Chemical Engineering Course Curriculum for the New Programme (B.Tech/Dual Degree) w.e.f 2007 Batch

May 2009

Department of Chemical Engineering
Indian Institute of Technology, Bombay

Course Credit Distribution

Sem	Code	Course	L	T	P	C
	Other Departments					
1	MA105	Calculus	3	1	0	8
1	HS101	Economics	3	0	0	6
1/2	CH103	Chemistry	2	1	0	6
1/2	PH105	Modern Physics	3	1	0	8
1/2	CH117	Chemistry Lab	0	0	3	3
1/2	PH117	Physics Lab	0	0	3	3
1/2	ME113	Workshop Practice	0	1	3	5
1/2	ME119	Engg. Graphics	0.5	0	3	4
1	CS101	Computer Programming & Utilization	2	0	2	6
2	IC102	Data Analysis & Interpretation	2	1	0	6
2	MA106/MA108	Linear Algebra / Diff. Eqns I	3	1	0	8
3	IC211	Experimentation and Measurements Lab	0	0.5	3	4
3	MA205/MA207	Complex Analysis / Diff. Eqns II	3	1	0	8
4	HS200	Environmental Studies	1	1	0	3
4	ES200	Environmental Studies - Science and Engineering	1	1	0	3
5	EE101	Intro to Electrical and Electronics Circuits	3	1	0	8
5	BT251	Molecular Cell Biology	2	1	0	6
5	HS202	Introduction to Psych/Sociol/Lit/Phil	3	0	0	6
		Subtotal	31.5	11.5	17	101
	ChE Department					
2	CL152	Introduction to Chemical Engg.	3	0	0	6
3	CL203	Introduction to Transport Phenomena	2	1	0	6
3	CL231	Solid Mechanics	2	1	0	6
3	CL253	Chemical Engineering Thermodynamics	3	1	0	8
4	CL242	Fundamentals of Heat and Mass Transfer	2	1	0	6
4	CL254	Process Fluid Mechanics	2	1	0	6
4	CL244	Introduction to Numerical Analysis	3	1	0	8
5	CL324	Chemical Reaction Engineering	3	1	0	8
6	CL317	Mass Transfer Operations	2	1	0	6
6	CL326	Material Science	3	0	0	6
7	CL415	Process Equipment Design & Economics	3	0	0	6
7	CL417	Process Control	3	1	0	8
8	CL408	Chemical Processes	3	0	0	6
8	CL451	Chemical Process Design	3	0	0	6
4	CL232	ChE lab 1	0	0	6	6
5	CL333	ChE lab 2	0	0	6	6
6	CL335	ChE lab 3	0	0	6	6
7	CL433	ChE lab 4	0	0	6	6
8	CL455	Design lab 1	0	0	3	3
8	CL457	Design lab 2	0	0	3	3
		Subtotal	37	9	30	122
6,7		Inst. electives (2)	6	0	0	12
6-8		Dept. electives (4)	12	0	0	24
		B. Tech. Total	86.5	18.5	47	259
	Honours					
4	CL260	Molecular and Statistical Thermodynamics	2	1	0	6
5	CL336	Advanced Transport Phenomena	3	0	0	6
6	CL325	Chemical Reaction Engineering 2	2	1	0	6
7,8		Dept electives (2) or Research Projects	6	0	0	12
		B. Tech. Honours Total	99.5	20.5	47	289
	DD	DD = B.Tech + Honours + Thesis + 4 courses				
		Thesis				72
		Departmental PG electives (4)	12	0	0	24
		D.D. Total	111.5	20.5	47	385

Notes

Department choices:

1. The ChE honours requirement is
   (a) CL260 Molecular and Statistical Thermodynamics (Sem. 4),
   (b) CL336 Advanced Transport Phenmomena (Sem. 5),
   (c) CL325 Chemical Reaction Engineering 2 (Sem 6),
   (d) 2 Departmental electives (in addition to the 4 Departmental electives for the B. Tech.) or Research Project (Sem. 7 and Sem. 8).
2. The ChE minor stream is
   (a) CL152 Introduction to Chemical Engg. (Sem. 3),
   (b) CL203 Introduction to Transport Phenomena (Sem. 5),
   (c) CL253 Chemical Engineering Thermodynamics (Sem. 6),
   (d) CL324 Chemical Reaction Engineering (Sem. 7),
   (e) CL417 Process Control (Sem. 8)
3. BTP, PT and seminar are dropped.
4. Works visit is still mandatory.

Semester-wise Schedule

Semester 1

Code	Course	L	T	P	C
MA105	Calculus	3	1	0	8
CH103	Chemistry I	2	1	0	6
PH105	Modern Physics	2	1	0	6
HS101	Economics	3	0	0	6
CH117	Chemistry Lab	0	0	3	3
PH117	Physics Lab	0	0	3	3
ME113	Workshop Practice	0.5	0	3	4
ME119	Engg. Graphics	0.5	0	3	4
CS101	Computer Programming & Utilization	2	0	2	6
					33

Semester 2

Code	Course	L	T	P	C
MA106+MA108	Linear Algebra + Diff. Eqns I	3	1	0	8
CH103	Chemistry	2	1	0	6
PH105	Modern Physics	2	1	0	6
IC102	Data Analysis & Interpretation	2	1	0	6
CH117	Chemistry Lab	0	0	3	3
PH117	Physics Lab	0	0	3	3
ME113	Workshop Practice	0.5	0	3	4
ME119	Engg. Graphics	0.5	0	3	4
CL152	Introduction to Chemical Engg.	2	1	0	6
					33

Semester 3

Code	Course	L	T	P	C
CL231	Solid Mechanics	2	1	0	6
MA205/MA207	Complex Analysis / Diff. Eqns II	3	1	0	8
CL253	Chemical Engineering Thermodynamics	3	1	0	8
CL203	Intro to Transport Phenomena	2	1	0	6
IC211	Experimentation and Measurements Lab	0	0.5	3	4
		10	4.5	3	32

Semester 4

Code	Course	L	T	P	C
HS200	Environmental Studies	1	1	0	3
ES200	Environmental Studies - Science and Engineering	1	1	0	3
CL242	Fundamentals of Heat and Mass Transfer	2	1	0	6
CL254	Process Fluid Mechanics	2	1	0	6
CL244	Introduction to Numerical Analysis	3	1	0	8
CL232	ChE lab 1	0	0	6	6
		10	3	6	32
CL260	Molecular and Statistical Thermodynamics	2	1	0	6
		12	4	6	38

Semester 5

Code	Course	L	T	P	C
EE101	Intro to Electrical and Electronics Circuits	3	1	0	8
BT251	Molecular Cell Biology	2	1	0	6
HS202	Psych/Sociol/Lit/Phil	3	0	0	6
CL324	Chemical Reaction Engineering	3	1	0	8
CL333	ChE lab 2	0	0	6	6
		10	4	6	34
CL336	Advanced Transport Phenomena	3	0	0	6
		13	3	6	40

Semester 6

Code	Course	L	T	P	C
CL317	Mass Transfer Operations	2	1	0	6
CL326	Material Science	3	0	0	6
	Inst. elective 1	3	0	0	6
	Dept. elective 1	3	0	0	6
CL335	ChE lab 3	0	0	6	6
		12	1	6	30
CL325	Chemical Reaction Engineering 2	2	1	0	6
		14	2	6	36

Semester 7

Code	Course	L	T	P	C
	Dept. elective 2	3	0	0	6
CL417	Process Control	3	1	0	8
CL415	Process Equipment Design & Economics	3	0	0	6
	Inst. elective 2	3	0	0	6
CL433	ChE lab 4	0	0	6	6
		12	1	6	32
	Honors elective 1 (or) Research Projects.	3	0	0	6
		15	1	6	38

Semester 8

Code	Course	L	T	P	C
CL408	Chemical Processes	3	0	0	6
CL451	Chemical Process Design	3	0	0	6
CL455	Design lab 1	0	0	3	3
CL457	Design lab 2	0	0	3	3
	Dept. elective 3	3	0	0	6
	Dept. elective 4	3	0	0	6
		12	0	6	30
	Honors elective 2 (or) Research Projects.	3	0	0	6
		15	0	6	36

Semester 9 (DD)

Code	Course	L	T	P	C
	DDP I				36
	DD elective 1	3	0	0	6
	DD elective 2	3	0	0	6
					48

Semester 10 (DD)

Code	Course	L	T	P	C
	DDP II				36
	DD elective 3	3	0	0	6
	DD elective 4	3	0	0	6
					48

Course outlines

Chemical Engineering courses

CL152: Introduction to Chemical Engineering, [2 1 0 6]

Historical overview of Chemical Engineering: Concepts of unit operations and unit processes, and more recent developments, Features of organized chemical processing- from chemistry to chemical engineering. The Chemical Industry-scope, features & characteristics. and scope. Principles of balancing with examples to illustrate differential and integral balances, lumped and distributed balances. Material balances in simple systems involving physical changes and chemical reactions; systems involving recycle, purge. and bypass. Properties of substances: single component & multicomponent, single and multiphase systems. Use of Compressibility charts, vapour pressure correlations/charts & Psychometric charts. Ideal liquid and gaseous mixtures. Energy balance calculations in simple systems. Introduction to Computer aided calculations-steady state material and energy balances.

Texts/References

1. R. M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd ed., John Wiley, New York, 2004.
2. D. M. Himmelblau and J. B. Riggs, Basic Principles and Calculations in Chemical Engineering. 7th ed., Prentice Hall, 2003.
3. B. I. Bhatt and S. M. Vora, Stoichiometry. 4th ed., McGraw Hill, 2004.

CL203: Introduction to Transport Phenomena, [2 1 0 6]

Introduction: Vectors/Tensors, Viscosity, Shell balance: Falling film, Circular tube; Equations of Change for isothermal systems: Continuity, Motion, Energy, Substantial derivatives; Unidirectional flows: Pipe flow, Variable viscosity falling film, Couette viscometer, Rotating Sphere; Unsteady flows: Startup Plate flow, Parallel plates, Oscillating plate; Thermal conductivity and mechanism of energy transport; Shell energy balances and temperature distributions in solids and laminar flow; The equations of change for nonisothermal systems; Diffusivity and the mechanisms of mass transport; Concentration distributions in solids and laminar flow; Equations of change for multicomponent systems; Introduction to the concept of heat and mass transfer coefficients.

Texts/References

1. R.B.Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, 2nd ed., Wiley, 2006.

CL231: Solid Mechanics, [2 1 0 6]

Rigid and deformable solids; Method of sections for evaluating internal forces in bodies - review of free body diagrams; Concept of stress - normal and shear stresses; State of stress; Concept of strain - normal and shear strains; State of strain; Hookes law; Constitutive relations; Axially loaded members, force and deflections; Indeterminate systems and compatibility conditions; Simple indeterminate systems and lack of fit problems; Generalized Hookes law; Stress in cylindrical and spherical shells; Thin-Walled Pressure Vessels; Torsion of circular shafts - determinate and simple indeterminate systems. Elastic theory of bending of beams; Shear force and bending moment diagrams; Bending and shearing stresses in beams of symmetrical cross-section; Concept of shear flow and shear centre; Principle of superposition and its limitations. Transformation of plane stress and strain; Principal stresses and strains; Mohrs circle. Bending deflection of beams by direct integration method; Application of direct integration method to simple indeterminate systems. Elastic buckling of compression members.

Texts/References

1. F.P. Beer, E.R. Johnston and J.T. DeWolf, Mechanics of Materials, 3rd Ed., Tata McGraw Hill, New Delhi, 2004.
2. E.P. Popov, Engineering Mechanics of Solids, 2nd Ed., Prentice Hill, New Delhi, 1999.
3. I.H. Shames and J.M. Pitarresi, Introduction to the Solid Mechanics, 3rd Ed., Prentice Hill, New Delhi, 1989.
4. J.M. Gere, Mechanics of Materials, 5th Ed., Brooks/Cole, Chennai, 2001.
5. S.H. Crandall, N.C. Dhal and T.J. Lardner, Mechanics of Solids: An Introduction, McGraw Hill, Tokyo, 1994.
6. S.M.A. Kazimi, Solid Mechanics, Tata McGraw-Hill, New Delhi, 1981.

CL242: Fundamentals of Heat and Mass Transfer, [2 1 0 6]

Review of conduction, resistance concept, extended surfaces, lumped capacitance; Introduction to Convection, boundary layer theory, natural and forced convection, correlations; Radiation; Heat exchangers: LMTD, epsilon-NTU method; Interphase mass transfer, mass transfer coefficient, theories for interphase mass transfer, overall mass transfer coefficient, correlations, mass transfer with chemical reaction, simultaneous heat and mass transfer, analogy between momentum, heat and mass transfer; Crystallization.

Texts/References

1. F.P. Incropera and D.P. Dewitt, Introduction to Heat Transfer, 5th ed., Wiley, 2006.
2. E.L. Cussler, Diffusion: Mass Transfer in Fluid Systems, 2nd ed., CUP, 1997.
3. R.B. Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, 2nd ed., Wiley, 2006.

CL253 Chemical Engineering Thermodynamics, [3 1 0 8]

Single-Phase Systems: Introductory concepts: Work, Heat, Reversible and Irreversible Processes; Equations of State and Generalized Correlations; First Law: Closed and Open Systems, Steady and Transient Processes. Second law and Entropy: Reversible Heat Engines; Availability and Exergy Analyses, Maxwell Relations and Fluid Properties Estimation; Pure Component Phase Equilibria, Power and Refrigeration Cycles; Flow Processes; Statistical Mechanics Basics: quantum states and degeneracy of energy levels. Liouiville theorem, microcanonical, canonical, grand canonical and the other ensembles, partition function and thermodynamic properties; monoatomic and diatomic gases, lattice statistics, ideal gas mixtures, imperfect gases; liquid state and solution theories. Single Phase Mixtures and Solutions: Ideal Solutions; Partial molar quantities; Gibbs-Duhem Equation; Phase-Rule; Phase Equilibrium Criteria, Non-ideal solutions; Residual and Excess Properties; Fugacity and Activity Coefficient models; Vapour-liquid equilibria (VLE) at low to moderate pressures; Raoult's Law, Henry's law High-Pressure VLE Availability Analysis of processes LLE, Triangular diagrams. Langmuir and BET isotherms; Chemical Reaction Equilibrium: Homogeneous and Heterogeneous reactions; Multireaction Equilibria; Combined Phase and Reaction Equilibria; Analytical Instrumentation: Calorimeters, Osmometers and their Principles.

Texts/References

1. J.M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 6th ed., McGraw-Hill, 2001.
2. S.I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4th Edition, Wiley India, 2006.
3. J.M. Prausnitz, R.N. Lichtenthaler and E.G. Azevedo, Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed., Prentice Hall, 1998.
4. J.W. Tester and M. Modell, Thermodynamics and its Applications, 3rd ed., Prentice Hall, 1999.
5. R.C. Reid, J.M. Prausnitz and B.E. Poling, Properties of Gases and Liquids, 4th ed., McGraw-Hill, 1987.
6. R. Balzheiser, M. Samuels, and J. Eliassen, Chemical Engineering Thermodynamics, Prentice Hall, 1972.
7. K. Denbigh, Principles of Chemical Equilibrium, 4th ed., CUP, 1981

CL254: Process Fluid Mechanics, [2 1 0 6]

Basic Fluid Concepts: Dimensions and Units, Velocity and Stress Fields, Viscosity and surface tension, Nonnewtonian viscosity, Dimensional Analysis (Buckingham PI theorem), Types of flows, Methods of Analysis, Fluid Statics; Differential Analysis: Review of NSE, Potential flows, Velocity potential, Boundary Layer Theory (Laminar), Viscous flows (past sphere), Integral Analysis: Mass, Energy (Bernouli), Momentum (Impinging jet, pitot tube, Orifice meter, rotameter, pipe flow: f vs Re charts); Chem Engg Equipment: Piping systems (K factors, networks), Flow past immersed objects (Packed beds, Fluidised beds, sedimentation, Centrifugal separation, filtration), Pumps, Agitation and Mixing, (Power consumption, mixing times, scale up), Particulate solids, characterisation, Other topics: Introduction to Turbulent Flows (Reynolds equations), Compressible flows, Compressors.

Texts/References

1. R.W. Fox, A.T. MacDonald and P.J. Pritchard, Introduction to Fluid Mechanics Wiley, 2008.

2. J.O. Wilkes, Fluid Mechanics for chemical engineers with microfluidics and CFD, 2nd ed., Prentice Hall, 1998.
3. M.Denn, Process Fluid Mechanics, Prentice Hall, 1979.
4. V.Gupta and S.K. Gupta, Fluid Mechanics and its applications, Wiley, 1984.
5. R.B. Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, 2nd ed., Wiley, 2006.

CL244: Introduction to Numerical Analysis, [3 1 0 8]

Interpolation by polynomials, divided differences, error of the interpolating polynomial, piecewise linear and cubic spline interpolation. Numerical integration, composite rules, error formulae. Solution of a system of linear equations, implementation of Gaussian elimination and Gauss-Seidel methods, partial pivoting, row echelon form, LU factorization Cholesky's method, ill-conditioning, norms. Solution of a nonlinear equation, bisection and secant methods. Newton's method, rate of convergence, solution of a system of nonlinear equations, numerical solution of ordinary differential equations, Euler and Runge-Kutta methods, multi-step methods, predictor-corrector methods, order of convergence, finite difference methods, numerical solutions of elliptic, parabolic, and hyperbolic partial differential equations. Eigenvalue problem, power method, QR method, Gershgorin's theorem. Exposure to software packages like IMSL subroutines, MATLAB.

Texts/References

1. S.D. Conte and C. de Boor, Elementary Numerical Analysis- An Algorithmic Approach, 3rd ed., McGraw-Hill, 1980.
2. C.E. Froberg, Introduction to Numerical Analysis, 2nd ed., Addison-Wesley, 1981.
3. E. Kreyszig, Advanced engineering mathematics, 8th ed., John Wiley (1999).

CL317: Mass Transfer operations, [2 1 0 6]

Distillation: batch distillation, continuous fractionation, calculations with multiple feeds and withdrawals; Special distillation techniques (azeotropic, extractive, etc.) steam and molecular distillation; Tray hydrodynamics and efficiencies; Liquid-Liquid extraction: Calculations with and without reflux for immiscible and partially miscible system; Gas absorption: packed tower design, effect of reaction; Simultaneous heat and mass transfer: Drying; Design of cooling towers; Adsorption: Types and nature of adsorption; Freundlich isotherm; Membrane processes: Gas separation processes; reverse osmosis processes.

Texts/References

1. J.D. Seader and E.J. Henley, Separation Process Principles, 2nd ed., Wiley, 2005.
2. E.L. Cussler, Diffusion: Mass Transfer in Fluid Systems, 2nd ed., Cambridge series, 1997.
3. P.C. Wankat, Separation Process Engineering, 2nd ed., Prentice Hall, 2006.

CL324: Chemical Reaction Engineering, [3 1 0 8]

Kinetics Reaction rate, order, rate constant; Batch reactors Design + basics; Kinetic constants from batch reactor data; Ideal flow reactors Mass and Energy balances; Isothermal, adiabatic and non-isothermal operation; Catalysts, Catalytic rates, Reaction mechanisms; Internal/External transport in catalysts; Non-catalytic solid-gas reactions; Reactor design for ideal flow reactors; Yield and Selectivity; Concept of RTD; Segregation and Maximum Mixedness models

Texts/References

1. H.S.Fogler, Elements of Chemical Reaction Engineering, 2nd ed., Prentice Hall, New Jersey, 1992.
2. O.Levenspiel, Chemical Reaction Engineering, 2nd ed., Wiley Eastern, 1972.
3. J.M.Smith, Chemical Engineering Kinetics, 3rd ed., McGraw Hill, 1980.

CL326: Material Science, [2 1 0 6]

Atomic Bonding, Crystal Structure and Defects, Mechanical and Thermal Behaviour: Failure Analysis and prevention, Phase Diagrams; Metals and alloys, Polymers (Plastics), Semiconductors, Ceramics & Glasses, Corrosion and its prevention, Environmental Effects, Nanotechnology, Biomaterials.

Texts/References

1. J.F. Shackelford, Introduction to Material Science for Engineers, 6th ed., Prentice Hall,2004.

CL 415: Process Equipment Design and Economics, [3 0 0 6]

Mechanical design of process equipment: pressure vessels, tall columns, etc., process piping design; Materials and Fabrication Selection;
Design Strategy and Optimum Equipment Design: Economic Design criteria; Cost and Asset Accounting; Cost Estimation; Interest and Investment Costs; Taxes and Insurance; Depreciation; Profitability, Alternative Investments and Replacement;
Illustrative Case Study in Process Equipment Design and Costing of Equipment in each of the following categories:
Material Transfer, Handling and Treatment Equipment
Heat Transfer Equipment: Shell and tube heat exchangers (Kern and Bell-Delaware design methods), Plate heat exchangers, Evaporators
Mass Transfer Equipment: Absorption/ Stripping columns (packed/tray), Multicomponent distallation colum (Fenske-Underwood-Gilliland correlations)
Reactors: choice of reactors, non-isothermal reactors, reactor configuration, interstage heating/cooling, multi-tubular reactors, catalyst deactivation.

Texts/References

1. M.S. Peters and K.D. Timmerhaus, Plant Design and Economics for Chemical Engineers, McGraw Hill, 1991.
2. D.F. Rudd and C.C. Watson, Strategy of Process Engineering, John Wiley, 1969.
3. F.C. Jelen and J.H. Black, Cost and Optimization Engineering, McGraw Hill, 3rd ed., 1992.
4. S. Walas, Chemical Process Equipment Selection and Design, Butterworth, 1988.
5. M.V. Joshi, Process Equipment Design, McMillan India, New Delhi, 1976.
6. R.K. Sinnot, An Introduction to Chemical Engineering Design, Pergamon Press, Oxford, 1989.
7. Relevant Design Codes BS,IS and ASME.
8. R. Smith, Chemical Process Design, McGraw Hill, 1995

CL 417: Process Control, [3 1 0 8]

First Principles model development; Process dynamics for first, second and higher order systems: linearisation, transfer function models, effect of poles, zeros and time delays on system response; Empirical models from data; control system instrumentation; introduction to feedback control: objectives, PID control; analysis of closed loop systems: stability, root locus, frequency response using Bode and Nyquist plots; control design techniques: design criteria, time and frequency domain techniques, model based design, tuning; advanced control strategies: cascade and feed forward, introduction to multivariable control; controller implementation through discretisation.

Texts/References

1. D.E. Seborg, T.F. Edgar, D. A. Mellichamp, Process Dynamics and Control, John Wiley and Sons, 2nd ed., 2004.
2. B.W. Bequette, Process Control: Modeling, Design and Simulation, Prentice Hall, New Delhi, 2003.
3. W.L. Luyben. Process Modeling Simulation and Control for Chemical Engineers, 2nd ed., McGraw Hill, 1990.
4. G. Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall, New Delhi, 1984.

CL 408: Chemical Processes, [3 0 0 6]

Introduction to fuels, Properties of fuels, Solid fuels and uses, liquid fuels and uses, Gaseous fuel and uses, Combustion and furnace calculations. Chemical processes based on agricultural and sylvicultural raw materials: Sugar, starch, alcohol, cellulose, paper, glyceride, oils, soaps, detergents; Petroleum refining Operations: Principles and details of Crude Distillation, Vacuum Distillation, coking, cracking, hydrotreating, isomerization and alkylation; Petrochemicals: Raw materials and principles involved in the production of olefins and aromatics. Acetylene, Butadiene and typical intermediates from olefins and aromatics such as ethylene glycol, ethyl benzene, phenol, cumene and DMT/PTA; dyes and pharmaceuticals, coal chemicals. Inorganic heavy chemicals: Processes for manufacture of acids, alkalis, salts and fertilizers. Typical products such as sulphuric, nitric, and phosphoric acids, soda ash, ammonia, superphosphates. Renewable resources, Biorefineries. Biopharmaceuticals. Fine chemicals and Biotransformations.

Texts/References

1. J.A. Moulijn, M. Makkee and A.V Diepen, 1st ed., Wiley, 2001
2. C.E. Dryden, Outlines of Chemical Technology, Edited and revised by M.Gopala Rao and Marshall Sitting, 2nd ed., Affiliated East-West Press, New Delhi, 1973
3. G.T. Austin, R.N. Shreve, Chemical Process Industries, 5th ed., McGraw Hill, 1984.
4. P.H. Groggins , Unit processes in organic synthesis, 5th ed., McGraw Hill, 1958.
5. Kirk-Othmer D.F., Encyclopedia of Chemical Technology, 4th ed. Interscience, New York, 1991.
6. J.H. Gary and G.E. Handwerk, Petroleum Refining: Technology and Economics, Marcel Dekker, New York, 2001
7. S. Sarkar, Fuels and Combustion, 2nd ed., Orient Longmans, Bombay, 1990.

CL 451: Chemical Process Design, [3 0 0 6], Prerequisite: CL415

Process Design and Development: General Design Considerations; The Hierarchy of Chemical Process Design; The Nature of Process Synthesis and Analysis;
Reactor networks in process flowsheets: Attainable region
Separation systems in process flowsheets: multicomponent distillation for ideal and non-ideal systems, distillation column sequences, heat integration in distillation columns
Heat exchange networks synthesis and utilities: Energy targets
Introduction to optimization approaches to optimal design, role of simulations in process design, Design under uncertainty and failure tolerance, Engineering around variations, Introduction to process integration

Texts/References

1. J. Douglas, Conceptual Design of Chemical Processes, McGraw Hill, 1989.
2. R. Smith, Chemical Process Design, McGraw Hill, New York, 1995.
3. D.F. Rudd and C.C. Watson, Strategy of Process Engineering, John Wiley, 1969.
4. R.K. Sinnot, An Introduction to Chemical Engineering Design, Pergamon Press, Oxford, 1989.
5. L.T. Biegler, E.I. Grossmann, and A.W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall International Inc. Series in the Physical and Chemical Engg. Sciences, 1997.
6. W.D. Seider and J.D. Seader, Product and Process Design Principles: Synthesis, Analysis and Evaluation, 2nd ed., John Wiley, 2004

CL260: Molecular and Statistical Thermodynamics, [2 1 0 6], Prerequisite: CL253

Review: Elementary Statistical Mechanics, Postulates, Ensembles, Relation between microscopic and macroscopic thermodynamics; Equivalence of ensembles, Legendre Transformation. Intermolecular Potential Energy functions (Non-Polar molecules); Distribution functions: Radial Distribution Function (RDF) Physical Interpretation: Structure of Fluids and Solids, Experimental Measurement Thermodynamics from RDF; Molecular Simulation Techniques: Mass, Length and Time Scales at atomic levels, LJ reduced units, Molecular Dynamics: Autocorrelation Functions: Transport properties;

Random Walks; Diffusion and Einstein's Equation; Stochastic: Monte Carlo Numerical Integration versus Monte Carlo Integration Importance Sampling, Markov Chains, Metropolis Monte Carlo Metropolis MC applied to NVE ensemble (eg. Demon Algorithm), NVT ensemble, NPT ensemble and VT ensemble Applications of Statistical Mechanics: Thermophysical property calculations in ensembles; Cooperative Phenomenon: Phase Equilibria: Ising model, Gibbs Ensemble (VLE), Thermodynamic Integration, Gibbs-Duhem Integration, Free Energy Evaluation; Virial EOS: second virial coefficient; Special Appluications: From Surface Adsorption: Adsorption Isotherms; Einstein Crystal; Self Assembly; Polymer Solution Thermodynamics

Texts/References

1. D. Frenkel and B. Smit, Understanding Molecular Simulations: From Algorithms to Applications, 2nd ed., Academic press, 2001.
2. M.P. Allen and D.J. Tildesley, Computer Simulation Of Liquids, Oxford science publications,1989.
3. D.A. McQuarrie, Statistical Mechanics, 2nd ed., University science books,2000.
4. D.A. McQuarrie, Molecular Thermodynamics, University science books,2000.
5. T.L. Hill, An Introduction to Statistical Mechanics.
6. T. Pang, An Introduction to Computational Physics, 2nd ed., CUP,2006.

CL336: Advanced Transport Phenomena [3 0 0 6], Prerequisite: CL203

Introduction: Review of Transport Equations, Scaling and Ordering analysis, Asymptotic solutions. Exact solutions: Pulsatile flow in circular tube, Creeping flows and streamfunction solutions. Motion of deformable and slender bodies: Conditions at an deformable interface, Creeping flow past a drop, Marangoni Effects, Flows past Sphere and Oblate Solid bodies, Slender-Body Theory. Asymptotic Approximations for simple flows: Pulsatile flow limiting cases, Motion of fluid through curved tube, Bubble growth in Quiescent fluid. Thin films and Lubrication: Eccentric Couette cylinder, Lubrication theory, Slider block, Cylinder and Plane. Convective Heat and Mass transfer: Heat transfer from sphere (Pe << 1) in uniform and shear flow, Low Re expansion for Pe << 1, Pe >> 1 for low Re, Mass transfer from a Drop Laminar Boundary layer Theory: Review of Boundary Layer Equations and Solution, Boundary layer separation, Approximate method to estimate shear stresses, Spherical bubble, Limiting cases of Thermal boundary layers. Natural convection: Boussinesq Equations, Combined forced and free convection, The Raleigh-Benard Problem,

Texts/References

1. L. G. Leal, Laminar Flow and Convective Transport Processes, Butterworth-Heinemann, 1992.

CL325: Chemical Reaction Engineering II, [2 1 0 6], Prerequisite: CL324

Multiphase reactors (Gas-Liquid; Liquid-Liquid); Yield, Selectivity, Reactor Design for Multiple Reactions; Models of Industrial Reactors: Pressure Drop considerations, Heat management, Non-isothermal reactors, Steady State multiplicity; Residence Time Distribution: Theory; Evaluation from Tracer Experiments; Non-Ideal Reactor Modelling: Use of RTD; Zero, One and Two Parameter Models; Compartment Modelling; Applications: Polymerisation; Combustion; Biochemical Reactions; Multi-functional Reactors; Stochastic approaches to kinetics.

Texts/References

1. H.S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, 2nd ed., New Jersey, 1992.
2. O. Levenspiel, Chemical Reaction Engineering, Wiley Eastern, 2nd ed., 1972.
3. J.M. Smith, Chemical Engineering Kinetics, 3rd ed., McGraw Hill, 1980.

CL455: Design Lab 1, [0.5 0 2 3]

Steady-state simulation of flow sheets; Optimization and costing in flow sheets; Design and analysis of control systems; Simulations using commercial simulators (e.g. ASPEN, HYSYS), Computational Fluid Dynamics, Molecular modeling.

CL457: Design Lab 2, [0.5 0 2 3]

Process and mechanical design calculations for process equipment; Numerical studies in reactor design; Design and analysis of separation equipment.

CL232: Chemical Engineering Lab 1, [0.5 0 2 3]

(Focus: Fluid Mechanics, Thermodynamics) Experiments on the flow through piping networks, Nature of flow, Venturi / Orifice meter, Stokes Law, pumps in series / parallel, determination of partial molar enthalpies, vapour pressures, infinite dilution activity coefficient,vapour-liquid equilibrium, adiabatic calorimetry, size reduction (ball mill), porosity measurement

CL333: Chemical Engineering Lab 2, [0.5 0 2 3]

(Focus: Heat and Mass Transfer) Experiments on hydrodynamics of a packed column, Differential distillation, Heat transfer in laminar and turbulent flow, boiling and condensation, Plate heat exchanger, Fluidization with heat transfer, heat transfer through a submerged helical coil, heat transfer in an agitated vessel, finned tube heat exchanger

CL335: Chemical Engineering Lab 3, [0.5 0 2 3]

(Focus: Reaction Engineering and Unit Operations) Experiments on esterification kinetics, Batch reactive distillation, micellar catalysis, homogeneous reaction, metal recovery from dilute solutions, reaction in CSTR, reaction in PFR, Gas chromatography, Cooling tower, gas liquid absorption

CL433: Chemical Engineering Lab 4, [0.5 0 2 3]

(Focus: Process Control, Unit Operations) Experiments on Residence time distribution, continuous distillation, Dynamic process modeling, identification of transfer functions, P /PI control, Temperature measurement and signal conversion, Control valve characteristics, Fixed bed reactor, drying

Non-ChE courses

BT251: Introduction to Molecular Cell Biology [2 1 0 6]

Biology and Bioprocess, Relevance to society. Procaryotes and eucaryotes. Classification of microorganisms and important cell types. Structures of the bacterial cell. Organization of plant and animal cells, organelles, structure, chemical composition, function. Biomolecules: properties of water amino acids, proteins, carbohydrates, lipids and nuclic acids. Cellular processes: carbon and nitrogen cycle in nature, metabolic grid, glycolysis. TCA cycle and forms of energy in biology. Signal transduction, receptor concept, nature of ligand-receptor interactions. Information transfer in cells: Central dogma, DNA replication, RNA transcription, genetic code and translation. Genetics and inheritance: chromosomes, Mendel's laws, phenotype and genotype, genetic diseases in humans. Special topics: Genetic engineering, Cell culture and immune system

Texts/References

1. B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J. D. Watson. Molecular Biology of the Cell. Garland Publishing, Inc 2nd edition, 1989.
2. E. J. Gardner, M. J. Simons and D. P. Snustad, Principles of Genetics, John Wiley & Sons, 8th edition, 1991
3. D. Voet and J. G. Voet, Biochemistry John Wiley & Sons, 1990
4. L. Stryer, Biochemistry W.H. Freeman and Company, 1965

CH103: Chemistry I, [2 1 0 6]

Schrodinger equation; interpretation of wave function; hydrogen atom; atomic and molecular orbitals. Structure, bonding and energy levels in molecules and solids. Intermolecular forces. Chemical Potential; fugacities activities and equilibrium constants; Relation between G and emf; Standard potentials; Chemical Kinetics: steady state approximation; Collision theory.
Trends in the periodic table; metallurgy; basic principles and applications; purification of elements and metals; transition metal ions and complexes; coordination chemistry, magnetochemistry, role of metal ions in biological processes; some relevant uses of transition elements; catalysis; semiconducting and super conducting materials; zeolites; VSEPR; spinel.
Conformations of alkanes and cycloalkanes; configurations, molecular chirality, geometrical isomerism. Linear and cyclic conjugation, benzene, aromaticity, properties of conjugated systems. Reactivity, reaction types, reaction mechanisms, reaction energetics and kinetics. Study of selected reactions and their mechanisms; nucleophilic substitution reaction, electrophilic and free radical addition reactions, electrophilic aromatic substitutions, nucleophilic addition; principles of nucleophilic addition to carbonyl groups. Molecular systems of technological and biological importance.

Texts/References

1. P. W. Atkins, Physical Chemistry, ELBS/Oxford, 7th Edition, 1995.
2. B.H. Mahan and R. J. Myers, University Chemistry, 4th edition, Benjamin, California, 1987.
3. H.V. Keer, A.Q. Contractor, B. L. Tembe (Editor), R. S. Singh, P. Mathur, G. K. Trivedi, M. Sharan, N. S. Punekar, et al ET-105 Part B, Chemistry (5 Blocks/booklets): Atoms and Molecules, Energetics and Kinetics, Equilibria and Electrochemistry, Inorganic Chemistry and Organic Chemistry. Written for the First Year B. Tech. Course of the Indira Gandhi National Open University, 1995
4. D. A. McQuarrie and J.D. Simon, Physical Chemistry - a molecular approach, Viva Books Pvt. Ltd. (1998)
5. R.T. Morrison and R.N. Boyd, Organic Chemistry, Prentice Hall of India Pvt. Ltd., 5th edition,1990.
6. M. J. Sienko and R. A. Plane, Chemical Principles and Applications, McGraw Hill, 1980.
7. J. D. Lee, Concise Inorganic Chemistry, 4th Edition, ELBS, 1991.
8. D. D. Ebbing, General Chemistry, Houghton Miffin Co., 1984.

CH117: Chemistry Laboratory [0 0 3 3]

Experiments illustrating the concepts of 1) galvanic cells, (2) thermochemistry, (3) chemical kinetics, (4) equilibrium constant, (5) analysis by oxidation reduction titration.
Experiments pertaining to (1) volumetric analysis by complexometry, (2) analysis by ion exchange resins, (3) analysis of a drug, (4) organic/inorganic synthesis, (5) instrumental methods of analysis.

Texts/References

CS101: Computer Programming and Utilization, [2 0 2 6]

An introduction to problem solving with computers using a modern language such as Java or C/C++.
A. Utilization: Developer fundamentals such as editor, integrated programming environment, Unix shell, modules, libraries.
B. programming features: Machine representation, primitive types, arrays and records, objects, expressions, control statements, iteration, procedures, functions, and basic i/o.
C. Sample problems in engineering, science, text processing, and numerical methods.
2 hours of laboratory time which will include practice on computers.

Texts/References

1. G. Dromey, How to Solve It by Computer, Prentice-Hall, Inc., Upper Saddle River, NJ, 1982
2. Polya, G., How to Solve _It (2nd ed.), Doubleday and co. (1957).
3. Coohoon and Davidson, C++ programme Design: An introduction to programming and Object-Oriented Design. Tata McGraw Hill. 3rd edition. 2003.
4. Y Kanetkar, Let's C, Allied Publishers, 1998.
5. The Java Tutorial, Sun Microsystems. Addison-Wesley, 1999.

EE 101: Introduction to Electrical and Electronics Circuits, [3 1 0 8]

Introduction, basic physical laws, circuit elements. KVL, KCL, and a few important circuit theorems, simple circuits. Transients in R-L, R-C, R-L-C.
Sinusoidal Steady State, Real/Reactive Power, three phase.
Working Principles of Transformers/AC/DC machines.
Functional Characteristics of Diode, BJT, OP-AMP. Analog circuit Examples: rectifiers, amplifiers, oscillators, etc.
Digital Circuits: AND/OR gates, Flip Flops, DAC/ADC, etc.

Texts/References

1. Vincent Del Toro, Electrical Engineering Fundamental, Prentice Hall, 1989
2. K. A. Krishnamurthy and M. R. Raghuveer, Electrical and Electronics Engineering for Scientists' Wiley Eastern Ltd., 1993.

HS200: Environmental Studies [1 1 0 3]

ES200: Environmental Studies Science and Engineering [1 1 0 3]

Course contents same as offered at present.

Texts/References

HS 101: Economics, [3 0 0 6]

Basic economic problems. resource constraints and Welfare maximizations. Nature of Economics : Positive and normative economics; Micro and macroeconomics, Basic concepts in economics. The role of the State in economic activity; market and government failures; New Economic Policy in India.
Theory of utility and consumer's choice. Theories of demand, supply and market equilibrium. Theories of firm, production and costs. Market structures. Perfect and imperfect competition, oligopoly, monopoly.

An overview of macroeconomics, measurement and determination of national income. Consumption, savings, and investments. Commercial and central banking. Relationship between money, output and prices. Inflation - causes, consequences and remedies. International trade, foreign exchange and balace payments, stabilization policies : Monetary, Fiscal and Exchange rate policies.

Texts/References

1. P. A. Samuelson & W. D. Nordhaus, Economics, McGraw Hill, NY
2. A. Koutsoyiannis, Modern Microeconomics, Macmillan, 1975.
3. R. Pindyck and D. L. Rubinfeld, Microeconomics, Macmillan publishing company, NY, 1989.
4. R. J. Gordon, Macroeconomics 4th edition, Little Brown and Co., Boston, 1987.
5. William F. Shughart II, The Organization of Industry, Richard D. Irwin, Illinois, 1990.

HS 202: Introduction to Psychology, [3 0 0 6]

Understanding human experience and behaviour: Definition, schools, methods, branches and application of psychology for engineers; Measuring human abilities; Intelligence, Personnel testing. The individual working life : personality - definition, approaches and theories; Psychological problems of everyday life: Stress and coping; Psychological disorders, work and mental health; Human learning; Motivation : the concept and theoretical framework, motivating people at work; Attitude and work behaviour, Group dynamics.
Intergroup relations, conflict resolutions; Leadership and management.

Texts/References

1. J.V. McConnel, Psychology, New York, Holt, Rinehart & Winston, 1986.
2. C. T. Morgan, R. A. King, J. R. Weiss and J. Schopler, Introduction to Psychology, 7th ed., McGraw Hill, 1986.
3. D. G. Myers, Psychology, 4th ed., Worth, New York, 1995.
4. S. E. Asch, Social Psychology, OUP Oxford, 1987.

HS 202: Introduction to Sociology, [3 0 0 6]

What is Sociology, some sociological concepts: Social structure, status, role, norms, values, etc. Socialization, and culture and change.
Social stratification - various approaches and concept of social mobility.
Population and society - Trends of demographic change in India and the world; Human ecology; Trends of Urbanization in the developing countries and the world.
Major social institutions - Family and marriage, caste and tribe; Organizations : (i) formal organization (bureaucracy) (ii) informal organization.
Processes of social change - Modernization (including Sanskritization), industrialization, environmental / ecological changes and development.
Social movements - protest movements, reformist movement and radical movements in India.

Texts/References

1. L. Broom, P. Selznick and D. Dorrock, Sociology, 11th ed., Harper International, 1990.
2. M. Haralambos, Sociology : Themes and Perspectives, OUP, 1980.
3. M. S. A. Rao (Ed), Social movements in India, Vols 1-2, Manohar, 1984.
4. David Mandelbaum, Society in India, Popular, 1990.
5. Guy Rocher, A General Introduction to Sociology, MacMillan, 1982.

HS 204: Introduction to Literature, [3 0 0 6]

Nature of Literature: literature as a humanistic experience. Definitions : (i) Humanities : concern with culture, values, ideologies; (ii) Literature : concepts of imitation, expression, intuition and imagination. Major themes of literature: Nature, science, selfhood, love, rebellion.
The language of Literature : modes of literary and non-literary expression. The concepts of Figurative language, Imagery, Symbolism, Style.
The Forms of Literature: Prose narratives (short stories and novels), Poetry, Drama and Essays.
Note: (1) Suitable texts are to be chosen by the instructor from the Texts and References listed below as well as from other sources. (ii) Use of a Learner Dictionary (e.g. Oxford Advanced Learner's Dictionary is prescribed for language work).

Texts/References

1. David Murdoch (Ed.), The Siren's Song : An Anthology of British and American Verse, Orient Longman, 1988.
2. S. Alter and W. Dissanayake (eds.), The Penguin Book of Modern Indian Short Stories, Penguin Books (India), 1989.
3. Bertrand Russel, Impact of Science on Society, Allen and Unwin, 1952.
4. George Orwell, Animal Farm, Penguin, 1951.
5. J. Bronowski, The Ascent of Man, BBC, 1973.

HS 204: Introduction to Philosophy, [3 0 0 6]

The course will acquaint the students of science and engineering with some issues on the nature and methods of science and mathematics, and the ethical issues arising out of the application of science and technology. The objective is to develop a critical, reflective and historical awareness on the issues related to the following topics:
Philosophy and History of Science: Growth of scientific knowledge : factors leading to th emergence of modern science. Conceptual evolution : internal and external history. Methodology of science : induction, falsificationism, confirmation and probability. Nature of scientific laws and theories : realism, instrumentalism and underdetermination. Relationship between scientific observation, experiment and scientific theory. ature of scientific explanation : teleological explanations and the covering law model. Selected case studies on scientific theories.
Logic and the nature of mathematical reasoning: Inductive and deductive forms of reasoning. Nature of axioms: formal axiomatic systems. Concept of consistency, independence and completeness. Nature of rules of inference and proof. Selected examples of axiomatic systems and proof procedures.
Cognition : Current approaches to the understanding of mind and mental processes : empiricist, rationalist, behaviourist and cognitivist.
Ethics : Impact of science and technology on man and society: elements of environmental and professional ethics.

Texts/References

1. A. C. Grayling (ed.), Philosophy : A guide through the Subject, Oxford University Press, London, 1995.
2. M. W. Wartofsky, Conceptual Foundations of Scientific Thought: An Introduction to the Philosophy of Science, Macmillan, London, 1968.
3. I. B. Cohen, The Birth of a New Physics, Penguin Books, 1985
4. H. Eves and C. Newsom, Foundations and Fundamental Concepts of Mathematics, Boston, PWS-Kart Pub. Co., 1990
5. K. E. Goodpaster and K. M. Sayre (eds.), Ethics and Problems of 21st Century, Univ. of Notre Dam Press, London, 1979.
6. S. D. Agashe, A. Gupta and K. Valicha (eds.), Scientific Method, Science, Technology and Society : A Book of Readings, Univ. of Bombay Press, 1980.

MA105: Calculus, [3 1 0 8]

Review of limits, continuity, differentiability. Mean value theorem, Taylors Theorem, Maxima and Minima. Riemann integrals, Fundamental theorem of Calculus, Improper integrals, applications to area, volume. Convergence of sequences and series, power series. Partial Derivatives, gradient and directional derivatives, chain rule, maxima and minima, Lagrange multipliers. Double and Triple integration, Jacobians and change of variables formula. Parametrization of curves and surfaces, vector Fields, line and surface integrals. Divergence and curl, Theorems of Green, Gauss, and Stokes.

Texts/References

1. Hughes-Hallett et al., *Calculus - Single and Multivariable* (3rd Edition), John-Wiley and Sons (2003).
2. James Stewart, *Calculus* (5th Edition), Thomson (2003).
3. T. M. Apostol, *Calculus, Volumes 1 and 2* (2nd Edition), Wiley Eastern 1980.
4. G. B. Thomas and R. L. Finney, *Calculus and Analytic Geometry* (9th Edition), ISE Reprint, Addison-Wesley, 1998.

MA106: Linear Algebra, [3 1 0 4]

Vectors in $\mathbf{R^n}$, notion of linear independence and dependence, linear span of a set of vectors, vector subspaces of $\mathbf{R^n}$, basis of a vector subspace. Systems of linear equations, matrices and Gauss elimination, row space, null space, and column space, rank of a matrix. Determinants and rank of a matrix in terms of determinants. Abstract vector spaces, linear transformations, matrix of a linear transformation, change of basis and similarity, rank-nullity theorem. Inner product spaces, Gram-Schmidt process, orthonormal bases, projections and least squares approximation. Eigenvalues and eigenvectors, characteristic polynomials, eigenvalues of special matrices (orthogonal, unitary, hermitian, symmetric, skew-symmetric, normal). algebraic and geometric multiplicity, diagonalization by similarity transformations, spectral theorem for real symmetric matrices, application to quadratic forms.

Texts/References

1. H. Anton, *Elementary linear algebra with applications* (8th Edition), John Wiley (1995).
2. G. Strang, *Linear algebra and its applications* (4th Edition), Thomson(2006).
3. S. Kumaresan, *Linear algebra - A Geometric approach*, Prentice Hall of India (2000).
4. E. Kreyszig, *Advanced engineering mathematics* (8th Edition), John Wiley (1999).

MA108: Differential Equations-I, [3 1 0 4]

Exact equations, integrating factors and Bernoulli equations. Orthogonal trajectories. Lipschitz condition, Picard's theorem, examples on nonuniqueness. Linear differential equations generalities. Linear dependence and Wronskians. Dimensionality of space of solutions, Abel-Liouville formula. Linear ODE's with constant coefficients, the characteristic equations. Cauchy-Euler equations. Method of undetermined coefficients. Method of variation of parameters. Laplace transform generalities. Shifting theorems. Convolution theorem.

Texts/References

1. E. Kreyszig, *Advanced engineering mathematics* (8th Edition), John Wiley (1999).
2. W. E. Boyce and R. DiPrima, *Elementary Differential Equations* (8th Edition), John Wiley (2005).
3. T. M. Apostol, *Calculus, Volume 2* (2nd Edition), Wiley Eastern, 1980.

MA205: Complex Analysis, [3 1 0 4]

Definition and properties of analytic functions. Cauchy-Riemann equations, harmonic functions. Power series and their properties. Elementary functions. Cauchy's theorem and its applications. Taylor series and Laurent expansions. Residues and the Cauchy residue formula. Evaluation of improper integrals. Conformal mappings. Inversion of Laplace transforms.

Texts/References

1. R. V. Churchill and J. W. Brown, *Complex variables and applications* (7th Edition), McGraw-Hill (2003).

2. J. M. Howie, *Complex analysis*, Springer-Verlag (2004).

3. M. J. Ablowitz and A. S. Fokas, *Complex Variables- Introduction and Applications*, Cambridge University Press, 1998 (Indian Edition).

4. E. Kreyszig, *Advanced engineering mathematics* (8th Edition), John Wiley (1999).

MA207: Differential Equations-II, [3 1 0 4]

Review of power series and series solutions of ODE's. Legendre's equation and Legendre polynomials. Regular and irregular singular points, method of Frobenius. Bessel's equation and Bessel's functions. Sturm-Liouville problems. Fourier series. D'Alembert solution to the Wave equation. Classification of linear second order PDE in two variables. Laplace, Wave, and Heat equations using separetion of variables. Vibration of a circular membrane. Heat equation in the half space.

Texts/References

1. E. Kreyszig, *Advanced engineering mathematics* (8th Edition), John Wiley (1999).

2. W. E. Boyce and R. DiPrima, *Elementary Differential Equations* (8th Edition), John Wiley (2005).

3. R. V. Churchill and J. W. Brown, *Fourier series and boundary value problems* (7th Edition), McGraw-Hill (2006).

ME113: Workshop Practice, [0.5 0 3 4]

Introduction to - wood work: hand tools & various operations; pattern making: types of patterns, allowances, color coding. etc; bench work & fitting: tools & operations; metal cutting and machine tools; safety measures; principles of operation of basic machine tools like lathe, shaping, & drilling; important operations on these machines; cutting tools and their usage, selection of cutting speeds, feeds, etc;. welding, brazing and soldering.

Practical assignments in wood work, fitting, lathe and shaping machine and arc welding.

Texts/References

1. Elements of Workshop Technology, Vol. I by S. K. Hajrachoudhury, 13th Edition, 2003, Asia Publishing House.

2. Elements of Workshop Technology, Vol. II by S. K. Hajrachoudhury, 13rt Edition, 2003, Asia Publishing House.

3. Workshop Practice by H. S. Bawa, 1st Edition, Tata-McGraw Hill, 2004.

ME119: Engineering Drawing, [0.5 0 3 4]

Introduction to engineering drawing and orthographic projections, Projection of points and straight lines, Projection of planes and solids, Projection of simple machine elements, Development of surfaces, Intersection of surfaces, Construction of isometric views from orthographic projections.

Texts/References

1. N.D. Bhatt and V.M. Panchal, Charotar Publishing House, Anand, 2004.

2. Narayana.K.L., & Kannaiah,P.E.,Engineering Drawing, Charotar Publishing House, 1998.

PH 105: Modern Physics, [2 1 0 6]

Review of quantum concepts: particle nature of light, photoelectric effect, Compton effect, matter waves, wave packets, phase and group velocity, Davisson Germer experiment, Heisenberg uncertainty principle.
Schrödinger equation: probabilistic interpretation of wave function, one dimensional problems – particle in a box, harmonic oscillator, potential barrier and tunneling. Hydrogen atom, electrons in a magnetic field, Landau levels.
Elements of statistical physics : density of states, Fermi energy, Bose condensation. Solid state physics: Free electron model of metals, classical and quantum Hall effect, superconductivity, London equation, coherence and penetration depth, flux quantization, applications of superconductivity, SQUIDS. Nuclear physics: binding energy, nuclear reactions, elements of nuclear reactors, fission and fusion, fundamental forces, elementary particles, quarks and leptons.

Texts/References

PH 117: Physics Laboratory, [0 0 3 3]

Experiments on: Moving Coil Galvanometer; Fresnel‘s Biprism; Prism Spectrometer; Newton‘s Rings; Anderson‘s Bridge; Young‘s Modulus by Koenig‘s Method; Moment of Intertia Of a Flywheel; Therimstor Characteristics; Helmholtz Coils; Compound Pendulum

Texts/References

1. B. L. Worsnop and H. T. Flint, Advanced Practical Physics for students, Asia Publishing House, 1971.

IC 102 : Data Analysis and Interpretation, [2 1 0 6]

This course will help ask, design the experiment and then answer questions of the following kind. (1) Which of the two department stores is less expensive. (2) Given the responses from a student survey, is the curriculum satisfying the students needs. (3) The effectiveness of a new drug vis-a-vis existing drugs given the treatment responses. (4) A sample is extracted from a manufacturing line and tested for conformity with specifications. With what confidence can we assert that a product of this batch conforms to the specifications.
Sources of data, data representation, measurement of data, gathering of data and design of experiments; errors in measurement bias and random error); multivariate data and regression; posing statistical hypothesis.
Elementary probability and statistics (random variables, distribution, central limit theorem), population sampling, confidence intervals; elementary hypothesis testing; exposure to standard models of physical processes, parameter estimation using least squares.

Texts/References

1. Douglas C. Montgomery, G. C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons, 2003.
2. A. M. Mood and F. A. Graybill, An Introduction to the Theory of statistics, Prentice Hall of India, 1963
3. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Statistical Theory, Houghton Miffin, 1971

IC 115 : Experimentation and Measurement Laboratory, [0 0.5 3 4]

Measurement and measuring systems - Exposure to ideas of accuracy, precision, repeatability, reproducibility, linearity etc; Design of experiments with elements of statistics, uncertainty analysis; Exposure to common sensors to measure physical variables such as displacement/rotation, strain, temperature, flowrate, acceleration, voltages, currents, pressure, force etc; Exposure to interfacing of sensors to digital computational devices and A/D conversion; Exposure to processing/analysis of sensed information - Low pass filtering, Fourier spectrum analysis etc
Typical laboratory experiments involve using electronic prototying equipment - oscilloscopes, multimeters, breadboards etc for interfacing (to computational devices) and characterizing outputs of sensors electronic circuits. Basic material and lab objectives are developed in lectures. Instruction and practice in oral and written communication provided.

Texts/References