow, Compressible versus Incompressible Flow, Laminar versus Turbulent Flow, Natural versus Forced Flow, Steady versus Unsteady Flow, 1D, 2D, 3D Flows, System and Control Volume, Fundamental Concepts of Mathematical Modelling of Fluid Mechanics Problem, Properties of Fluids: Density and specific gravity, Vapor pressure and cavitation, Energy and specific heats, Coefficient of Compressibility, Viscosity, Surface tension, Capillary Effect

Pressure: Pascal's Law, The Manometer, The barometer and Atmospheric Pressure, Fluid Statics: hydrostatic forces on submerged plane and curved surfaces, Buoyancy, Fluids in rigid body motion, Fluid Kinematics: Lagrangian and Eulerian descriptions, Deformation of Fluid Elements, The Reynolds Transport Theorem, The Boundary Layer Theory, The Bernoulli's Equation: Unsteady and Compressible Flow, Static, Dynamic and Stagnation Pressure, Hydraulic Grade Line, Application of Bernoulli's Equation

Recommended Books

1. Fluid Mechanics, Fundamentals and Applications, Yunus A. Cengel, John M. Cimbala
2. Engineering Fluid Mechanics, Clayton T. Crowe, Donald F. Elger, John A. Roberson
3. Fluid Mechanics, John F. Douglas, Janusz M. Gasiorek, John A. Swaffield
4. Fundamentals of Fluid Mechanics, Munson, Young and Okiishi
5. Fluid Mechanics, F.M. White
6. Fluid Mechanics, Irving H. Shames

ME 212 & ME 212L Thermodynamics-II 4(3, 1)

Prerequisite: ME 111: Thermodynamics-I,

Non-reacting gas mixtures: Composition of a gas mixture, mass & mole fraction, mixture of perfect gases, Dalton's law and the Gibb's Dalton law, Exergy, Amagat's law, properties of ideal gas mixtures, adiabatic mixture of perfect gases real gas mixture, gas vapor mixtures, wet cooling towers,

Mixture with chemical reaction: Fuels and types of fuels, combustion, theoretical and actual combustion processes, calorimeter, simple reaction equation, stoichiometric chemical reaction, rich and lean air-fuel ratio mixture, enthalpy of formation and combustion reaction,

first law analysis of reacting system, adiabatic flame temperature. third law of thermodynamics,
Compressors: classification and working principles, single stage and multistage rotary and reciprocating compressors, inter-cooling, efficiencies and P-V diagrams of all compressors, velocity diagrams of all compressors, performance characteristics and working regimes.
Boilers: generation of steam through boilers, classification and configurations of boilers and their applications, Boil fuels, boiler efficiencies, rating, and heat balance sheet,
Nozzles: Introduction to air/gas nozzles, flow through steam nozzle, their classification, working principles and efficiencies, jet propulsion. Turbines: Steam turbine, their classification and working principles, comparison of reaction & impulse steam turbines, velocity diagrams, multi row and multi stage turbines, blade height, efficiencies of turbine, compounding, gas turbines, analysis, design considerations and selection.

Recommended Books

1. Thermodynamics, An Engineering Approach, Y.A. Cengel and M.A. Boles
2. Applied Thermodynamics for Engineering Technologists, T.D. Eastop, A. McConkey
3. Fundamentals of Thermodynamics, Sonntag, Borgnakke, Van Wylen
4. Basic Engineering Thermodynamic, Rayner Joel
5. Fundamentals of Engineering Thermodynamics, Moran, Shapiro

ME 213 Fluid Mechanics-II 3(3, 0)

Prerequisite: ME 211: Fluid Mechanics-I

Mass and Energy Equations: Conservation of mass, Mechanical Energy and Efficiency, Conservation of Energy, Energy Analysis of Steady Flows**,** Momentum Analysis: Conservation of Momentum, Body and surface forces, The Linear Momentum Equation, Rotational Motion and Angular Momentum, The Angular Momentum Equation**,** Dimensional Analysis: Dimensional Analysis and Similarity, Buckingham Pi Theorem**,** Flow in Pipes:Laminar Flow in Pipes, Turbulent Flow in Pipes, Pipe Losses, Flow rate and velocity Measurements – Flow meters**,** Differential Analysis of Fluid Flows: Continuity Equation, The Stream Function, Cauchy's Equation, The Navier-Stokes Equation**,** Approximate Solution of the Navier-Stokes Equation
Flow over bodies**:** Drag and Lift, Friction and Pressure Drag, Drag coefficients of common geometries, Parallel Flow Over Flat Plates, Flow Over Cylinders and Spheres**,** Compressible Flow: Stagnation properties, Speed of Sound - Mach number, Isentropic Flow, Adiabatic Flow**,** Open Channel Flow: Uniform and Varied Flow**,** Introduction to Computational Fluid Dynamics

Recommended Books

1. Fluid Mechanics, Fundamentals and Applications, Yunus A. Cengel, John M. Cimbala
2. Engineering Fluid Mechanics, Clayton T. Crowe, Donald F. Elger, John A. Roberson
3. Fluid Mechanics, John F. Douglas, Janusz M. Gasiorek, John A. Swaffield
4. Fundamentals of Fluid Mechanics, Munson, Young and Okiishi
5. Fluid Mechanics, F.M. White
6. Fluid Mechanics, Irving H. Shames

ME 221 & ME 221L Mechanics of Materials-I 4(3, 1)

Prerequisite: ME 123: Engineering Dynamics

Stress-Strain and Mechanical Properties: Stress, Normal Stress, Shear Stress, Deformation, Strain, Normal Strain, Shear Strain, Tension and Compression Test, Stress-Strain Diagram, Elastic and Plastic Deformation, Stress-Strain Diagram for Ductile and Brittle Materials, Toughness, Hardness, Creep, Fatigue, Hooke's Law, Poisson's Ratio, Elastic Modulus, Shear Modulus, Bulk Modulus, Relationship between Mechanical Properties, Allowable Stresses and Factor of Safety, Thermal Stresses, Stress Concentrations.
Section Properties: Centroid of Simple and Composite Sections, Radius of Gyration, Parallel Axis Theorem, Section Modulus, First Moment of Area of Simple and Composite Structural Shapes, Second Moment of Area of Simple and Composite Structural Shapes.
Bending of Beams: Simple Bending Theory, Pure Bending of Symmetric Members and Composite Members. Shear Force and Bending Moment Diagrams. Graphical Method for Constructing Shear Force and Bending Moment Diagram. Shear Force and Bending Moment Diagrams for Beams carrying Concentrated Loads only, Uniformly Distributed Loads, Combined Concentrated and Uniformly Distributed Loads, Applied Moments,
Torsion of Shafts: Simple Torsion Theory, Torsional Deformation of Circular Shaft, Angle of Twist, Power Transmission for Solid and Hollow Shafts, Torsion of Solid Non-Circular Shafts.
Buckling of Columns: Buckling, Ideal Column with Different Supports, Euler's Formula for Buckling of Columns.
Deflection in Beams: The Elastic Curves, Slope and Displacement by Integration, Method of Superposition.

Recommended Books

1. Mechanics of Materials, F. P. Beer and E.R. Johnston
2. Mechanics of Engineering Materials, P.P. Benham and R.J. Crawford
3. Mechanics of Materials, R.C.Hibbeler
4. Mechanics of Materials, J M Gere, S.P Timoshenko
5. Strength of Materials, Andrew Pytel, Ferdinand L.Singer

ME 231 Manufacturing Processes 3(2, 1)

Introduction to manufacturing processes, Casting, Welding (joining of metals), Metal working and powder metallurgy, Casting, solidification of a pure metal and alloy, heating furnaces and pouring mechanisms, fluidity, shrinkage, Patterns and cores making, molds, types of molds and mold materials
Types of casting, expendable and nonexpendable mold casting, sand casting, CO_2 process, shell molding, investment casting, slush casting, expanded polystyrene pattern casting process, Die casting, hot chamber and cold chamber die casting, centrifugal casting, Casting defects, Bulk deformation processes, rolling, roll mills, thread rolling, gear rolling, ring rolling, roll piercing, forging, open die and impression die forging, forging dies, hammers and presses, upsetting extrusion, types of extrusion, drawing, sheet metal working
Joining processes (welding) types of welding, oxyfuel gas welding, arc welding, SMAW, GMAW, GTAW, resistance welding, resistance spot and seam welding, weld quality, defects, inspecting and testing of welds, brazing, soldering, types of weld joints, types of welds, features of welded joints
Sheet metal forming/working, bending operations, drawing, roll bending and forming, mechanical assembly, threaded fasteners, washers, rivets and eyelets, press fitting, shrink and expansion fits, snap fits, retaining rings, cotter pins, shaping processes for plastics, extrusion, injection molding, compression molding, blow molding, thermoforming, introduction to rapid prototyping,
Cutting operations, Powder metallurgy, techniques to prepare powders, preforms and sintering.

Recommended Books

1. Manufacturing Engineering and Technology, Kalpakjian, Shmid
2. Processes and Materials of Manufacture, Lindberg

3. Materials and Processes in Manufacturing, Degarmo, Black, Kohser
4. Fundamentals of Modern Manufacturing, Materials, Processes and Systems, Groover
5. Manufacturing Engineering by Ostwald

ME 222 & ME 222L Mechanics of Machines 4(3, 1)
Prerequisite: ME 123: Engineering Dynamics

Mechanisms: link, lower and higher pair joints, kinematic chain, frame, linkage, kinematically equivalent mechanisms, degrees of freedom, connectivity and mobility, inversion, Grashof rules, motion limit for slider crank mechanism,
Techniques of Mechanism Analysis:graphical and analytical, position, velocity and acceleration analysis of four-bar slider crank mechanism, crank effort diagram, relative velocity and relative acceleration analysis, linkages with rotating sliding joints, steering mechanism, Geneva mechanism, quick return mechanism analysis, Acceleration Analysis, Position Analysis, The Acceleration Polygon, Graphical Analysis of the Four-Bar Linkage, An Analytical Solution Based on the Acceleration Polygon, Graphical Analysis of Sliding Contact Linkages, Trial Solution Method Applied to Linkage Acceleration Analysis, Spatial Linkages, Acceleration Analysis of an RSSR
Time Ratio, Timing Charts, Design of Slider Crank Mechanism, Design of Crank Shaper Mechanism, Mechanism to Move a Link Between Two Positions
Cam Design: cam contact analysis, cam profile design, cam dynamics analysis, Balancing: balancing of rotating and reciprocating masses, balancing of in-line engines, V-engines and radial engines, balancing machines, Gear trains: simple, compound, concentric and planetary gear trains, torques on gear trains, Flywheels: moment of inertia, design calculation methods, Gyroscope: working principle and applications
Fundamentals of Vibrations, Degrees of Freedom, Discrete and Continuous Systems, SHM, Vibration Analysis Procedure

Recommended Books

1. Mechanics of Machines, Elementary theory and Examples, John Hannah and R.C Stephens
2. Mechanics of Machines, Advanced theory and Examples, John Hannah and R.C Stephens
3. Kinematics, Dynamics and design of Machinery, Kenneth J. Waldron/ Gary L. Kinzal
4. Mechanics of Machines, W.L Cleghorn
5. Theory of Machines and Mechanisms, John J. Uicker, Gordon R. Pennock, Joseph E. Shigley
6. Kinematics and Dynamics of Machinery, Charles E. Wilson, J.Peter Sadler
7. Design of Machinery, Robert L. Norton

ME 223 & ME 223L Machine Design and CAD-I 4(3, 1)
Prerequisite: ME 122L: Engineering Drawing,

Introduction to Mechanical Engineering Design: Mechanical Engineering Design, Design process. Problem formulation and calculation. The engineering models. Computer-Aided Design and Engineering. Dimensions and Tolerances.
Standards and Codes: Introduction to International design codes and standards. International organization of Standardization (ISO), British Standards (BS), American National Standards Institute (ANSI), Japanese Industrial Standards (JIS), German Institute for Standardization

Standards (DIN), Pakistan Standards and Quality Control Authority (PSQCA). International design codes and standards related to Mechanical Engineering Design.
Failure Prevention: Design factor and Factor of safety. Failures resulting from Static loading. Fatigue failure resulting from Variable loading.
Shafts and Shaft Components: Introduction to shafts, Shaft materials, Shaft layouts. Shaft design for stress. Deflection considerations. Critical speeds for shafts. Miscellaneous shaft components. Limits and fits.
Screws and Fasteners: Thread Standards, Mechanics of power screws, Threaded fasteners. Joints-fastener stiffness, Joints-member stiffness. Bolt strength, Tension joints, Bolt torque and bolt tension, Statically loaded tension joint with preload. Gasketed joints. Fatigue loading for tension joints. Bolted and Riveted joints in Shear.
Welding, Bonding and Permanent Joints: Welding symbols, Butt and Fillet Welds. Stresses in welded joints in torsion and bending. Strength of welded joints. Statically loaded joints, Fatigue loaded joints. Resistance welding. Adhesive bonding.
Flexible Mechanical Elements: Belts, Flat and Rounded belt drives, V belts, Timing Belts. Roller Chains. Wire rope. Flexible shafts.
CAD-I: 2-D drawing of mechanical components assembly and dimensioning.

Recommended Books

1. Mechanical Design: An Integrated Approach. R. L. Norton
2. Shigley's Mechanical Engineering Design. R. G. Budynas and J. K. Nisbett
3. Machine Elements in Mechanical Design. R. L. Mott
4. Design of Machine Elements. M. F. Spotts, T. E. Shoup and L. E. Horberger

ME 381 Health Safety and Industrial Environment 2(2, 0)

Introduction of Health and Safety, Industrial Safety: Objectives of Safety, Importance of Safety in an industry, Industrial accidents, Effects of accidents, Types of accidents incidence of fire. Fire prevention and control. Principles of accident prevention, hazard analysis. Legal, humanitarian and economic reason for action. Safety inspection procedures. Safety training, First aid and emergency procedures. Importance of clean environment, Scale of Environmental Pollution. Environmental Act. Health and Safety Act. Atmospheric Pollution: Types of Atmospheric pollution, Their Causes and Effects on Human Health, Available Technologies for Controlling Pollution. Industrial Waste: Solid Waste, Industrial Effluents and Waste Gases, waste treatment plants. Noise Pollution: Measurement of Noise level, Effect of excessive noise on human health. Remedial Measures. ISO Standards for Safety and Health and Environment, ISO 14000, OHSAS 18001 standards, Pakistan standards and regulations for health, safety and environment, EPA,

Recommended Books:

1. Safety at Works, John Ridley, Butter Worths Publishers
2. Factory & Production Management, K. G. Lockyer, Pitman Publishing
3. Environmental Pollution and Control, J. Jeffrey Peirce, Ruth F. Weiner and P. Aarne Vesilind

ME 311 & ME 311L HVAC 4(3, 1)

Introduction and types of cooling systems: Definition and basic terminology, refrigeration cycle, vapor compression cycle, COP, introduction to pressure-enthalpy chart, types of refrigerants, air cycle refrigeration, vapor absorption refrigeration and air conditioning, working principle of thermally driven cooling machines, single, double and triple effect absorption chiller, adsorption chiller, desiccant evaporative cooling, ejector cycle.
Passive heating and cooling:
Cooling and heating: Indoor and outdoor air conditions, comfort air conditions and comfort zone, indoor air quality, psychrometry, psychometric chart and psychometric properties, central air conditioning system, essential components of central air conditioning plant, water

chiller and water heater, air handling unit, chilled water and hot water re-circulating system, return air supply system, fresh air supply system and air mixture chamber, supply fan, air dust cleaning and bacteria removal, air supply and air return terminals, diffusers, dampers, grillers and registers,

Air-conditioning system design: CFM rating and tons of air conditioning of central air conditioning plant, cooling and heating loads, calculation procedures, duct sizing and piping design, pumps and fans selection, air ventilation, calculation of fresh air supply of multi-story buildings, air handling units for treatment of fresh and return, forced convection-based air ventilator design,

Cooling towers: Types of cooling towers, performance of cooling tower, hydronic terminal units

Indoor air quality: Dust and bacteria removal methods.

Alternative cooling techniques: Thermo-electric, Magnetocaloric, Electrocaloric, Thermo-acoustics, solar-assisted cooling systems

Building energy codes and standards: ASHRAE, CIBSE, BECP

HVAC system modelling and simulation programs

Text and Reference books:

1. Air Conditioning Principles and Systems, Edward G. Pita, Prentice Hall, ISBN: 0130928720,
2. Principles of Refrigeration. Dossat, R. J., John Wiley,
3. Refrigeration and Air Conditioning,
4. McQuiston, Parker and Spitler, Heatin W. F. Stoecker, g, Ventilating, and Air-Conditioning Analysis and Design, John Wiley & Sons
5. Heating and Cooling of Buildings, Ed. Kreider, Curtiss &Rabl, Mc-Graw-Hill
6. HVAC Systems Design Handbook, Haines, Roger W. Wilson, Lewis, McGraw-Hill Companies
7. Integrated Absorption Refrigeration Systems, Dincer, Ibrahim, Ratlamwala, Tahir Abdul Hussain Comparative Energy and Exergy Analyses, Springer
8. Handbook of Air Conditioning and Refrigeration. Shan K. Wang,

ME 361 Energy Resources and Utilization 3(3, 0)

Introduction to energy & energy resources- fundamentals; Mineral Energy resources, Fossil Fuels in solid, liquid and gaseous state; Oil, Gas and Coal reserves, production technologies and trends, consumption trends, Technologies for conversion for heat, electricity and transport

Solar radiation–extraterrestrial solar radiation, components of radiation, geometry of the earth and sun, geometry of collector and the solar beam, effects of the earth's atmosphere, measurements of solar radiation, estimation of solar radiation. Solar Thermal: Types of solar Collectors, Solar water heating–calculation of heat balance, uncovered solar water heaters – progressive analysis, improved solar water heaters, systems with separate storage, selective surfaces, evacuated collectors, social and environmental aspects; Air heaters, energy-efficient buildings, crop driers, space cooling, water desalination & solar ponds. Solar CSP systems,

Solar PV: Photovoltaic generation: the silicon p–n junction, photon absorption at the junction, solar radiation absorption, maximizing cell efficiency, solar cell construction, and types & adaptations of photovoltaics.

Hydro-power; Conventional, mini and micro hydro systems,

Power from the wind: linear momentum and basic theory, dynamic matching and blade element theory. The photosynthetic process & Biomass and biofuels: biofuel classification, biomass production for energy farming, pyrolysis, alcoholic fermentation, anaerobic digestion for biogas, and vegetable oils and biodiesel.

Wave power: wave motion, wave energy, power and patterns. Tidal power: the cause of tides, enhancement of tides, tidal current/stream, tidal range power and world range power sites. Ocean thermal energy conversion (OTEC) & geothermal energy, Energy systems, storage and transmission: biological storage, chemical storage, heat storage and fuel cells.

Text and Reference books:

1. Renewable Energy Resources by John Twidell, Tony Weir
2. Renewable Energy: Power for a Sustainable Future by Godfrey Boyle
3. Energy Resources, Utilization and Technologies by Anjaneyulu Yerramilli and Francis Tuluri
4. Renewable Energy Sources for Electricity and Fuels, T. B. Yohansson, H. Kelly, A. K. N Reddy, and R.H. Williams: Island press, Washington, D.C.
5. New Renewable Energy Resources, World Energy Council: Kogan Page, London.
6. Biomass energy in developing countries, S.C. Bhattacharya and P. Abdul Salam, RERIC, AIT.
7. Fundamentals of Renewable Energy Processes, Aldo V. Da Rosa, Elsevier.

ME 321 Mechanics of Materials - II 4(3, 1)

Pre-requisite: ME221 Mechanics of Materials-I

Plane Stress and Strain: Plane stress transformation, General Equation of Plane transformation, Stresses in Shaft Due to Axial Load and Torsion, Absolute Maximum Shear Stress, Plane Strain, General equation of Plane Strain Transformation, Mohr's circle for stress and strain, Material Properties Relations, Principal Stresses and Principal strains, Theories of failure, Yield criteria. Strain Rossets

Stress in Cylinder: Types of cylinders, Thin and thick curved bars. Thin walled pressure vessels, Thin Cylinder, stresses in thin cylinders, thick cylinders, Stresses in thick cylinders

Transverse Shear Stress: Shear in Straight Members, Shear Formula, Shear Stresses in Beams, Shear Flow in Built-up Materials, Shear Center

Beams: Analysis of statically indeterminate beams, Macaulay's method, Virtual work principle, energy methods, Castiglione's theorem.

Recommended Books

1. Mechanics of Materials, F.P. Beer, E.R. Johnston.
2. Mechanics of Engineering Materials, P.P. Benham and R.J. Crawford.
3. Advanced Theory and Applications, J. Alexander and J.S. Gunasekra

ME 331 Machine Tool and Machining 3(2, 1)

Principles of metal cutting, lathe machine tools, Types of Lathes, working principle of lathe machines, lathe processes, lathe tools, cutting tools nomenclature, geometry and materials, and their effects on machining, cutting speed, feed and depth; Types of drilling machine and drills, speed, feed calculations; Milling machine classifications, milling processes, milling cutters and related mechanics, speed, feed, depth of cut, calculations; grinder, and its types, grinding processes, grinding wheel structure; working principles, Shaper, planer, slotter; working principle, introduction to CNC Machining, CNC Machining center and Turning center, Non-Conventional machines and operations (Ultrasonic, EDM, Laser machining, water-jet, plasma cutting), Additive Manufacturing Machines & Operations (RP, 3DP, FDM, EBM), Hybrid Manufacturing

Recommended Books:

1. Machine Tools Practice by Kibbe, Meyer, Neely, White

2. Technology of Machine Tools by Krar, Gill, Smid
3. Manufacturing and Machine Tool operation by: Pollack
4. 3D P and Additive Manufacturing: Principles and Applications, Chu
5. Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Yang et al.
6. Fundamentals of Modern Manufacturing, Materials, Processes and Systems by Groover

MGT 315 Professional Ethics & Engineering Entrepreneurship 2(2,0)

Morals and ethics, comparison of ethics and engineering ethics, ethics at personal and student level, The concept of professions, The importance of ethics in science and engineering, The role of codes of ethics, Professional responsibilities of engineers, The concept of morality, The importance of core values, Moral/ethical dilemmas and hierarchy of moral values, Factors affecting moral responsibility, and degrees of responsibility, Overview of ethical theories and applications, Basics of ethical analyses and decision-making, The importance if intention, Truth (personal and social), The concept of whistleblowing, Ethical leadership in engineering and society, Conflicts of interests, Ethics in the workplace, Fairness (personal and social), Ethics in the electronic and digital age, Responsible conduct of research, Intellectual property and society, Sustainable engineering

Evolution of the concept of entrepreneur, Characteristics of an entrepreneur, Distinction between an entrepreneur and a Manager, Economic Development, Factors affecting entrepreneurial growth (economic, Non-Economic and Government factors), Critical factors for starting a new enterprise. Ingredients for a successful new business. Self-assessment and feedback, Personal entrepreneurial competencies. Goal setting. Creativity and sources of new business ideas, the difference between ideas and opportunity and creativity. Assessing business opportunities in Pakistan. Screening and evaluating opportunities Product planning and development process. Creating parallel competition by developing a similar product or service, Product life cycle, finding sponsorship. Acquiring a going concern, E-Commerce and business start-up and growth. Marketing as a philosophy, marketing management: Creating a marketing plan, Analyze the environmental situation and the market opportunity, setting marketing objective, formulating a marketing strategy. The business plan as selling document, reasons for writing a business plan your company:

Recommended Readings:

1. Fundamental of Ethics for Scientists and Engineers, Seebauer, E.G. and Barry, R.L. Oxford University Press)
2. Ethics in Engineering – Practice and Research, Whitbeck, Caroline. Cambridge University Press
3. Entrepreneurship/lip, Rober D. Hisrich and Michael P. Peter McGraw Hill

MGT 316 Project Management & Engineering Economics 2(2,0)

Introduction to project management, Project life cycle; Project selection criteria and models, Risk consideration in project selection, Project portfolio process, Initial project coordination and project charter, Work Breakdown Structure, RACI matrix, Agile projects, Interface coordination, Project risk management, Estimating project budgets, Methods of improving estimates, Risk estimation, Scheduling with network techniques: PERT (ADM) and CPM (PDM), Risk analysis tools in scheduling, Project crashing, Resource allocation, Resource loading, Resource leveling, Constrained resource scheduling, Planning, monitoring, controlling cycle, Earned value analysis, Project management information system, Project control process and its types, Design of project control systems, Control of change and scope creep.

Recommended books

1. Project Management – A Managerial Approach. Jack R. Meredith & Samuel J. Mantel, Jr.:

2. Project Management – A Systems Approach to Planning, Scheduling and Controlling. Harold Kerzner
3. Project management body of knowledge "PMBOK" .

ME 322 & ME 322L Machine Design and CAD-II 4 (3, 1)

Pre-requisite:ME223 Machine Design & CAD-I

Mechanical Springs: Introduction to several types of springs. The terminology used for helical compression, helical extension, helical torsion and Belleville spring. Spring Materials for above four types. Stresses and Deflection in springs for above four types. Design of helical compression, extension and torsion springs for static and fatigue loading. Design of Belleville spring for static loading.
Bearings: Introduction to several types of rolling-element bearings. Failure of rolling-element bearings. Selection or rolling-element bearings. Rolling-element bearing mounting details.
Introduction to lubricants and sliding contact bearings. Types of lubrications. Hydrodynamic lubrication theory. Materials for sliding contact bearings. Design of sliding contact bearings.
Gears: Introduction to several types of gears. Nomenclature of the gear tooth. Conjugate action and Involute properties. Interference and undercutting. Determination of gear tooth and gear mesh parameters. Gear manufacturing. Geometry and nomenclature of Spur, Helical, Bevel and Worm gears. Force analysis of Spur, Helical, Bevel and Worm gears. Stress and Strength equations for Spur, Helical, Bevel and Worm gears. Analysis and Design of gear mesh for Spur, Helical, Bevel and Worm gears.
Clutches and Brakes: Introduction to several types of clutches and brakes. Clutch and brake materials. Static Analysis of clutches and brakes. Design of Disk clutches. Design of Disk and Drum Brakes. Coupling. Flywheels.
CAD-II:3-D modelling of mechanical components and assembly. Interconversion of 2D and 3D drawings.

Recommended Books

5. Mechanical Design: An Integrated Approach. R. L. Norton
6. Shigley's Mechanical Engineering Design. R. G. Budynas and J. K. Nisbett
7. Machine Elements in Mechanical Design. R. L. Mott
8. Design of Machine Elements. M. F. Spotts, T. E. Shoup and L. E. Horberger

ME 332 & ME 322L Metrology and Quality Assurance 3 (2, 1)

Introduction to quality improvement, Dimensions of quality, Quality function deployment, Product liabilities, Computer & quality control, Quality standards, Introduction to Lean, Lean fundamentals, lean implementation, Six sigma and DMAIC, SPC Tools (Pareto Chart, Cause & Effect, Scatter Plot, Histogram, Check Sheets), Data & data types, accuracy & precision, measurement of central tendency, population and sample, normal curve, tests for normality, control charts for variables, control charts for attributes, process capability, Process state of control, experimental design, Comparators, Gauges, Taylor's theory of gauging systems, Design of limit gauges, CMM, Profile projector, 3D laser scanner, metal fits and tolerances, standards of fits and tolerances, surface finish, surface analyzer,

Recommended Books:

1. Quality Improvement, Dale H. Besterfield,
2. Fundamentals of Dimensional Metrology, Doston, Harlow, Thompson

3. Introduction to Statistical Quality Control, Douglas C. Montgomery

ME 341 & ME 341L Control Systems 3(2, 1)

Basic tools in modeling, analysis and design for linear feedback control systems. Modelling of mechanical, electrical, and electromechanical systems as differential equations, transfer functions and state equations.
stability of open loop and closed-loop systems, time responses and frequency responses of low order systems.
Bode plots for designing PID and lead/lag controllers. automatic control theory to real engineering problems with Matlab. state-space control techniques, nonlinear control, robust control and system identification.

Recommended Books:

1. Automatic Control System by B.C.Kuo , John Wiley & Sons.
2. Control Systems Engineering, N.S.Nise, John Wiley & Sons.

ME 411 & ME 411L Power Plants 3(2, 1)

Review of mass and energy balances for steady flow devices, energy sources and classification; Fossil fuels. Steam Generators and Turbines, Steam Powerplants, Ideal and actual Rankine cycle, Techniques to improve thermal efficiency of Steam Power Plant, Cogeneration systems, Gas Turbine Powerplants, Ideal and actual Brayton cycle, Thermal efficiency improvement techniques of Brayton Cycle including intercooling, regeneration and reheating, Combined Cycle Power plant, Gas Turbine classification and Application in aircraft propulsion, introduction to Diesel Engine and Nuclear Power Plants, Plant siting, Economics and Management, Environmental Pollution and control techniques.

Recommended Books:

1. Power Plant Technology, El-Wakil, M.M., McGraw-Hill
2. Advanced Power generation systems, I. Dincer, C. Zamfirescu, Elsevier
3. "Powerplant Engineering", Larry Drbal, Pat Boston, CBS Publishers
4. "Power Plant Engineering", Black, Veatch, Springer.
5. "Power Plant Engineering", P.K. Nag, McGraw-Hill.
6. "Steam Plant Operation", McGraw-Hill.
7. Thermodynamics: Fundamentals of Engineering Thermodynamics by Michael J. Moran et al.

ME 412 Heat and Mass Transfer 4(3, 1)

Basics of Heat Transfer & Introduction to various modes of heat transfer: Fourier's law of conduction, Newton's law of cooling and Stefan Boltzmann's law. Thermal conductivity, heat diffusion equation in Cartesian, Cylindrical and Spherical coordinates; one dimensional steady state heat conduction through plane composite walls, cylinders and spheres with and without heat generation sources, Insulation, critical radius/thickness of insulation, The overall heat transfer co-efficient; Fins, heat transfer through extended surfaces, Thermal contact resistance; Unsteady-state conduction, Lumped-heat-capacity system; Principles of convection, Viscous flow, Laminar boundary layer on a flat plate, The thermal boundary

layer, Relation between fluid friction and heat transfer, Heat transfer in laminar tube flow, Bulk temperature, Turbulent flow in a tube, non-dimensional parameters related to convective heat transfer and their applications, shear stress; Empirical and practical relations for forced convection heat transfer, empirical relations for pipe and tube flow, flow over cylinders and spheres; Radiation heat transfer – Radiation properties, black body radiation, absorptivity, reflectivity, transmissivity, Wien's law, Kirchoff's law, Grey body radiation, Radiation shape factor and relations between shape factors, Heat exchange between non-blackbodies, Infinite parallel planes, Radiation shields, Heat exchangers - overall heat transfer co-efficient, fouling factors, types of heat exchangers, Log mean temperature difference (LMTD) and Effective-NTU methods, Compact heat exchanger, Heat exchanger design considerations; Mass transfer - Fick's law of diffusion, diffusion in gases, liquids and solids, analogy between momentum, heat and mass transfer; simultaneous heat and mass transfer, Evaporation processes in the atmosphere.

Recommended books

1. Heat Transfer, J. P. Holman
2. Heat Transfer: A Practical Approach, yunus A. Cengel
3. Engineering Heat Transfer, William S. Janna
4. Fundamentals of Heat and Mass Transfer, Incropera and Dewitt
5. Principles of Heat Transfer, Frank Kreith, Raj M. Manglik, Mark S. Bohn

ME-431 Production and Operations Management 2(2, 0)

Functions of management, production systems, the inputs to a production system and their relationship with the cost of production. Organizational structure. Selection of plant location and factors affecting industrial development in Pakistan. Productivity and factors contributing to productivity of organizations. Implementation of productivity based comprehensive continuous improvement system in production systems. Job production, intermittent batch production, continuous production, group technology. Inventory management techniques. Demand Forecasting using various time series techniques incorporating seasonality, growth trends and randomness. Regression based demand forecasting. Production planning and scheduling and capacity planning. Introduction to push and pull based manufacturing systems, Plant Maintenance strategies, their costing and relation to cost of production, total productive maintenance, RAMS. Computer applications, Case studies

Recommended Readings:

1. Operations Management by Jay Heizer, Barry Render, Jagdesh Raja shekhar
2. Industrial Management by M.H. Zuberi and Nasir Hayat
3. Work Systems: The Methods, Measurement and Management of by Mikell P. Groover

ME 451 Finite Element Analysis 3(2, 1)

Introduction to FEA and Element Performance; Introduction to Finite Element Modeling and preliminary decisions; Elements types and their properties; Basic concepts of equilibrium & compatibility; General factors affecting element performance – Sources of errors; Convergence.

FE Methods, Shape Functions, Stiffness Matrix and Transformation; Direct Stiffness Method, Energy Methods; Shape Function: Linear and Quadratic Element; Beam Elements, Truss Elements, Linear and Planar elements; Stiffness matrix, Local to Global Co-ordinate Transformation Assembly

Static Structural Analysis; Modeling and analysis of 1D, 2D and 3D structures under static loading
Heat Transfer and Thermal Stress Analysis: Introduction to Heat transfer, Thermal and Thermal Stress analysis concepts; Selection of Boundary Conditions based on the identification of problem; Thermal Analysis (Steady State); Thermal stress Analysis
Dynamic Analysis; Introduction to diverse types of dynamic analysis; Modal Analysis, Frequency Response Analysis, Transient Response Analysis, master's Degrees of Freedom

Text and Reference books:
1. Advanced Strength and Applied Stress Analysis, Richard G. Budynass, McGraw-Hill
2. Finite Element Analysis – Theory and Applications with ANSYS, Saeed Moaveni, Prentice Hall
3. Finite Element Analysis – Theory and Practice, M J Fagan, Pearson Publications

ME 413 IC Engines 3(2, 1)

Prerequisite: ME 312: Heat and Mass Transfer

Introduction and historical perspective, classifications, operating cycles, components and operations of Reciprocator and Rotary IC engines. Stratified-Charge engines.
Ideal models of Engine Cycles, Processes and Thermodynamic Relations, analysis of ideal gas and fuel-air cycles, comparison with real engine cycles. Working principle of (2-stroke ,4-stroke) S I and C I engines. Engine design and operating parameters, Geometrical properties and performance characteristics of SI and CI engines under variable conditions of load and speed. Calculation of engine power and other parameters. Ignition/Injection timing advance. Variable Valve timing.
Fuel metering and carburetion. Electronic Fuel Injection (EFI) in SI and CI engines. Octane number and Cetane rating.
Combustion in SI and CI engines, Thermodynamics analysis, abnormal combustion (knocking) in SI and CI engines. Conventional and alternative fuels, fuel additives. Fuel injection and combustion in DI (Common Rail) and Gasoline direct injection (GDI) engines. multi-spray systems, analysis of cylinder pressure data, heat release analysis, fuel spray analysis, ignition delay.
IC Engine testing and control, exhaust gas analysis, regulated and unregulated emissions, controlling of emissions using in-cylinder and out-cylinder (after treatment) techniques, implications of exhaust gas recirculation (EGR) system, thermal reactor and catalytic converters.
Forced induction in IC Engines. Working principle of Turbocharging and Supercharging, its performance characteristics and comparison with naturally aspirated (NA) engine of equal power;
Engine Coolants and Cooling Systems. Types and Grades of Engine Lubricants and lubrication systems of the Engines. Latest developments in IC Engines.

Recommended Books
1. Internal Combustion Engine Fundamentals, J.B. Heywood
2. Introduction to I. C. Engines, Richard Stone
3. Engineering Fundamentals of the Internal Combustion Engine, Willard W. Pulkrabek
4. Internal combustion Engines, C. R. Ferguson and A. T. Kirkpatrick

ME461 Energy Conservation and Management 2(2,0)

Fundamentals of Energy Management: Concepts of Energy conservation & Management, Energy Units and Calculations, Energy Benchmarking, Engineering Economic Analysis, Energy Auditing, Energy Performance Models, Electricity Tariffs

Energy Conservation in Electrical Systems: Introduction to Electrical Systems, Power Factor Upgrade, Power Quality Issues and Harmonics, Energy Conservation Opportunities in Motors, Variable Speed Drives, Energy Conservation Opportunities in Lighting Systems

Energy Conservation in Thermal Systems: Introduction to Boilers, Combustion Reactions and Stoichiometry, Energy Conservation Opportunities in Boilers & Steam Networks, Introduction to Cooling Equipment and Chillers, Energy Conservation Opportunities in Chilled Water Systems, Thermal Energy Storage

Energy Conservation in Compressors, Pumps, Heat Recovery & CHP: Introduction to Compressors and Compressed Air Systems, Energy Conservation Opportunities in Compressors, Introduction to Pumps, Energy Conservation Opportunities in Pumps, Waste Heat Recovery Opportunities, Cogeneration Options

Energy Management System ISO 50001: Introduction to ISO 50001, Benefits of ISO 50001, ISO 50001 Approach & Methodology, Requirements of Energy Management System (EnMS), Energy Policy & Energy Planning, Implementation & Operation of EnMS, Energy conservation standards: Pakistan building energy code, NEECA, PEECA

Recommended Books:

1. Energy Management and Conservation Handbook, by Frank Kreith and Yogi Goswami
2. Energy: Management, Supply and Conservation by Clive Beggs.
3. Energy Conservation Guidebook by Dale R. Patrick, Stephen W. Fardo, Ray E. Richardson, Brian W. Fardo.
4. Plant Engineers and Managers Guide to Energy Conservation Albert Thumann, Scott Dunning
5. Inside Energy: Developing and Managing an ISO 50001 Energy Management System by C.H. Eccleston, F. March T. Cohen

ME 421 & ME 421L **Mechanical Vibrations** **3(2, 1)**

Prerequisite: ME123 Engineering Dynamics

Fundamentals of Vibration: Basic concepts of vibration, Classification of vibration, Vibration analysis procedure, Spring elements, Mass or inertia elements, Damping elements, Harmonic motion, Harmonic analysis.

Free Vibration of Single-Degree-of-Freedom Systems: Free vibration of an undamped translational system, Free vibration of an undamped torsional system, Free vibration with viscous damping, Graphical representation of characteristic roots, Parameter variations and root locus representations, free vibration with Coulomb damping, free vibration with Hysteretic damping.

Harmonically Excited Vibration: Response of an undamped system under harmonic force, Response of a damped system under harmonic force, Response of a damped system under harmonic motion of the base, Response of a damped system under rotating unbalance, forced vibration with Coulomb damping, forced vibration with Hysteretic damping, Self-excitation and Stability analysis, Transfer-function approach, Solutions using Laplace transform, Frequency transfer functions.

Two-Degree-of-Freedom Systems: Equations of motion for forced vibration, Free vibration analysis of an undamped Translational system, Free vibration analysis of an undamped

Torsional system, Coordinate coupling and Principal coordinates, Forced-vibration analysis, Self-excitation and Stability analysis.
Determination of Natural Frequencies and Mode Shapes: Dun Kerley's Formula, Rayleigh's Method
Vibration Measurement and Applications: Transducers, Vibration Pickups, Frequency-measuring instruments, Vibration exciters, Signal analysis, Dynamic testing of machines and structures, Experimental modal analysis, Machine-condition monitoring and Diagnosis.

Recommended Books

1. Mechanical Vibrations, S. S. Rao.
2. Mechanical Vibrations: Theory and Applications, S. G. Kelly
3. Theory of Vibration with Applications, W. T. Thomson and M. D.

ELECTIVES

ME 414 Gas Dynamics 3(3,0)

Prerequisite: ME 212 Thermodynamics-II

ME 213 Fluid Mechanics-II

Basic concepts, Introduction to compressible flow, A brief review of thermodynamics and fluid mechanics, Integral forms of conservation equations, Differential conservation equations, Continuum Postulates, Acoustic speed and Mach number, Governing equations for compressible flows, One-dimensional compressible flow: One dimensional flow concept, Isentropic flows, Stagnation/Total conditions, Characteristics speeds of gas dynamics, Dynamic pressure and pressure coefficients, Normal shock waves, Rankine-Hugonoit equations, Rayleigh flow, Fanno flow, Two-dimensional flows: Oblique shock wave and its governing equations, θ-B-M relations, The Hodograph and Shock Polar, Supersonic flow over wedges and cones, Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves,Quasi-one dimensional flows: Governing equations, Area velocity relations, Isentropic flow through variable-area ducts, Convergent-divergent (or De Laval) nozzles, Over-expanded and under-expanded nozzles, Diffusers, Unsteady wave motions: Moving normal shock waves, Reflected shock waves, Physical features of wave propagation, Elements of acoustic theory, Incident and reflected waves, Shock tube relations, Piston analogy, Incident and reflected expansion waves, Finite compression waves, Shock tube relations, Introduction to experimental facilities, Subsonic wind tunnels, Supersonic wind tunnels, Shock tunnels, Free-piston shock tunnel, Detonation-driven shock tunnels, and Expansion tubes.

Recommended Books

1. "Modern Compressible Flow with Historical Perspective", John D & Anderson Jr. McGraw-Hill, Singapore.
2. "Elements of Gas Dynamics", Liepmann HW and Roshko A. John Wiley & Sons, Inc., New York.
3. "The Dynamics and Thermodynamics of Compressible Flow", Shapiro A. Ronald Press, London.
4. "Compressible fluid flow", Oosthusien P & Carscallen W. McGraw Hill.

ME 415 Clean Coal Technology 2(2, 0)

Prerequisite: ME 212 Thermodynamics-II

Introduction to Clean Coal Technologies: Role of coal in the overall energy situation, History of energy production from coal, Indigenous coal reserves, Recent advances in clean energy generation from coal, Coal Preparation for clean energy generation: Coal preparation methods including fine coal treatment, Properties of coal and impurities in relation to preparation (emphasis on Thar coal), Wash ability studies and evaluation of coal for different uses, Breaking and crushing; screening, wet concentration methods of coarse coal; wet concentration methods of fine coal, Status & scope of coal preparation by flotation, Dust collection in coal processing and handling Clean coal gasification: Coal gasification basics/types, Coal gasifier designs/Reaction kinetics, Direct blowing & reverse blowing concepts, Air separation and gas cleanup, Syngas cleanup/ CO2 capture for CCS. Underground Coal Gasification (UCG): Technology Description , Geological aspects in UCG/ coal seam, overburden and water table , Thar coal UCG case study, Process flow diagrams, Channel formation b/w injection & production wells, Process parameters/Coal & Rock properties, Economics of UCG Coal to liquid (CTL): Direct coal liquefaction, Process description, Process parameters & flow sheet diagrams, Single stage & two stage liquefaction, DCL catalytic reactors/ overview, Commercial Plants, Environmental considerations

Indirect coal liquefaction (Fischer Tropsch Process): Process Description/ Process Flow diagrams, FT Process/ Reaction mechanism & kinetics, FT process parameters, Catalyst Preparation & Characterization, FT Reactor core concepts/Process control, Energy analysis/ Heat exchanger network optimization in FT synthesis, Products refining Integrated gasification combined cycle (IGCC) : Process description, Thermodynamic cycle of IGCC, Development of process flow diagram, CO_2 pre combustion capture & storage, Energy requirements

Text and Reference books:

1. Clean Coal Engineering Technology, Bruce G. Miller, (ISBN: 978-1-85617-710-8)
2. Coal Gasification and Its Applications, Brian F. Towler, David Bell, and Maohong Fan (ISBN: 978-0-8155-2049-8)
3. Carbon Capture and Storage, Stephen A. Rackley, (ISBN:9780128120422)
4. Integrated Gasification Combined Cycle (IGCC) Technologies, Ting Wang Gary Stiegel (ISBN: 9780081001851)

ME 416 Nuclear Power Plant 3(3, 0)

Role and importance of nuclear energy, Particle wavelength, Excited states and radiation, Nuclear stability and radioactive decay, Nuclear reaction, Binding energy, Radioactive decay, Interaction of radiation with matter: Neutron interaction, Cross-sections, Neutron attenuation, Neutron flux, Neutron cross-section data, Energy loss in scattering collision, Fission, γ-ray interaction with matter

Nuclear reactor: Fission chain reaction, Nuclear reactor fuel, Nuclear power plants

Nuclear Reactor Systems and components: Steam generator, Pressurizer, Steam supply system, Reactor Containment, Turbine, Cooling Tower; Nuclear reactor theory: Neutron flux, Fick's law, Equation of continuity, Diffusion equation, heat Removal from reactor, Heat generation in reactors, Conduction, Convention, Two Phase Flow, Boiling Heat transfer, Nuclear reactor safety: Reliability, Risk, Safety, Case studies of Nuclear power plant accidents,

Text and Reference Books:

1. Introduction to Nuclear Engineering, J. R. Lamarsh and A. J. Baratta ., Prentice Hall.
2. Fundamentals of Nuclear Reactor Physics, E. E. Lewis.
3. Nuclear Energy: An introduction to the concepts, systems, and applications of nuclear processes, R. L. Murray. Elsevier Inc.
4. Nuclear Engineering Theory and Technology of Commercial Nuclear Power, R. A. Knief

ME 417 Hydroelectric Power Plant 3(3, 0)

Hydroelectric power plant includes topics Hydropower Resources, Hydropower Sites, categories of hydropower Plant, large Hydropower Plants: Dams and Barrages, run-of-river Scheme, Flow duration curve, estimation of gross energy, by-pass channel, Dam and Reservoir, Dam types, Hydropower Turbines, Impulse Turbines, Reaction Turbines, Francis turbine, Propeller and Kaplan Turbines, Deriaz Turbine, Generators, Small Hydropower, Environmental Considerations, Environmental Assessment, Resettlement, Biodiversity, Geological Effects, Sedimentation and Downstream, Effects, Greenhouse Gases, Interregional Effects, Hydropower and Intermittent renewable Generation and Cost of Electricity Generation from Hydropower Plants.

Recommended Books:

1. Hydropower, Paul Breeze Elsevier
2. Introduction to Hydro Energy Systems, Wagner, H.J. and M. Jyotirmay. Springer-Verlag Berlin Heidelberg.

ME 418 Environment and Pollution control 2(2, 0)

Introduction to environmental engineering and environmental legalization, clean and polluted air, water and pollution effect. Air, water, land, noise and thermal pollution. Sources and nature of pollution, industrial furnaces automobiles, aircrafts, thermal power plants, industrial waste, accidental and shortage leakage of hydrocarbon. Pollution control; pre- pollution control of air and water, improvement in combustion process, industrial waste treatment. Post pollution control, air pollution control technologies, water pollution control technologies. Thermal and noise pollution control, Nuclear power plants pollution, ISO 14000, pretreatments, post treatment, EPA, Recycling,

Recommended Books:

1. Fundamentals of Environmental Engineering by Danny D. Reible
2. Environmental Engineering by Weiner, Mathews, Aarne

ME 422 Bio Engineering 3(3, 0)

Introduction to Bioengineering: Introduction to some major diseases/biological systems and the engineering used in current treatments. Regulatory and ethical issues in the design and development of medical devices.

Biomaterials and Manufacturing Processes: Introduction to Biomaterials, Current clinical applications of biomaterials. Nano-biomaterials manufacture, characterization and use as biomaterials. Case studies on the design and manufacture of both external and internal implants (e.g. prosthetics for amputees, joint replacements, tissue scaffolds, etc.). Manufacturing processes used to biomaterials.

Biomechanics: Muscles and movement. Skeletal biomechanics, Introduction to Biomechanics of human movement, human hand and foot biomechanics, functional biomechanics of the spinal column. In-vivo musculoskeletal diagnostic technique.

Biofluid Mechanics: The application of experimental techniques and computational fluid dynamics (CFD) to the study of medical and biological problems. Mechanics of heart values, Pulsatile flow in large arteries. Flow and pressure measurements. The computational modelling of artificial heart pumps and assistive devices.

Recommended Books

1. An Introductory Text to Bioengineering, by S. Chien, P.C. Y. Chen, Y. C. Fung.
2. Biomaterials Science: An Introduction to Materials in Medicine, by B. D. Ratner, A. S. Hoffman, F. J. Schoen and J. E. Lemon.
3. Biomaterials: Principles and Practices, by J. Y. Wong, J. D. Bronzino, D. R. Peterson.
4. Introductory Biomechanics: From Cells to Organisms, by C. R. Ethier and C. A. Simons.
5. Fundamentals of Biomechanics, by D. Knudson.
6. Biofluid Mechanics, by J. Mazumdar.
7. Biofluid Mechanics in Cardiovascular Systems, by L. Waite.
8. Applied Biofluid Mechanics, by L. Waite and J. Fine.

ME 423 Fatigue & Fracture Analysis 3(3,0)

Prerequisite: ME 321 Mechanics of Materials-II

Introduction to fracture and fracture mechanics, principles of linear-elastic and elastic-plastic fracture mechanics, micro-structural effects on fracture in metals, ceramics, polymers, thin films, biological materials and composites, toughening mechanisms, crack growth resistance and creep fracture, failure assessment diagram and quantitative analysis of fracture. Introduction of fatigue and fatigue damage, fatigue classification, stress and strain-life approach to fatigue, dislocation sub-structures in single crystals, fatigue crack growth models and mechanisms, variable amplitude fatigue, corrosion fatigue, predicting failure loads on flawed structures, predicting time to failure due to fatigue loading on cracked and uncracked structures, designing to prevent failure, analysing stress corrosion cracking, and conducting ASTM standard tests and case studies of fracture and fatigue in structural, bio-implant, and microelectronic components.

Books:

1. Fatigue and Fracture: Understanding the Basics, F.C Campbell, ASM International, .
2 *Fatigue of Materials.* Suresh, S.. Cambridge University Pres
3 Fracture Mechanics. Anderson, T. L. CRC Press,
4 Deformation and Fracture Mechanics of Engineering Materials. Hertzberg, R. W. John Wiley & Son

ME 424 Advanced Mechanics of Materials 3(3, 0)

Prerequisite: MA 225: Differential Equations and Transforms, ME 321: Mechanics of Materials-II

Three-dimensional stress at a point, stress equation of equilibrium, laws of stress transformation, principal stresses, displacement and strain, equations of strain transformation, principal strains, compatibility. inelastic bending and torsion, Thick cylinders, axial stresses in thick cylinders, compound cylinders, plastic deformation of thick cylinders, thin circular plates, beams on elastic foundation.

Recommended Books

1. Mechanics of Engineering Materials by R.J. Crawford and P.P. Benham.
2. Advanced Mechanics of Materials by Arthur P. Boresi, Richard J. Schmidt

ME 425 Aerodynamics and Aerospace Structures 3(3,0)

Prerequisite: ME 213 Fluid Mechanics-II

ME 321 Mechanics of Materials-II

Introduction to aerodynamic and aerospace structures, Compressible Aerodynamics, Analysis and design of compressible, inviscid flows; isentropic flow, shock waves, Prandtl-Meyer expansions, supersonic nozzles and diffusers. Airfoils in compressible flow and small perturbation theory, introduction to hypersonic-flow theory.
Incompressible Aerodynamics, Dynamics of vector fluid flow fields. Ideal fluid flow. Introduction to viscous boundary layers. Airfoil Theory. Finite-wing theory.
Experimental aerodynamics, aerodynamic testing and instrumentation. Supersonic and low-speed wind tunnel testing including shock waves, aerodynamic forces, pressure distribution on an airfoil and boundary layers, application of schlieren optics, thermal anemometry and laser doppler velocimetry, Aerospace structures, Torsion of thin-walled beams. Flexural shear flow. Thermal analysis of aerospace structures. Introduction to composite materials. Buckling of plates.

Recommended Books:

1. Aerodynamics for Engineers by J. J. Bertin and R. M. Cummings
2. Aircraft Structures for Engineering Students by T. H. G. Megson

ME 432 Fundamentals of Tool Design 2(2,0)

Introduction to tool design, Design process, Economics of tool design, Cutting Tool Material, Cutting Tool Design, Factors effecting tool design, Tool wear, Cutting Forces and Tool Life Calculations, Nomenclature of single and multi-edge cutting tools, Locating and Workholding Principles, Locating and Clamping types and methods, Clamping principles, non-mechanical & power clamping, Jig design, Jig design principles, fixture design, classification of fixtures, fixture principles, fixture forces, Die Design, die operations, die forces, progressive and compound dies, power presses, Modular and Automated Tool Handling, Tool design for Inspection and Gaging, Tool Design for Joining Processes, Computer aided modular fixture design, Form feature classification, fixture setup planning, layout design, computer aided die design.

Recommended Books:

1. Integrated Process & Fixture Planning, Theory, Application & Practice, Awais A. Khan, CRC Press
2. Fundamentals of Tool Design, John G. Nee
3. Jigs and Fixture Design, Edward G. Hoffman,
4. Advanced Computer Aided Fixture Design, Rong

ME 433 Computer Integrated Manufacturing 2(2,0)

Prerequisite: ME 231 Manufacturing processes

ME 331 Machine Tools & Machining

Introduction to CIM -Type of Manufacturing System -Elements of CIM -Automation and CAD/CAM Concurrent Engineering. Manufacturing System -Group Technology (GT) -Process Planning -Production Planning and Control. Fundamental of CAM -Numerical Control (NC) -Control Systems of the NC Machine Tool -Adaptive Control -Sensors for

Computer-Controlled Machine Tool -NC Part Programming. Material Handling and Storage -Automated Material Handling -Analysis for Material Handling System -Automated Guided Vehicle System -Automated Storage System -Automated Storage/Retrieval System -Applications. Flexible Manufacturing Systems -FMS Workstation -Material Handling and Storage System -Computer Control System -Planning the FMS -Analysis Methods for FMS -Applications. Numeric Control and Robots -Numerical Control -Industrial Robotics -Programmable Logic Controllers. Material Requirements Planning (MRP) -Objectives of MRP -Basic Concepts and Inputs to MRP -Bill of Material (BOM) -How MRP works. Shop Floor Control (SFC) -Functions of SFC System -Operation Scheduling -Priority Rules for Job Sequencing. Just-In-Time (JIT) -Introduction -Prerequisites for JIT -Elements of JIT -Toward Eliminating Inventories in JIT System. Implementation of CIM

Recommended Readings:

1. Automation, Production Systems, and Computer-Integrated Manufacturing, Mikell P. Groover, Pearson/Prentice Hall.
2. Computer Integrated Manufacturing James A. Rehg , Henry W. Kraebber
3. Computer Integrated Manufacturing, N. Venkateshwaran
4. Systems Approach to Computer-Integrated Design and Manufacturing, Nanua Singh

ME-434 Micro and Nano Manufacturing 3(3, 0)
Prerequisite: ME 231 Manufacturing Processes

Basics PCB manufacturing process, basic semiconductor manufacturing process, Introduction of Top-down approaches, Introduction of Bottom-up approaches, Lithography, etching basics, Thin-film deposition methods, evaporation, sputter deposition, Chemical vapor deposition, Physical Vapor Deposition, Molecular Beam Epitaxy. Introduction to nanotechnology and nanomanufacturing, Taxonomy and geometry of nanostructures, Techniques for characterizing nanostructures, Electronic and optical properties of nanostructures, Mechanical properties of nanostructures, Thermal properties of nanostructures, Nanoparticle synthesis in solution, Self-assembly of monolayers and multilayers

Recommended Readings:

1. Fundamentals of semiconductor manufacturing and process control. May, Gary S., and Costas J. Spanos. John Wiley & Sons,
2. Nanomanufacturing handbook. Busnaina, Ahmed. CRC press,

ME 435 Engineering Tribology 2(2, 0)

Basic principles of tribology--the study of friction, wear, and lubrication--including the importance of materials, surfaces, design, operating conditions, environment, and lubrication on friction, wear, and surface damage in any system. Hydrodynamic lubrication, Hydrostatic lubrication, Elasto-hydrodynamic lubrication, Lubricants, Surface modification, Application of tribological theories, concepts, techniques, and approaches to design, research, development, evaluation, and problem-solving. Thin Films and ceramic coatings for tribological applications, mechanical properties of the ceramic coatings, frictional performance of ceramic coatings, wear performance of ceramic coatings, Toxicology and chemical analysis of ceramic coatings for bio medical applications,

Recommended Texts:

1. Engineering Tribology, John A. Williams, Cambridge University Press,
2. Tribo-physics and Design of Tribological Systems Suh, N. P. Englewood Cliffs, NJ: Prentice-Hall,. ISBN: 9780139309830
3. Tribology, Principles and Design Applications, Arnell et al.
4. Fundamentals of Machine Elements, Hamrock, Jacobson, and Schmid

ME 441 Robotics and Automation 3(3,0)

Prerequisite: ME 123 Engineering Dynamics

Robot definition and its types. Robot kinematics. 2D and 3D spatial relationships in Cartesian coordinate systems. Body fixed and space fixed transformations. Velocity and acceleration analysis of robot manipulators. Manipulate robot arms: kinematic chains, forward and inverse kinematics, differential kinematics. Eulerian angles and quaternions. Robot kinetics. Program and navigate mobile robots: robot and map representations, motion planning.

Automation of industrial control systems. Role of discrete control in manufacturing industries. Input/output devices for discrete data systems. Sensors and actuators. Analog to digital converters. Digital to analog converters.

Computer control/Embedded control (PLC) architecture. Programming in ladder logic or flow charts. Usage of subroutines, counter, timers, memory section and I/O scanning in PLCs. Scan cycle of PLC. Interacting of PLC to PC or human machine interface (HMI) for data analysis and control aspects. Case studies for different machining and assembly processes using a PLC.

Industrial communications and its protocols. Sensor Bus (RS 485, ASI, HART Multidrop), Device Bus (ModBus, ProfiBUS-DP, CANopen, DeviceNet). Control network (Ethernet). Introduction to SCADA (supervisory control and data acquisition systems). Interfacing of PLC or control devices to NC, CNC or robot to form a single station FMS.

Recommended Readings:

1. Introduction to Robotics, Mechanics and Control, Craig, Prentice Hall, 2003. ISBN 9780201543612.
2. Industrial Automation and Robotics: An Introduction , A.K. Gupta and S.K. Arora, Mercury Learning & Information, ISBN: 1938549309
3. Robotics and Manufacturing Automation by C Ray Asfahl.
4. Automation, Production Systems, and Computer-Integrated Manufacturing by Mikell P. Groover
5. Manufacturing Automation: Metal cutting machines, Machine Tools, Vibrations and CNC design. By Yusuf Altintas.
6. PLC application manuals from Siemens, Mitsubishi and Allen Bradley etc.

ME-442 Instrumentation 2(2, 0)

Introduction to sensors and transducers. Basic sensor technology. Sensor characteristics. Signal conditioning circuits used for sensors and transducers. Analog to digital converters. Identification of different measuring variables in mechanical engineering.

Displacement and dimensional measurement. Contact and noncontact position sensors. Linear and rotary position sensors. Explanation of Encoders and resolvers for angular position measurement of rotating shafts. Acceleration, shock and vibration sensors. Stress and strain measurements. Force and torque measurement. Pressure sensors. Piezo resistive

pressure sensors. Piezoelectric pressure sensors. Temperature Sensors. RTD sensors. Thermocouples. Semiconductor sensors. Fluid flow sensors: operation of flow sensors based on heat transfer flow and differential pressure technology. Contact and non-contact type of torque sensors. Placement of torque sensors for engine power measurement. Introduction to stress and strain measurement in mechanical links. Case studies for the different mechanical applications.

Recommended Books:

1. Mechanical Measurements, Thomas G. Bechwith
2. Sensor technology Handbook, Editor in chief: Jon S. Wilson, Newnes press
3. Automotive Sensors, John Turner. Momentum Press

ME 452 Computational Fluid Dynamics 3(3,0)

Introduction to CFD, Methods of prediction, advantages and disadvantages of numerical prediction, mathematical description of physical phenomena, governing differential equations, general transport equation, nature of coordinates, discretization method, methods of deriving the discretization equations, discretization of diffusion terms, heat conduction, steady one dimensional conduction, unsteady one dimensional conduction, two and three dimensional situations, over-relaxation and under-relaxation, convection and diffusion terms, steady one dimensional convection and diffusion, discretization of two dimensions, discretization of three dimensions, false diffusion, calculations of the flow field, pressure and velocity corrections, SIMPLER algorithm, source term linearization, illustration applications, finite volume methods for unsteady flows, boundary conditions in finite volume methods, errors and uncertainties in CFD, turbulence modelling, different turbulence models in finite volume methods.

Recommended Books:

1. "An Introduction to Computational Fluid Dynamics" Versteeg and Malelasakera.
2. "Computational Fluid Dynamics: The Basics with Applications" John M. Anderson.
3. Numerical Heat Transfer and Fluid Flow, Suhas V. Patankar , Hemisphere Publishing,

ME 462 Renewable Energy Applications 3(3,0)

Introduction to renewable energy technologies; Solar energy systems, Solar Desalination technologies; Principles and operation of direct and indirect solar desalination technologies; Solar Systems for Heating and Cooling of Buildings; Solar Water-Heating Systems; Solar House; solar water pumping system;
Wind power technology; principle and operation of wind power technology;
Biomass, Bio fuel, hydroelectric, Geothermal and other applications in existing energy utilization systems (Heating, Cooling, Transport, Water Treatment, and Electricity)
Hydrogen production technologies; Principles and operation of hydrogen production systems, Principles and operation of various types of fuel cells; Configuration of individual cells, stack

and fuel cell system; Thermodynamics of fuel cells; Introduction to electrochemical kinetics; Transport-related phenomena and conservation equations for reacting multi-component systems; Fuel cell system design, optimization and economics; Fuel cell performance simulation; Applications of fuel cells; Social and environmental aspects; Challenges of fuel cell commercialization; Future of fuel cells

Text and Reference books:

1. Handbook of Solar Energy Theory, Analysis and Applications, Tiwari, G. N., Tiwari, Arvind, Shyam, Springer.
2. Renewable Energy Applications for Freshwater Production: Jochen Bundschuh, Jan Hoinkis, CRC Press
3. Wind Energy Explained: Theory, Design and Application, James F. Manwell, Jon G. McGowan, Anthony L. Rogers, WILEY. ISBN: 978-0-470-68628-7
4. Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning, Bent Sørensen Bent Sørensen, ELSEVIER, ISBN: 9780123750259
5. Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications, Stolten, D. and B. Emonts. John Wiley & Sons

ME 463 Energy Economics and Planning 2(2,0)

Energy and Resource Economics - Economic theories and management of energy resources, Evaluation of external effects of energy use; Modeling energy and resource use; Using energy mix in devising sustainable development strategies and plans, econometric models. Energy Challenges, Pricing and Macro Economy-Concepts - Energy pricing, Measures to reduce energy import bill, Role of energy resources in economic development, analyze the impact on different economies.

Energy Tariffs, Taxation and Subsidies - Types of tariffs, current tariff system, Taxation and Subsidies, Need for comprehensive reforms for pricing system, Energy contracts, levelized cost of electricity, energy audits, asset management.

The Economics of Climate Change - Energy and Climate Change, Clean Development Mechanism Estimation of damage costs from climate change; evaluation of climate change mitigation options; problems of international cooperation on climate change policy; distributional implications of climate change and climate change policy. Energy Management - Project management, Demand side management; Electrical Systems load scheduling/shifting, Energy modeling and forecasting; Financing energy conservation programs.

Optimal planning of resources, logistics, distribution and storage in the end to end energy value chain from upstream natural gas production through mid-stream transportation and storage to downstream power generation, utility distribution and consumption. Smart Grid Optimization. Supplier and customer relationship management, contracts management. Lean-Six Sigma energy system process design. Power systems reliability and control, preventive maintenance, predictive maintenance, process and service quality control. Future Readiness: Key Trends, Business Opportunities and Challenges, Future Scenario Planning

Text and Reference books:

1. Energy Economics: Concepts, Issues, Markets and Governance. Bhattacharyya, S.C. Springer
2. Energy Engineering and Management, Chakrbati, A. PHI publishers, India.
3. Energy Management Handbook, Turner, W.C. and S. Doty. Fairmont Press. USA.
4. Environmental and Natural Resource Economics, Thomas Tietenberg.
5. Resource Economics, Jon M. Conrad, Cambridge University Press; ISBN: 978-0521697675

ME 464 Energy Storage Technologies 3(3,0)

Intro to Energy Storage: Introduction to the traditional bulk power system, its operation, layout and control. Design tradeoffs of applying energy storage solutions throughout the transmission, sub-transmission and distribution networks. System impacts and effects of distributed generation on the operation and control of the bulk power system.

Electrochemical Energy Storage: Batteries, Introduction to battery storage including lead acid, lithium ion, flow, and emerging battery technologies. Comprehensive analysis of design considerations and application specific needs. Impacts on system cost in terms of life cycle, environmental, and reliability of the end solutions. Ultra-Capacitors: Introduction to ultra-capacitors including operation, applications, and emerging technologies. Topics include the usage in mobile applications and proximity to renewable energy sources. Discussion of primary target market usage in today's energy and power sectors

Super Conducting Magnetic Energy Storage: Introduction to Super Conducting Magnetic Energy Storage (SMES) operation, theory of usage and emergent research. Case study large utility scale energy storage facilities

Mechanical Energy Storage: Pumped hydroelectric energy storage, Models for pumped hydro capacity and availability, System cost, capacity, conversion efficiency,

Compressed Gas: Models for compressed gas capacity, efficiency, and availability. System cost, capacity, conversion efficiency, and siting will be discussed along with barriers to adoption. Possible applications in carbon capture and sequestration

Flywheel: Models for flywheel capacity, availability, efficiency, and self-discharge. Applications in transportation, uninterruptible power supply (UPS), pulse power, and bulk storage. Selection and design of flywheels for safety and availability in various applications.

Thermal: Introduction to thermal storage with an emphasis on residential and utility scale applications including molten salts, cold reservoirs, and phase change materials. Analysis of design considerations, material selection, and application specific constraints. Applications in renewable energy particularly utility scale solar and geothermal power production.

Text and Reference Books:

1. Energy Storage for Power Systems, Ter-Gazarian, A.G. , IET Publications (ISBN: 978-1849192194)
2. Energy Storage, Huggins, R.A. Springer, (ISBN: ISBN 978-1441910240)
3. Thermal Energy Storage; Systems and Applications, İbrahim Dincer, Marc A. Rosen , John Wiley & Sons,
4. Sustainable Thermal Storage Systems: Planning, Design, and Operations, Lucas B. Hyman McGraw-Hill
5. Large Energy Storage Systems Handbook Frank S. Barnes, Jonah G. Levine (ISBN 9781138071964)

ME-472 Principles of Management 2(2,0)

Introduction and fundamental of Management, Management functions, Management Roles, Skills, Communicating, Coordinating, Planning, Decision Making and Controlling, Manager's job, Rewards and Challenges of being a Manager, Styles of Management, Humanistic Styles of Management, Organization Structure, wok specialization, departmentalization, chain of command and formulization, Organizational Culture, Source of Culture, Decision Making Process and Role of Manager, Foundation of Behavior,

Leadership, Motivation, Team and Team Work, Personal Time Management, Managing Change. Human Resource Management, Introduction to Management Information System,

Recommended Books

1. Management, Stephen P. Robbins & Mary Coulter
2. Principles of Management, Charles W. L. Hill and Steven McShane
3. Principles of Management, Tony Morden

ME 473 Industrial Management Systems 2(2,0)

Quality Management System, implementation planning, documentation planning, defining organizational processes, quality practices, refinement, deployment, continual improvement, ISO 9001 standards, environmental management system, introduction and importance, typical plan, do, check and act processes of environmental management system, familiarization with ISO 14000 standards, Energy Management System: Energy policy, planning, implementation, operation, auditing, reporting, Familiarization with ISO 50001 standards, occupational health and Safety management system, management responsibility, identifying and analyzing workplace hazards, developing and implementing safety based procedures, workforce involvement, familiarization with OHSAS 18001 standards, IT Management System, introduction, supply chain management system, introduction

Recommended Books:

1. Quality Management System Handbook for Product Development Companies by V. Nanda
2. Installing Environmental Management Systems: A Step-by-Step Guide by C. Sheldon and M. Yoxon
3. Inside Energy: Developing and Managing an ISO 50001 Energy Management System by C.H. Eccleston, F. March T. Cohen
4. Energy Management Handbook by W.C.Turner and S. Doty
5. Occupational Health and Safety Management: A Practical Approach by C.D. Reese

ME 474 Total Quality Management 2(2,0)

Introduction to Quality, Total quality concept, Quality management system, Evolution of quality concepts and quality paradigms, Cost of Quality, TQM principles and strategies, Contributions of Deming, Juran and Crosby - Barriers to TQM, Organization for total quality, process management, Quality teams and teamwork processes, Basic problem solving tools for quality improvement, Leadership and empowerment, Performance Measures for TQM, Quality standards, Global quality awards (Deming Prize, Malcolm Baldrige), Quality improvement: Six sigma, Lean, kaizen, 5S, SPC, Quality through planning and design: QFD, policy deployment, Quality through innovation, Quality through IT, TQM implementation and case studies

Recommended Books:

1. Quality Management, Goetsch and Davis, Prentice Hall
2. Quality Management Essentials, Hoyle, Elsevier.
3. Quality planning and analysis: from product development through use, Gryna, McGraw-Hill.
4. Total Quality Management, D. H Besterfield, Pearson Education,
5. Total Quality Management by John Oakland