# B TECH in CHEMICAL ENGINEERING

## THIRD SEMESTER

| Year | Sub. Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|---|
| | MAT 2153 | Engineering Mathematics – III | 2 | 1 | 0 | 3 |
| | CHE 2151 | Chemical Engineering Thermodynamics-I | 3 | 1 | 0 | 4 |
| | CHE 2152 | Chemical Process Calculations | 3 | 1 | 0 | 4 |
| | CHE 2153 | Momentum Transfer | 3 | 1 | 0 | 4 |
| II | CHE 2154 | Particle Technology | 2 | 1 | 0 | 3 |
| | CHM 2151 | Physical and Organic Chemistry | 3 | 1 | 0 | 4 |
| | CHM 2161 | Physical & Organic Chemistry Lab | 0 | 0 | 6 | 2 |
| | | **Total Contact Hours (L + T + P)** | **16** | **6** | **6** | **24** |
| | | | | 28 | | |
| | | | | 25+3=28 | | |

## FOURTH SEMESTER

| Year | Sub. Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|---|
| | MAT 2254 | Engineering Mathematics – IV | 2 | 1 | 0 | 3 |
| | CHE 2251 | Chemical Engineering Thermodynamics-II | 3 | 1 | 0 | 4 |
| | CHE 2252 | Chemical Process Industries | 3 | 0 | 0 | 3 |
| | CHE 2253 | Heat Transfer Operations | 3 | 1 | 0 | 4 |
| II | CHE 2254 | Mass Transfer-I | 3 | 1 | 0 | 4 |
| | **** | Open Elective – I | | | | 3 |
| | CHE 2261 | Momentum Transfer & Particle Technology Lab | 0 | 0 | 3 | 1 |
| | CHE 2262 | Numerical Methods for Chemical Engineers Lab | 0 | 1 | 3 | 2 |
| | | **Total Contact Hours (L + T + P)** | **14** | **5** | **6** | **24** |
| | | | | 25+3=28 | | |

## FIFTH SEMESTER

| Year | Sub. Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|---|
| | HUM 3151 | Engg Economics and Financial Management | 2 | 1 | 0 | 3 |
| | CHE 3151 | Chemical Reaction Engineering | 3 | 1 | 0 | 4 |
| | CHE 3152 | Mas Transfer-II | 3 | 1 | 0 | 4 |
| | CHE 3153 | Process Modelling and Simulation | 3 | 1 | 0 | 4 |
| III | CHE 3154 | Transport Phenomena | 2 | 1 | 0 | 3 |
| | **** | Open Elective – II | | | | 3 |
| | CHE 3161 | Heat Transfer Lab | 0 | 0 | 3 | 1 |
| | CHE 3162 | Process Modelling and Simulation Lab | 0 | 1 | 3 | 2 |
| | | **Total Contact Hours (L + T + P)** | **13** | **6** | **6** | **24** |
| | | | | 25+3=28 | | |

## SIXTH SEMESTER

| Year | Sub. Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|---|
| | HUM 3152 | Essentials of Management | 2 | 1 | 0 | 3 |
| | CHE 3251 | Design and Drawing of Chemical Process Equipment* | 1 | 3 | 3 | 5 |
| | CHE 3252 | Process Dynamics and Control | 3 | 1 | 0 | 4 |
| | CHE***** | Program Elective – I | 3 | 0 | 0 | 3 |
| III | CHE***** | Program Elective – II | 3 | 0 | 0 | 3 |
| | **** | Open Elective – III | | | | 3 |
| | CHE 3261 | Mass Transfer Lab | 0 | 0 | 3 | 1 |
| | CHE 3262 | Reaction Engineering and Process Control Lab | 0 | 0 | 3 | 1 |
| | | **Total Contact Hours (L + T + P) + OE** | **13** | **4** | **9** | **23** |
| | | | | 26+3=29 | | |

## SEVENTH SEMESTER

| Year | Sub. Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|---|
| | CHE **** | Program Elective – III | 3 | 0 | 0 | 3 |
| | CHE **** | Program Elective – IV | 2 | 0 | 3 | 3 |
| | CHE **** | Program Elective – V | 3 | 0 | 0 | 3 |
| IV | CHE **** | Program Elective – VI | 3 | 0 | 0 | 3 |
| | CHE **** | Program Elective – VII | 3 | 0 | 0 | 3 |
| | **** | Open Elective – IV | | | | 3 |
| | | **Total Contact Hours (L + T + P) +OE** | **14** | **0** | **3** | **18** |
| | | | | 17 + 3 = 20 | | |

## EIGHTH SEMESTER

| Year | Sub. Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|---|
| | CHE 4298 | Industrial Training | | | | 1 |
| | CHE 4299 | Project Work/Practice School | | | | 12 |
| | CHE 4296 | Project Work (Only for B.Tech honour Students) | | | | 20 |
| | | | | | | |
| | | | | | | **13** |

**Minor Specializations**

**I. Petroleum Engineering**
CHE 4051: Natural Gas Engineering
CHE 4052: Oil and Gas Reservoir Engineering
CHE 4053: Petroleum Refinery Engineering (Theory and Lab)*
CHE 4054: Process Integration for Petroleum Industries

**II. Pollution Control Engineering**
CHE 4055: Environmental Pollution Control Engineering
CHE 4056: Environmental Impact Assessment and Management Plan
CHE 4057: Industrial Waste Water Engineering (Theory and Lab)*
CHE 4058: Solid and Hazardous Waste Material Management.

**III. Environmental Biotechnology**
BIO 4051: Bioremediation
BIO 4052: Design of Biological Treatment Processes
BIO 4053: Microbial Treatment of Wastewater
BIO 4054: Solid Waste Management

**IV. Material Science**
PHY  4051: Physics of Low Dimensional Materials
PHY  4052: Physics of Photonic & Energy Storage Devices
CHM 4051: Chemical Bonding
CHM 4052: Chemistry of Carbon Compound

**V. Business Management**
HUM 4051: Financial Management
HUM 4052: Human Resource Management
HUM 4053: Marketing Management
HUM 4054: Operation Management

**VI. Computational Mathematics**
MAT 4051: Applied Statistics and Time Series Analysis
MAT 4052: Computational Linear Algebra
MAT 4053: Computational Probability and Design of Experiments
MAT 4054: Graphs and Matrices

**Program Electives**
CHE 4059: Advanced Process Control
CHE 4060: Applied Interfacial Engineering
CHE 4061: Chemical Reactor Theory
CHE 4062: Environmental Pollution Control Engineering
CHE 4063: Fuels and Combustion
CHE 4064: Introduction to Biochemical Engineering
CHE 4065: Introduction to Petroleum Engineering
CHE 4066: Materials Science and Engineering
CHE 4067: Non Newtonian Flow in Process Industries
CHE 4068: Process Data Analysis
CHE 4069: Project Engineering
CHE 4070: Renewable Energy Engineering
CHE 4071: Risk and Safety Management in process Industries
CHE 4072: System Identification
CHM 4051: Analytical Techniques and Instrumentation

**Open Electives**
CHE 4301: Industrial Pollution Control
CHE 4302: Risk and Safety Management in Industries
CHE 4303: Water Treatment Technology

## MAT 2153: ENGINEERING MATHEMATICS-III [2 1 0 3]

Periodic Functions, odd and even functions, Euler's formulae. Half range expansions, Harmonic analysis. Fourier integrals & transforms, Parseval's identity. Functions of complex variable. Analytic function, C-R equations, differentiation, Integration of complex function, Cauchy's integral formula.  Taylor's and Laurent Series, Singular points, Residues, Cauchy's residue theorem. Conformal mappings, bilinear transformations. Gradient, divergence and curl, their physical meaning and vector identities. Line, surface and volume integrals. Green's theorem, divergence and Stokes' theorem, applications. Formation, solutions of equations involving derivatives with respect to one variable only. Solutions by indicated transformations and separation of Variables. Derivation of one dimensional wave equation (vibrating string) and its solution by using the method of separation of Variables. D'Alembert's solution of wave equation. Derivation of one dimensional heat equation using Gauss divergence theorem and solution of one dimensional heat equation. Solution by separation of variables.

**References:**
1. Eewin Kreyszig, Advanced Engineering Mathematics, 7(e), John Wiley & Sons, Inc.1993.
2. Murray R.Spiegel., Vector Analysis, 2(e), Schaum Publishing Co., 2009.
3. Grewal, B.S., Higher Engineering Mathematics, 43(e), Khanna Publishers, 2014.
4. Ramana B.V., Engineering Mathematics, 2(e), Tata McGraw Hill Publishing Company limited, 2007.

## CHE 2151: CHEMICAL ENGINEERING THERMODYNAMICS-I [3 1 0 4]

Basic concepts, definitions and approaches for thermodynamics. First law of thermodynamics for different processes. The concept of heat capacity and enthalpy. PVT behaviour of gases, the concept of ideal gas, and the phase diagrams. Equations of state used for the real gases. Determination of deviation of a gas from ideal behaviour, different correlations used for the calculation of compressibility factor. Second law of thermodynamics, the difference between heat and work, the irreversibility of a process and the concept of entropy, thermodynamic temperature scale. Thermodynamic processes, Maxwell relations and its applications. The applications thermodynamics in refrigeration, liquefaction processes, steam power plant and internal combustion engines.

**References:**
1. Narayanan, K.V.A Text Book of Chemical Engineering Thermodynamics, Prentice Hall of India, 2006.
2. Smith, J.M., VanNess H.C., Abbot, M.M., Introduction to Chemical Engineering Thermodynamics,
   (7e), McGraw Hill, 2004.
3. Rao, Y.V.C., An Introduction to Thermodynamics, Universities Press, 2004.
4. Daubert, T.E.,Chemical Engineering Thermodynamics, McGraw – Hill, 1985.

## CHE 2152: CHEMICAL PROCESS CALCULATIONS [3 1 0 4]

Chemical engineering as a Profession – Role of Chemical Engineer – Unit operations and unit processes –Units and dimensions – Physical and chemical properties of compounds and mixtures – Techniques of problem solving – Choice of basis – Chemical equations and stoichiometry – Properties of gases – Ideal and real gases – Phase equilibrium – Vapor pressure – Raoult's law – Calculation of bubble point and dew point – Humidity and Saturation –Humidity charts and their use

– Concepts of steady and unsteady state processes and material balance equations – Material balances involving unit operations and unit processes – Material balance with recycle, bypass and purge – Energy and energy balances – Balances on non-reactive and reactive systems – Heat of reaction, heat of formation and heat of combustion – Standard state – Calculation of heat of reaction at temperature different from standard state – Adiabatic reaction temperature and theoretical flame temperature

**References:**
1. Sikdar, D.C., Chemical Process Calculations, Prentice Hall India, 2013.
2. Bhat B.I., Thakur, S.B., Stochiometry, (5e), Tata McGraw-Hill, New Delhi, 2010.
3. Himmelblau, D.M., Basic Principles and Calculations in Chemical Engineering, Eastern Economy ed., Prentice Hall India, (6e). 2009.
4. Felder R., Rausseau, R.W., Elementary Principles of Chemical Processes, (2e), John Wiley and Sons, 2004.
5. Denn, M.M., Chemical Engineering- an Introduction, Cambridge University Press, NY, 2012.

## CHE 2153: MOMENTUM TRANSFER [3 1 0 4]

Properties of fluids – Rheological classification - Fluid statics – Static pressure – Variation of pressure with elevation – Pressure measurement – Manometers – Introduction to fluid flow – Types of flow – Basic equations of fluid flow – Continuity equation – One dimensional Eulerand Bernoulli equation and applications – Laminar flow – Steady incompressible viscous flow through circular pipes – Hagen-Poiseuilli equation – Flow between parallel plates – Flow through annuli – Turbulence – Turbulent flow in smooth pipes – Velocity profiles – Darcy equation – Flow in noncircular conduits – Losses in pipe flow - Power law of fluids – Flow of liquids in thin layers – Fluid flow past immersed bodies – Boundary layer and friction drag Drag coefficient – Motion of particles through fluids – Flow of fluids through bed of solids – Ergun equation – Principles of fluidization – Hydrodynamic characteristics – Pneumatic conveyance – Agitation and mixing of liquids – Dimensional analysis – Flow of compressible fluids – Basic equations of one dimensional flow – Reversible adiabatic flow – Effect of area variation – Flow in convergent and divergent nozzles – Flow measurement – Venturi, Orifice and Pitot-tube – Variable area meter – Flow measurement in open channels – Introduction to unsteady flow – Time required for emptying tank – Fluid transportation machinery – Pumps and classification of pumps – Pump characteristics.

**References:**
1. McCabe and Smith, Unit Operations in Chemical Engineering, (5e), McGraw-Hill, NY,1993
2. Coulson and Richardson, Chemical Engineering –Vol I, (3e), Pargamon and ELBS, 1977
3. Foust et al, Principles of Unit Operations, (2e), John Wiley and Sons, NY, 1980
4. Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY, 1990.

## CHE 2154: PARTICLE TECHNOLOGY [2 1 0 3]

Particle size analysis, Sphericity of particle, Shape factor, Specific surface area and specific number of particle in the sample mixture, Sieve methods of analysis, Ideal and actual screen, Effectiveness and capacity of screen, Screening equipment, Size reduction, Energy relationships, Size reduction equipment, Crushers, Grinders, Separation based on motion of particle through fluids, Terminal settling velocity of particle, Free and hindered settling, Sedimentation, design of continuous thickener, Classifiers, Filtration, Filter aids, design of filter, Filtration equipment.

**References:**
1. McCabe and Smith, Unit Operations in Chemical Engineering, (5e), McGraw-Hill, NY, 1993.
2. Foust et al, Principles of Unit Operations, (2e), John Wiley and Sons, NY, 1980.
3. Badger and Banchero, Introduction to Chemical Engineering, McGraw-Hill, NY, 1990.
4. Coulson and Richardson, Chemical Engineering –Vol II, (3e), Pargamon and ELBS, 1970.

## CHM 2151: PHYSICAL AND ORGANIC CHEMISTRY [3 1 0 4]

Thermodynamic treatment of solutions, Ideal mixtures, Raoult's law Henrry's law Gibb's Duhem relation, colligative properties. Phase Equilibria: Pressure-Temperature Phase diagrams, Phase rule, Immiscible liquids, Eutectic formation, solid compound formation Boiling point diagrams, Distillation, adsorption isotherm. Electroanalytical methods of analysis: Conductometric and Potentiometric titrations Chemical Kinetics: Rate equation, First-order rate equations, second order rate equations, Half-life, Arrhenius equation, Numericals Stereochemistry: Constitutional isomerism - Geometrical isomerism, Polarimeter, specific rotation ,RS configuration, Enantiomers, Diasteromers, meso compounds Reaction Intermediates: Structure, Stability and reactions of intermediates Strengths of organic acids and bases: Factors affecting strength of acids and bases Aromatic and Heterocyclic compounds: Structure of benzene and aromaticity, Classification of Heterocyclic compounds, Basicity. Carbohydrates: Classification, Aldose to ketose and vice versa transformations, epimerisation, Monosaccharides, disaccharides and Polysaccharides. Amino acids & Proteins: Classification, Synthesis, Physical and chemical properties Dyes: Theories of dyes - Classification of dyes, Preparation and uses of Azodyes, Triphenyl methane dyes, Anthraquinone dyes.

**References:**
1. Gordon M. Barrow, Physical Chemistry, (5e), Tata Mc Graw Hill Education Private Limited, New Delhi
   Special Indian Edition, 2007.
2. Skoog D.A. West D.M. Holler F.J. Gouch S.R. Fundamentals of Analytical Chemistry, (8e), Thomson
   Brooks/Cole, Singapore, 2004.
3. Atkins. P., J. de Paula, Physical Chemistry, (7e), Oxford Publication, New York, 2002.
4. Puri,B.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, (46e), Vishal Publications, Jalandhar, 2012.
5. Finar I.L., Organic Chemistry, Vol I, (6e). Pearson Education, Singapore, 2009.
6. Morrison R.T. Boyd R.N. , Organic Chemistry, (6e), Prentice - nHall New Delhi, 2007.
7. Bruice P.Y., Organic Chemistry, (3e). Dorling Kindersley, New Delhi, 2009.
8. Bahl B.S. Arun Bahl, Advanced Organic Chemistry, (15e), S. Chand & Co. Ltd., New Delhi, 2001.

## CHM 2161: PHYSICAL AND ORGANIC CHEMISTRY LAB [0 0 6 2]

Physical Chemistry: Titration of a given mixture of weak and strong acids against a strong base by conductometric method ,Precipitation titration between lithium sulphate and barium chloride by conductometric method, Redox titration of Mohr's salt against $K_2Cr_2O_7$ by potentiometric method, Colorimetric determination of Copper, Percentage composition of binary mixture using viscometer, Bimolecular reaction between $K_2S_2O_8$

and KI, Determination of velocity constant for the saponification of ethyl acetate, Determination of surface tension of a liquid using stalagmometer, Kinetics of inversion of sucrose using polarimeter, Determination of percentage composition of binary mixture using Abbe's refractometer

Organic Chemistry: Preparation of m-dinitrobenzene from nitrobenzene, Preparation of acetanilide from aniline, preparation of p-bromo acetanilide from acetanilide, preparation of benzoic acid from benzaldehyde, preparation of salicylic acid from methyl salicylate.

Determination of the % purity of phenol by Winkler's method, Determination of the amount of acetone by iodoform method, Determination of the % purity of acetic acid by titration method, Determination of the amount of acetamide by alkali hydrolysis method, Determination of acid value, iodine value and saponification value of the given sample of oil.

# FOURTH SEMESTER

## MAT 2254: ENGINEERING MATHEMATICS-IV [2 1 0 3]

Formation of Linear Programming problem, Graphical method, Simplex method, Penalty cost and two phase methods. Finite sample spaces, conditional probability and independence, Bayes' theorem. One dimensional random variable, mean, variance, Chebyshev's inequality. Two and higher dimensional random variables, covariance, correlation coefficient, regression, least squares principles of curve fitting. Binomial, Poisson, uniform, normal, gamma, Chi-square and exponential. Finite difference expressions for first and second order derivatives (ordinary and partial).Solution of BVP's in ODE. Classification of second order linear partial differential equations. Numerical solutions of two dimensional Laplace and Poisson equations by standard five point formula. Solution of one dimensional heat and wave equations by explicit methods. Crank-Nicolson method. Finite element method, Introduction, simple applications. Difference equations representing physical systems, the z transforms, properties of z transforms, initial and final value theorems, solution of difference equations by the method of z transforms, convolution theorem.

### References:
1. Erwin Kreyszig, Advanced Engineering Mathematics, 7(e), John Wiley & Sons, Inc., 1993.
2. Meyer P.L., Introduction to probability and Statistical applications, 2(e), American Publishing Co., 1970.
3. Hamdy A Taha - Operation research, (7e), Pearson Education, Inc., 2002.
4 Grewal B.S - Higher Engineering Mathematics, (43e), Khanna Publishers, 2014.
5. Sastry S.S., Introductory methods for Numerical Analysis, (5e), PHI Learning Private Limited, 2012.

## CHE 2251: CHEMICAL ENGINEERING THERMODYNAMICS-II [3 1 0 4]

Thermodynamic properties of pure fluids, fugacity. The concept of solution thermodynamics, the concept of partial molar properties, its determination. Gibbs Duhem equation, its applications, property change of mixing, excess properties. The criteria of phase equilibrium, vapour liquid equilibrium, phase diagrams for binary solutions, azeotropes and its types, activity coefficient and dew point and bubble point calculations, thermodynamic consistency of VLE data. Introduction to LLE. The criteria of chemical reaction equilibria, equilibrium constant, Gibbs free energy change, effect of temperature, pressure and composition on equilibrium constant.

### References:
1. Narayanan, K.V., A Text Book of Chemical Engineering Thermodynamics, Prentice Hall of India, 2006.
2. Smith, J. M., VanNess H.C., Abbot, M.M., Introduction to Chemical Engineering Thermodynamics, (7e), McGraw Hill, 2004.
3. Daubert, T. E., Chemical Engineering Thermodynamics, McGraw –Hill, 1985.
4. Rao, Y. V. C., An Introduction to Thermodynamics, Universities Press, 2004.

## CHE 2252: CHEMICAL PROCESS INDUSTRIES [3 0 0 3]

Indian industry – A brief review - Description of the processes along with neat flow diagrams.
Industrial gases: Carbon dioxide – Hydrogen – Oxygen – Nitrogen – Synthesis gas
Chloralkali industry: Common salt – Caustic soda – Chlorine – Hydrochloric acid – Bleaching powder – Soda ash , Fertiliser industry: Ammonia – Nitric acid – Ammonium nitrate – Ammonium sulfate – Ammonium chloride – Urea , Oils, fats and waxes: Edible oils – Extraction of vegetable oil – Hydrogenation of oil – Soaps and detergents – Manufacturing processes – Glycerin recovery
Petroleum industry: Processing and refining of petroleum, Pulp and paper: Chemical and mechanical pulp – Pulping methods – Chemical recovery of black liquor – Paper and paper board
Sugar and starch: Sugar – Starch and modified starches – Glucose – Fermentation – Media for growth - Industrial alcohol – Absolute alcohol – Acetone and Butanol , Polyethylene – Viscose rayon, Nylon 6 and Nylon 66 – Natural and synthetic rubber

### References:
1. Groggins, P.H., Unit processes in organic synthesis, (5e), Tata Mcgraw-Hill, 2004.
2. Austin, G.T., Shreve's Chemical Process Industries, (5e), McGraw-Hill, 2017.
3. Dryden, C.E., Outlines of Chemical Technology, (3e), East Press Ltd., 1997.

## CHE 2253: HEAT TRANSFER OPERATIONS [3 1 0 4]

Mechanism of heat transfer; Heat transfer flux and resistance. Conduction: Thermal conductivity; Fourier's law of conduction; Conduction through plane, cylindrical and spherical and composite walls; Heat losses and insulation; Critical insulation thickness; Selection of insulating materials Convection: Natural and forced convection; Individual film and overall heat transfer coefficients; Convection in laminar and turbulent flows; Introduction to thermal boundary layer. Heat exchanger: Types of heat exchangers; Co-current and counter-current flows; Equivalent diameter; Fouling factors; Process design of heat exchangers including double pipe heat exchanger, shell and tube heat exchanger, extended surfaces and cross flow heat exchangers. Heat transfer with phase change. Evaporators: Types; Single and multiple effects: Boiling point rise; Feeding; Steam economy; Process design of evaporators. Heat transfer equipment auxiliaries: Steam trap. Radiation: Radiant energy-distribution; Black body; Emissive power; Exchange of energy between two surfaces; View factor; Furnace calculations. Combined heat transfers by conduction, convection and radiation. Crystallization: Nucleation and crystal growth; Controlled growth of crystals; Industrial crystallizers.

### References:
1. Kern D.Q., Process Heat Transfer, McGraw Hill, 2009.
2. McCabe and Smith, Unit Operations in Chemical Engg, (7e), McGraw Hill 2005.

3. Coulson and Richardson, Chemical Engineering, Vol.1 (6e), Elsevier India private limited 2006.
4. Dutta B. K., Heat transfer: Principles and Applications, PHI, 2001.

### CHE 2254: MASS TRANSFER-1 [3 1 0 4]
Introduction to mass transfer operation, Diffusion and mass Transfer: Molecular diffusion in fluids and solid, mass transfer coefficients, interphase mass transfer coefficient. Gas Liquid Operations: Equipment for gas liquid operations, Humidification operation, Gas absorption. Solid-Fluid Operations: Adsorption, Drying.

**References:**
1. Treybal, R.E. Mass Transfer Operations (3e), McGraw Hill Education, 2017.
2. McCabe, W., Smith, J., Harriott, P., Unit Operations of Chemical Engineering (7e), McGraw Hill Education;, 2017.
3. Patil, K.D., Principles and Fundamentals of Mass Transfer Operations–1 (4e), Nirali Prakashan Publications, 2013.
4. Dutta, B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006.

### CHE 2261: MOMENTUM TRANSFER AND PARTICLE TECHNOLOGY LAB [0 0 3 1]
Bernoulli's Experiment – Calibration of flow meters, flow through circular pipe, annulus, v-notch, packed bed and fluidized bed – Centrifugal pump characteristics – Screen effectiveness, verification of laws of size reduction, particle size analysis, filtration, sedimentation.

**References:**
1. McCabe and Smith, Unit Operations in Chemical Engineering, (5e), McGraw-Hill, NY,1993
2. Coulson and Richardson, Chemical Engineering –Vol. I, (3e), Pargamonand ELBS,1977
3. Foust et al, Principles of Unit Operations, (2e), John Wiley and Sons, NY, 1980

### CHE 2262: NUMERICAL METHODS FOR CHEMICAL ENGINEERS LAB [0 1 3 2]
Chemical engineering problems related to Process Calculations, Momentum Transfer, Heat Transfer and Mass Transfer-I will be solved using numerical methods such as Bisection method, False position method, Secant method, Newton-Raphson method, Linear Algebraic Equations, Runge-Kutta method, Predictor-Corrector method, Shooting method, Finite difference method, Crank-Nicholson method; Bender Schmidt method with the help of computer software such as MAT LAB and EXCEL.

# FIFTH SEMESTER

### HUM 3151: ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT [2 1 0 3]
Nature and significance, Micro & macro differences, Law of demand and supply, Elasticity & equilibrium of demand & supply. Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of single, Uniform gradient cash flow. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with return, Rate of return method, Incremental approach for economic analysis of alternatives, Replacement analysis. Break-even analysis for single product and multi product firms, Break-even analysis for evaluation of investment alternatives. Physical & functional depreciation, Straight line depreciation, Declining balance method of depreciation, Sum-of-the-years digits method of depreciation, Sinking fund and service output methods, Introduction to balance sheet and profit & loss statement. Ratio analysis - Financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios.

**References:**
1. Prasanna Chandra., Fundamentals of Financial Management, Tata Mc-Graw Hill Companies, New Delhi, 2005.
2. James L Riggs, David D Bedworth and Sabah U Randhawa., Engineering Economics, Tata McGraw – Hill Publishing Company Ltd, New Delhi, 2004.
3. T. Ramachandran., Accounting and Financial Management, Scitech Publications Pvt. Ltd. India, 2001.
4. Eugene F. B. & Joel F. H., Fundamentals of Financial Management, (12e), Cengage Learning Publisher, 2009.
5. M. Y. Khan & P. K. Jain., Financial Management, (5e), Tata McGraw Hill Publication, New Delhi, 2008.
6. Thuesen G.J., Engineering Economics, Prentice Hall of India, New Delhi, 2005.
7. Blank Leland T. Tarquin Anthony J. Engineering Economy, McGraw Hill, Delhi, 2002.
8. Chan S. Park, Fundamentals of Engineering Economics, (3e), Pearson Publication, 2013.

### CHE 3151: CHEMICAL REACTION ENGINEERING [3 1 0 4]
Elementary and Non elementary reaction kinetics, Kinetics of homogeneous chemical reactions, Rate expressions, Temperature dependence of rate, differential, integral, half-life and total pressure method, Isothermal reactor design, Design of batch, semi-batch, CSTR and PFR, Reactors in series or/and parallel, Recycle reactor, Series and parallel reactions in flow reactors, Product distribution, Yield and selectivity, Maximizing the desired product in parallel and series reactions, Isothermal non-ideal flow reactors, RTD in chemical reactors, distribution functions, Conversion in non-ideal flow reactors, Single and multi-parameter models.

**References:**
1. Fogler  S. H., Elements of Chemical Reaction Engineering(4e), Prentice Hall, 2005.
2. Levenspiel O., Chemical Reaction Engineering (3e), Wiley & Sons, 2003.
3. Rawlings J.B. and Ekerd, J.G., Chemical Reactor Analysis and Design Fundamentals, Nole. Hill, 2002.
4. Smith, J.M, Chemical Engineering Kinetics (3e), McGraw-Hill, International student edition
5. Davis M.E., Davis R.E., Fundamentals of Chemical Reaction Engineering (1e), McGraw-Hill, 2003
6. Missen R.W., Mims C.A., Saville B.A., Introduction to chemical reaction engineering and kinetics, John Wiley & Sons  Inc.

### CHE 3152: MASS TRANSFER-II [3 1 0 4 ]
Distillation: binary component distillation- Flash vaporization, simple distillation, steam distillation, multicomponent distillation: Flash vaporization, simple distillation, Multi stage tray towers: Ponchon and Savarit & McCabe and Thiele. Liquid-Liquid Extraction: Liquid Equilibria, separation of solute by stage-wise, cross current and continuous contact of solvent. Membrane Separations: introduction to membranes, Reverse osmosis, Nano filtration, Ultra and Micro filtration, Pervaporization, Dialysis.

**References:**
1. Treybal R.E., Mass Transfer Operations (3e), McGraw Hill Education, 2017.
2. McCabe W., Smith J., Harriott  P.,  Unit Operations of Chemical Engineering (7e), McGraw Hill Education, 2017.

3. Dutta B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006.
4. Kaushik N., Membrane Separation Processes, PHI Learning, 2008.

### CHE 3153: PROCESS MODELING AND SIMULATION [3 1 0 4]
Models and model building, principles of model formulation, precautions in model building, Classification of models. Numerical solutions of mathematical equations : Algebraic equation in one and two variables; simultaneous linear equations; ordinary differential equation in one variables and more than one variable, stiff differential equations. Lumped parameter Models: steady and unsteady state- tank model, Reaction –kinetic systems, Vapour –liquid equilibrium operation. Distributed parameter models (steady state): solution of split boundary value problems, counter current heat exchanger, tubular reactor with axial dispersion, counter current gas absorber, pipe line gas flow, permeation process, pipe line flasher, spray tower humidifier, packed bed catalytic reactor. Distributed parameter models (unsteady state, one dimension): Finite difference method, convection problems- explicit and implicit centered difference methods; diffusive problems- Crank Nicolson finite difference scheme, heat exchanger, gas absorbers and dynamics of tubular reactor with dispersion. Introduction to population balance models

**References:**
1. Ramirez W.F., Computational Methods in Process Simulations (2e), Butterworth publishers, 1997.
2. Franks R.E., Modelling and simulation in Chemical Engineering, John Wiley & Sons, 1972.
3. Hangos K., Cameron I., Process Modelling and Model Analysis, Academic Press, 2001.
4. Ramakrishna D., Population Balance-Theory and Applications to Particulate systems in Engineering (1e), Academic Press, 2000.

### CHE 3154: TRANSPORT PHENOMENA [2 1 0 3]
Prediction of transport coefficients: viscosity, thermal conductivity and diffusivity and their dependence with temperature, pressure and composition. Kinetic theories of viscosity, thermal conductivity and diffusivity. Shell balance for momentum, energy and mass transfer: unidimensional velocity-temperature and concentration profiles-momentum, energy and mass flux at the surface. Introduction to general transport equations for momentum, energy and mass transfer in Cartesian –cylindrical and spherical co-ordinates- simple solutions in one dimension.

**References:**
1. Bird R.B., Stewart W.E., Lightfoot E.W., Transport Phenomena (2e), John-Wiley, 2002
2. Brodkey R.S., Hershey C.,Transport Phenomena- A unified approach, McGraw Hill Book Company,1988
3. Slattery J.C., Advanced Transport Phenomena, Cambridge University Press, 1999
4. Geankoplis C.J, Transport Process and Unit Operation (3e) , Prentice-Hall , 1993.
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### CHE 3161: HEAT TRANSFER LAB [0031]
Experiments are based on the following topics: conduction, convection, radiation, overall heat transfer coefficient, dirt resistance calculation. Surface renewable coefficients, bare and finned tube heat exchangers, film and drop condensation.

### CHE 3162: PROCESS MODELING AND SIMULATION LAB [0132]
Experiments based on a) simulation of steady state – flash drum, reactors, distillation column, absorber and chemical plants using ASPEN PLUS. b) Simulation of unsteady state operation of chemical plants using ASPEN DYNAMICS.

## SIXTH SEMESTER
### HUM 3152: ESSENTIALS OF MANAGEMENT [2 1 0 3]

Definition of management and systems approach, Nature & scope. The functions of managers. Corporate social responsibility. Planning: Types of plans, Steps in planning, Process of MBO, How to set objectives, Strategies, policies & planning premises. Strategic planning process and tools. Nature & purpose of organising Span of management, Factors determining the span, Basic departmentation, Line & Staff concepts, Functional authority, Art of delegation, Decentralisation of authority. HR planning, Recruitment, Development and training. Theories of motivation, Special motivational techniques. Leadership- leadership behaviour & styles, Managerial grid. Basic control process, Critical control points & standards, Budgets, Non-budgetary control devices. Profit & loss control, Control through ROI, Direct, Preventive control. Managerial practices in Japan & USA, Application of Theory Z. The nature & purpose of international business & multinational corporations, Unified global theory of management. Entrepreneurial traits, Creativity, Innovation management, Market analysis, Business plan concepts, Development of financial projections

**References:**
1. Harold Koontz & Heinz Weihrich., Essentials of Management, McGraw Hill, New Delhi, 2012.
2. Peter Drucker., Management: Tasks, Responsibilities and Practices, Harper and Row, New York, 1993.
3. Peter Drucker., The Practice of Management, Harper and Row, New York 2004.

### CHE 3251: DESIGN AND DRAWING OF CHEMICAL PROCESS EQUIPMENT [1 3 3 5]
Introduction to equipment process design, piping design and economic pipe diameter, data collection and design information, Design of heat exchangers, condensers, evaporators, design of separators, distillation columns, absorption columns. Introduction to mechanical design, Vessel classification, design codes and general design consideration, Design of cylindrical and spherical vessels under internal pressure, Design of heads, closures and flanges, Design of cylindrical and spherical vessels under external pressure and stiffeners, Compensation of opening and pipes, Design vessels subjected to combined loading, Design of tall vessels, Design of vessel supports, Design of storage tanks and mixing equipment, Design of shell and tube heat exchangers, Design of high pressure vessels.

**References:**
1. Coulson and Richardson's Volume 6, Chemical Engineering design (4e), Elsevier Butterworth-Heinemann Publishers, 2005.
2. Kern D.Q., Process Heat transfer, McGraw-Hill Publishers, 1978.
3. Badger W. L., Banchero J. T., Introduction to Chemical Engineering, McGraw-Hill Publisher, 1998.
4. Joshi M.V., Mahajani V.V., Process Equipment Design (3e), MacMillan Publishers, 1998
5. Indian Standard for unfired pressure vessel, IS 2825-1969
6. Indian Standard for Heat Exchangers, BIS 4503-1967
7. Bhattacharya B.C., Introduction to Chemical Equipment Design – Mechanical aspects, CBS Publishers, 2012.
8. Brownell L.E., Young E.H., Process Equipment Design, Wiley Publications, 2009.

### CHE 3252: PROCESS DYNAMICS AND CONTROL [3 1 0 4]

First Principles model development; Introduction to Laplace Transform, Process dynamics for first, second and higher order systems: linearization, 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 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.

**References:**

1. Seborg D.E., Edgar T.F., Mellichamp D.A., Process Dynamics and Control (2e), John Wiley and Sons, 2004.

2. Stephanopoulos G., Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall, New Delhi, 1984.

3. Coughanowr D.R., Process Systems analysis and Control (2e), McGraw Hill, 1991.

4. Marlin T.E., Process Control: Designing of Processes and Control Systems for dynamic performance (2e), Mc Grew Hill, 2000.

5. Harmon Ray W., Ogunnaike B., Process dynamics, modeling and control (1e), Oxford University press. 1994

6. Bequette B.W., Process Control, Modelling, Design and Simulation, Prentice Hall International, 2003.

### CHE 3261: MASS TRANSFER LAB [0 0 3 1]

Experiments are based ob following topics: Vapour-liquid equilibria, Simple distillation – vaporization and thermal efficiency of steam distillation – distillation under total reflux in a packed column – studies in batch adsorption – diffusivity by stephen's method – mass transfer coefficient in dissolution of solid – liquid-liquid extraction –simple and cross flow leaching – experimental determination of liquid-liquid equilibrium data – drying of solids in fluidized bed dryer – extraction of solute in packed bed column – crystallization process in an batch crystallizer – tray efficiency of bubble cap distillation column –

### CHE 3262: REACTION ENGINEERING AND PROCESS CONTROL LAB [0 0 3 1]

Experiments based on the following topics: Homogeneous non-catalytic liquid phase kinetic studies using batch reactor, semi-batch reactor, PFR and CSTR. Studies on recycle reactor. RTD Studies in PFR and CSTR - Dynamic response of systems: first order non-linear, thermometric; second order non-interacting and interacting by introducing a step input. Linearization of a non-linear system and comparison of dynamic response with the actual response, Valve characteristics, Studies on P, PI, and PID controllers; control of systems with cascading and ratio effects

## SEVENTH SEMESTER

There are five program electives and one open elective with total of 18 credits to be taught in this semester.

## EIGHTH SEMESTER

### CHE 4298: INDUSTRIAL TRAINING

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry.

### CHE 4299: PROJECT WORK/PRACTICE SCHOOL

The project work may be carried out in the institution/industry/research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

### PROGRAM ELECTIVES

### CHE 4051: NATURAL GAS ENGINEERING [3 0 0 3]

Natural gas industry, types of natural gas resources; Properties of natural gas; Gas reservoir deliverability: analytical and empirical methods, construction of IPR curve, shale gas wells, well deliverability testing; Well bore performance: single-phase gas well and mist flow in gas wells; Choke performance: sonic and subsonic flow, dry and wet gas flow through chokes; Well deliverability: nodal analysis, production forecast; Natural gas processing: separation of gas and liquids, stage and low-temperature separation; dehydration; Compression and cooling; Natural gas measurement and transportation; Liquid loading, hydrate cleaning and pipeline cleaning; Advances in natural gas production engineering.

**References:**
1. Guo B., Ghalambor A., Natural Gas Engineering Handbook, Gulf Publishing Company, 2005.
2. Katz D. L., Lee R. L., Natural Gas Engineering, McGraw Hill, 1990.
3. Guo B., Lyons W. C., Ghalambor A., Petroleum Production Engineering: A Computer Assisted Approach, Elsevier, 2007.
4. Ahmed T., McKinney P. D., Advanced Reservoir Engineering, Elsevier, 2005.

### CHE 4052: OIL AND GAS RESERVOIR ENGINEERING [3 0 0 3]

Basic concepts of reservoir engineering: calculation of hydrocarbon volumes, fluid pressure regimes, recovery factor, volumetric gas reservoir study, hydrocarbon phase behavior; PVT analysis for oil: definition of parameters, fluid sampling, laboratory testing and conversion to field conditions; Material balance applied to oil reservoirs: general form of equation, reservoir drive mechanisms, solution gas drive, gascap drive, natural water drive; Darcy's law and applications: Darcy's law, fluid potential, radial steady state flow, well stimulation, two-phase flow: effective and relative permeability, supplementary recovery; Radial flow differential equation, conditions of solution; Application of the stabilized inflow equations.

**References:**
1. Dake L. P., Fundamental of Reservoir Engineering, Elsevier, 2011.
2. Smith H. C., Tracy G. W., and Farrar R. L., Applied Reservoir Engineering: Volume I and II, OGCI, 1999.
3. Salter A., Baldwin J., and Jespersen R., Computer-Aided Reservoir Management, Pennwell, 2000.
4. Ahmed Tarek, Reservoir Engineering Handbook (4e), Gulf professional publishers, 2010.

## CHE 4053: PETROLEUM REFINERY ENGINEERING (THEORY AND LAB) [2 0 3 3]

**Theory:** Crude oil origin, composition, characterization and classification; Refinery products and test methods; Design of crude oil distillation column; Refinery processes: thermal, catalytic, and hydrocracking, catalytic reforming, isomerization, alkylation, polymerization, lube oil processing, coking, hydro treatment, gas processing; New trends in petroleum refinery operations.

**Lab:** Experiments are based on determination of vapour pressure, flash point, fire point, pour point, smoke point, aniline point, viscosity, viscosity index, calorific value, carbon residue, softening point, and penetration index of petroleum fractions.

**References:**
1. James G Speight, The Chemistry and Technology of Petroleum (4e), CRC Press, 2006.
2. Nelson W. L., Petroleum Refining Engineering (4e), McGraw-Hill, 1974.
3. Bhaskara Rao B. K., Modern Petroleum Refining Processes (5e), Oxford& IBH, 2009.
4. Meyers R. A., Handbook of petroleum refining processes (3e), McGraw-Hill, 2004.

## CHE 4054: PROCESS INTEGRATION FOR PETROLIUM INDUSTRIES [3 0 0 3]

Energy consumption scenario in petroleum industries, Basic concepts of in Process Synthesis, Understand the importance of energy integration in a petroleum industry, Energy integration, Different Methods of Energy Integration, Focus on Pinch Analysis: Need of Pinch Technology, Role of thermodynamics, Problem addressed by Pinch technology. Key Steps of Pinch Technology: Data extraction, Targeting, Designing, and Optimization. Basic Elements of Pinch Technology: Grid diagram, Composite curve, Problem table algorithm, Grand composite curve. Heat Exchanger Network (HEN): Energy targeting, Area targeting, Number of units targeting, Shell targeting, cost targeting. Designing of HEN: Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER);Heat Integration of Equipment's: Heat engine, Heat pump, Distillation column, Reactor, Ideal distillation systems, Heat integrated distillation processes, Synthesis of distillation sequences, Refrigeration systems."HINT" Software Practice of software for HEN using Pinch Technology

**References:**
1. Ian C Kemp, Pinch, Analysis and Process Integration: A User Guide on Process Integration for the efficient use of energy (2e), Butterworth-Heinemann (Elsevier), publisher, 2007.
2. Robin M. Smith, "Chemical Process: Design and Integration", John Wiley & Sons, 2005.
3. Biegler, L. T.; Grossmann I. E.; Wasterberg, A. W., "Systematic Methods of Chemical Proces Design", Prentice Hall, New-Jersey, 1997.
4. El-Halwagi, M. M., "Process Integration", Process System Engineering series vol. 7, Academic press, San Diego, 2005.
5. Angel Martın, Fidel A. Mato, Hint: An educational software for heat exchanger network design with the pinch method, education for chemical engineers 3, e6–e14, 2008

## CHE 4055: ENVIRONMENTAL POLLUTION CONTROL ENGINEERING [3 0 0 3]

Man and environment Nutrient and hydrologic cycles Types of pollution Legislation to environmental pollution Aspects of pollution control Evaluation and characterization of wastewater Treatment methods Advanced wastewater treatment Sludge treatment and disposal Solid waste management. Noise pollution and control: Ambient and stack gas sampling analysis of air pollutants, Principles of air pollution Plume behavior Meteorological factors affecting air Pollution. Equipment for control and abatement of air pollution. Pollution control of effluent in chemical industries such as Fertilizer, Petroleum refinery, Pulp and paper and Tannery industries.

**References:**
1. Mahajan S.P., "Pollution Control in Process Industries", Tata McGraw Hill, 2008.
2. Rao C.S., "Environmental Pollution Control Engineering", (2e), New Age International Publishers, 2006.
3. Cavaseno V, "Industrial Air Pollution Engineering", McGraw Hill, NY, 1980

## CHE 4056: ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT PLAN [3 0 0 3]

Environmental impact assessment (EIA), definitions and concepts, rationale and historical development of EIA, EIA process in India and other countries, EIA laws and regulations, The Environmental protection Act, The water preventation Act, The Air (Prevention & Control of pollution Act.), Wild life Act etc.

E I A Methodologies: introduction, Criteria for the selection of EIA Methodology, E I A methods, Adhoc methods, matrix methods, Network method Environmental Media Quality Index method, overlay methods and cost/benefit Analysis. Initial environmental examination, Introduction and Methodology for the assessment of ground water, surface water, Assessment of Impact of development Activities on Vegetation and wildlife, Assessment of air, soil. Case studies.

Environmental management - principles, problems and strategies; Environmental audit, definitions and concepts, partial audit, compliance audit, methodologies and regulations; introduction to ISO and ISO 14000; Life cycle assessment; Triple bottom line approach; Ecological foot printing; Carbon trading; Sustainable development

**References:**
1. Canter L. W., Environmental Impact Assessment, (2e), McGraw-Hill, 1997
2. Anjaneyulu Y., Environmental Impact Assessment Methodologies, by, B.S. Publication, Sultan Bazar, Hyderabad (2006).
3. Judith P., Eduljee G., Environmental Impact Assessment for Waste Treatment and Disposal Facilities, John Wiley & Sons, 1994
4. Burke G., Singh B. R., Theodore L., Handbook of Environmental Management and Technology, (2e), John Wiley & Sons, 2000
5. Eccleston C. H., Environment Impact Statements: A Comprehensive Guide to Project and Strategic Planning, John Wiley & Sons, 2000
6. Welford R., Corporate Environmental Management - Systems and Strategies, Universities Press, 1996
7. Whitelaw K., Butterworth, ISO 14001: Environmental System Handbook, 1997

8. The Economist Intelligence Unit, Best Practices - Environment, Universities Press, 1993
9. Therivel R., John Glasson, Andrew Chadwick, Introduction to Environmental Impact Assessment (Natural and Built Environment), Routledge, 2005

## CHE 4057: INDUSTRIAL WASTEWATER ENGINEERING [2 0 3 3]

Wastewater treatment quality criteria and effluent standards, Water and wastewater characteristics, Preliminary treatment processes: Screens, grit chamber, flow equalization, Primary sedimentation tank, Primary treatment process: Sedimentation, Coagulation and Flocculation, Softening, Sand filtration, Biological treatment processes: Introduction to microbiology, microbial kinetics, Aeration ponds and lagoons, Activated sludge process, Nitrification and denitrification, Trickling filters and rotating biological contactors, Sludge treatment, Advanced treatment processes: Adsorption, Chemical oxidation, Ozonation, Photo catalysts, wet air oxidation, evaporation, Ion exchange, Membrane Technologies, Concept of zero liquid discharge, Wastewater disposal in receiving bodies, Case studies: Effluent treatment plants in Textile, Tanneries, Pulp and paper, Sugar and distilleries and Pharmaceutical industries.

Lab may include tests for water quality, pH, turbidity, COD, BOD, total solids, suspended solids, dissolved solids, fluoride, residual chlorine, determination of particulate matter in air, high volume sampler, determination of SO2, CODetermination of SPM, $PM_{10}$ and $PM_{2.5}$ using a High volume sampler

**References:**
1. Metcaff and Eddy, Wastewater Engineering: Treatment and Reuse (5e), McGraw Hill, 2007.
2. Edwards J. D., Industrial Waste Water Treatment: A Guide Book (1e), CRC Press, 1995.
3. Patwardhan A. D., Industrial Waste Water Treatment, Prentice Hall India, 2008.
4. Ranade V. V., Bhandari V. M., Industrial Wastewater Treatment, Recycling and Reuse (2e), Prentice Hall India, 2017.
5. Droste R. L., Theory and Practice of Water and Wastewater Treatment, John Wiley & Sons, 2005.

## CHE 4058: SOLID AND HAZARDOUS WASTE MANAGEMENT [3 0 0 3]

Classification of solid wastes, Functional elements of Solid Waste Management (SWM), Regulatory aspects of SWM, Waste Characteristics, Environmental and health effects, Solid waste storage and collection, Transfer stations, Waste Processing techniques, Source reduction, recycle and recovery, Sanitary landfill, Landfill liners, Leachate and landfill gas management, Composting, Biogasification, Incineration, Introduction to Hazardous Waste Management (HWM), Guidelines for (HWM), International regulatory framework for HWM, Characterization of hazardous wastes, Packing and labelling of hazardous wastes, Storage, transport and disposal of hazardous wastes, Concept of Integrated waste management.

**References:**
1. Tchobanoglous G., Theisen H., Eliassen R., Solid Wastes: Engineering Principles and Management Issues, McGraw Hill, 1977.
2. Freeman H. W., Standard Handbook of Hazardous waste Treatment and Disposal (2e), McGraw Hill, 1997.
3. McBean E. A., Rovers F. A., Farquhar G. J., Solid Waste landfill Engineering and Design, Prentice Hall, 1995.
4. Lees F., Lees' Loss Prevention in the Process Industries: Hazard identification, assessment and control (3e), Butterworth-

## CHE 4059: ADAVANCED PROCESS CONTROL [2 1 0 3]

Review of classical control, Enhancement of single loop control performance and MIMO system analysis: A brief review of classical control concepts, Design of feed forward and ratio controls, Study of cascade control system. Design of Time delay compensator (Smith predictor). Interaction Analysis in MIMO systems. RGA Analysis. Design of De-couplers. Introduction to adaptive control strategy. State space representation of continuous time systems & its analysis: Review of Matrix algebra, State space representation of continuous time systems. Development of state space models. Analysis of state space models. Linearization of nonlinear system, Concept of Controllability and Observability. Controller design using pole placement approach. Stability of linear control system. (Jury's stability criteria and Eigen value approach). Models for computer control: Introduction to discrete time system and analysis using Z-transform. Development pulse transfer function. Discrete state space representation. Stability of linear discrete systems. Design of experiments for development of control relevant models. Models for computer control from input-output data. Discrete dynamic models, Impulse response models and step response models. Parameter estimation problem. Parameter estimation of Black box models (i.e. ARX, ARMAX Models). State Estimator & model predictive control: Development of model based control. Design of State estimation and Observers, soft sensors, recursive least square estimation, Kalman Filter, linear quadratic optimal control (LQOC), model predictive control (MPC). Introduction to statistical process control.

**References:**
1. Seborg D.E., Edgar T.F., Mellichamp, Process dynamics and control, (2e), John Wiley & sons, 2004
2. Harmon Ray W., Babatunde Ogunnaike. Process dynamics, modeling and control, Oxford University press. 1994
3. Ogata K., Discrete Time Control systems (2e), Pearson Education, 2005.
4. Astrom K. J. and Wittermark B., Computer-Controlled Systems: Theory and Design (3e) Prentice Hall; 1996
5. Tangirala A. K., Principles of System Identification: Theory and Practice, CRC Press, 2005.
6. Lennart Ljung, System Identification: Theory for the users (3e), Prentice Hall; 2005.

## CHE4060: APLLIED INTERRFACIAL ENGINEERING [3 0 0 3]

General introduction of colloids and interfaces, the role of mixing and entropy, Colloid stability, colloid behavior at surfaces, Experimental interrogation of colloids and surfaces, Understanding adsorption at surfaces (Thermodynamics of interfaces), and its application, Self –assembly of Amphiphiles (surfactants), Particles at interfaces and Applications, Novel fabrication of nanostructured particles and applications, Electron transfer across interfaces and applications, Latest trends in interfacial science and latest innovation in interfacial engineering applications.

**References:**
1. Hiemenz, P. C, Rajagopalan, R., Principles of Colloid and Surface Chemistry, (3e), Marcel Dekker, New York, 1997.
2. Rosen M. J., Surfactants and Interfacial Phenomena, Wiley-Interscience Publication, New York, 1978.
3. Adamson, A. W. Gast, A. P., Physical Chemistry of Surfaces, Wiley-Interscience, New York, 1997.
4. Evans D. F., Kakan Wennerstrom, The Colloidal Domain: Where Physics, Chemistry, Biology, and Technology Meet (Advances in Interfacial Engineering), Wiley-VCH, 1999
5. Israechvili J., Intermolecular & Surface Forces (2e), Academic Press, 1992

## CHE 4061: CHEMICAL REACTOR THEORY [3 0 0 3]

Non-isothermal reactors, Nature of the problem, Energy balances, Temperature effects, Design of adiabatic and non-isothermal batch semi-batch and flow reactors, Optimum temperature progression, multiple steady states. Heterogeneous reactions, Rate equation for heterogeneous systems, Fluid-particle non-catalytic reactions, Different models, Kinetic regimes, Multiphase reactors, Heterogeneous catalysis, Types and classification of catalysts Selection and preparation of catalysts for industrial reactions, Kinetics of heterogeneous solid catalyzed gas reactions, Mathematical models on different mechanism, External transport processes, Intrapellet mass transfer, Heat transfer, Effectiveness factors.

**References:**
1. Scott Fogler, H, Elements of Chemical Reaction Engineering, (4e), PHI, 2005.
2. Octave Levenspiel, Chemical Reaction Engineering, (3e), Wiley & Sons, 2003.
3. Rawlings J.B. and Ekerd, J.G., Chemical Reactor Analysis and Design Fundamentals Nole. Hill 2002.
4. Smith, J.M, Chemical Engineering Kinetics, 3rd edition, McGrawl-Hill, International student edition
5. Mark E Davis, Robert E Davis, Fundamentals of Chemical Reaction Engineering, (1e), McGrawl-Hill, 2003
6. Ronald W. Missen, Charles A. Mims, Bradley A. Saville; Introduction to chemical reaction engineering and kinetics, John Wiley & Sons, Inc.

## CHE 4062: ENVIRONMENTAL POLLUTION CONTROL ENGINEERING [3 0 0 3]

Man and environment Nutrient and hydrologic cycles Types of pollution Legislation to environmental pollution Aspects of pollution control Evaluation and characterization of wastewater Treatment methods Advanced wastewater treatment Sludge treatment and disposal Solid waste management. Noise pollution and control: Ambient and stack gas sampling analysis of air pollutants, Principles of air pollution Plume behavior Meteorological factors affecting air Pollution. Equipments for control and abatement of air pollution Pollution control of effluent in chemical industries such as Fertilizer, Petroleum refinery, Pulp and paper and Tannery industries.
Classification of solid wastes, Functional elements of Solid Waste Management (SWM), Regulatory aspects of SWM, Waste Characteristics, Environmental and health effects, Solid waste storage and collection

**References:**
1. Mahajan S.P.,"Pollution Control in Process Industries", Tata McGraw Hill, 2008.
2. Rao C.S., "Environmental Pollution Control Engineering" (2e), New Age International Publishers, 2006.
3. Cavaseno V, "Industrial Air Pollution Engineering", McGraw Hill, NY, 1980

## CHE 4063: FUELS AND COMBUSTION [3 0 0 3]

Solid fuels: Testing methods – Proximate and ultimate analysis – Calorific value – Weathering and grindability index of coal – Theories of origin and stages of formation – Coal washing techniques – Carbonisation – Coke ovens – Gasification – Briquetted and pulverized fuels. Liquid fuels: Testing methods – Aniline point – Viscosity index – ASTM distillation – Flash and fire point – Carbon residue – Moisture – Smoke point and char value – Calorific value – Origin, composition and classification of petroleum – Distillation of crude and purification of petroleum products. Gaseous fuels: Fuel gas and flue gas analysis – Calorific value – Production and utilization of Natural gas, producer gas, water gas and carbonated water gas. Combustion Stoichiometry, theoretical & actual combustion processes –Air fuel ratio. Combustion Thermodynamics- calculation of heat of formation & heat of combustion – First law analysis of reacting systems. Heat Treatment Furnaces- Industrial furnaces – process furnaces – Kilns –Flame, Flame Structure, Ignition and Igniters – flame propagation – deflagration – detonations- flame front – Ignition – self & forced ignition – Ignition temperature Combustion Appliances- Gas burners- Functional requirement of burners – Gas burner Classification –Stoker firing –pulverized system of firing.

**References:**
1. Sharma, S.P.and Chander Mohan, Fuels and Combustion, Tata McGraw-Hill, 1982
2. Saha, A.K., Combustion Engineering and Fuel technology, Oxford Press
3. Gilchrist, J.D., Fuels, Furnaces and Refractories, Pergamon Press, 1977
4. Samir Sarkar, Fuels and Combustion, (3e), Universities Press, 2010

## CHE 4064: INTRODUCTION TO BIOCHEMICAL ENGINEERING [3 0 0 3]

Introduction – Principles of microbiology, Chemicals of life – Lipids – Sugars and polysaccharides of cellular organization – cell nutrients – Macronutrients – Growth media Kinetics of enzymes – Enzyme substrate complex and enzyme action – Isolation and utilization of enzymes – Production, purification, immobilization and application of enzymes. Metabolic pathways and energetic of the cell – Glucose metabolism - Metabolism of nitrogenous compounds – Nitrogen fixation – Metabolism of hydrocarbons – Overview of biosynthesis – Anaerobic metabolism – Photosynthesis - Autotropic metabolism – transport across cell membranes, Cell growth – Batch growth – Growth patterns and kinetics in batch culture – Factors affecting growth kinetics-Quantification of growth kinetics – Unstructured non-segregated models to predict specific growth rate – Models with growth inhibitors – Logistic equation – Growth models for filamentous organisms.

**References:**
1. Bailey J.S.and Ollis D.F., Biochemical Engineering Fundamentals, McGraw-Hill, NY, 1986
2. Shuler M.L.and Kargi F., Bioprocess Engineering Basic Concepts, Prentice Hall of India, New Delhi, 1998
3. Blanch H.W. and.Clerk D.S, Biochemical Engineering, Mercel Dekker Inc., 1996

## CHE 4065: INTRODUCTION TO PETROLEUM ENGINEERING [3 0 0 3]

Overview and history of the petroleum industry; Petroleum reserves, production and consumption statistics of the world; Crude oil origin, exploration, drilling; Crude composition, characterization and classification; Estimation of oil and gas in place; Hydrocarbon phase diagrams; Reservoir properties and drive mechanisms; EOR; Fundamentals of refinery major operations and processes; Refinery products and test methods.

**References:**
1. Nelson W. L., Petroleum Refining Engineering, (4e), McGraw-Hill, 1990.
2. Dake L. P, Fundamental of Reservoir Engineering, Elsevier, 2011.
3. Ahmed Tarek, Reservoir Engineering Handbook, (4e), Gulf professional publishers, 2010.
4. Bhaskara Rao B. K., Modern Petroleum Refining Processes, (5e), Oxford& IBH, 2009.

## CHE 4066: MATERIALS SCIENCE AND ENGINEERING [2 1 0 3]

Historical perspective, scope of materials science and engineering, Atomic structure and interatomic bonding, Lattices, basic idea of symmetry, Bravais lattices, unit cells, crystal structures, crystal planes and directions, co-ordination number. Single crystals, polycrystalline, non-crystalline, nanocrystalline materials. Imperfections in solids: point defects, line defects, surface defects. Solid solutions, phases, phase diagrams. Diffusion phenomenon, phase transformations. Strengthening mechanisms. Classification of materials, properties of materials. Structure, properties and applications of different metals and alloys, ceramics and polymers.

**References:**
1. Callister W. D. Materials Science and Engineering, an Introduction,. John Willey and Sons Inc. Singapore.
2. Raghavan. V., Physical Metallurgy: Principle and Practice,. Prentice Hall India Pvt Ltd.
3. Dieter G. E, Mechanical Metallurgy,. Mcgraw Hill, London

## CHE 4067: NON-NEWTONIAN FLOW IN THE PROCESS INDUSTRIES [2 1 0 3]

Classification of fluid behaviour, Rheometry for non-Newtonian fluids: capillary, rotational, normal stress, controlled stress, yield stress rheometers, Power law fluids flow in pipes and in conduits, Flow of multiphase mixtures in pipes: two phase gas non Newtonian liquid flow.

**References:**
1. Chhabra R..P. and Richardson J. F., Non-Newtonian flow in the process Industries, Butterworth and Heinemann, 1999.
2. McCabe W., Smith J., Harriott P.,  Unit Operations of Chemical Engineering (7e), McGraw Hill Education, 2017.
3. Carreau P. J., DeKee D. C. R., Chhabra R. P., Rheology of Polymeric Systems: Principles and Applications, Hanser Publishers, 1997.

## CHE 4068: PROCESS DATA ANALYSIS [2 1 0 3]

Fundamental Statistical Analysis and Multivariate Linear Regression Analysis: Fundamental statistical analysis, Simple regression analysis, Multiple regression analysis, Parameter estimation, grey model, black-box model , Statistical properties of linear regression  Analysis of variance , Determine model adequacy, Statistical inferences based on multivariate linear regression models ,Weighted least squares. Nonlinear Regression Analysis: linearization through data transformation, nonlinear regression, Statistical analysis of nonlinear, regression, Determine model adequacy, Statistical inferences based on nonlinear regression models, Linear versus nonlinear regression. Design of Experiments: Strategies for experimentation, Single factor experiments, Two-level factorial experiments, Fractional factorial design, multiple level factorial experiments, Analysis of variance, Interpretation of results from experiments. Selected Advanced Topics: Response surface methods for optimal experimentation decision making, Statistical quality Control, Introduction to control monitoring charts. Laboratory exercises includes: Computational Experiment & Pilot-scale Experiments (laboratory experiments on linear and nonlinear regression analysis)

**References:**
1.  Montgomery D.C., Design and Analysis of Experiments (8e), Wiley, 2012.
2. Montgomery D.C. and Runger G.C., Applied Statistics and Probability for Engineers.1994
3. Box G.E.P, Hunter W.G. and Hunter J.S., Statistics for Experimenters, John Wiley & Sons, 1978.

## CHE 4069: PROJECT ENGINEERING [3 0 0 3]

Preliminary data on projects; Process engineering, Block flow diagram, Process flow diagram,  Piping and instrumentation diagram, Pilot plants, General considerations for plant location and layout, piping design, plant utilities, insulation, instrumentation, safety in chemical plant, Project engineering management, Project scheduling and its importance, PERT and CPM techniques, Gantt chart,  Optimum project design, optimum production rates, selected examples such as heat exchangers, pumps , vessels, evaporators, and driers.

**References:**
1. Howard F. Rase, M.H. Barrow, Project Engineering of Process Plants, John Wiley, 1957
2. Warren Sieder, J.D. Seader, Daniel Lewin, Product and Process Design Principles, John Wiley, 2004
3. Gael D.U., A Guide to Chemical Engineering Process Design and Economics, John Wiley, 1984
4. Peters M. S, Klaus D. T., Ronald E. W., Plant Design and Economics for Chemical Engineers, McGraw- Hill, 2003
5. Ludwig E.E., Applied Project Engineering, Gulf Publishing Co., Houston, 1988
6. Modes J, Philips, Project Engineering with CPM & PERT, Renhold Publishing Co.
7. Coulson and Richardson's Chemical Engineering Series Chemical Engineering Volume 6, Chemical Engineering Design, (3e), 2003

## CHE 4070: RENEWABLE ENERGY ENGINEERING [3 0 0 3]

Solar radiation, availability, measurement and estimation; empirical relations, solar collectors and types, Selective coatings Solar water heating, Solar cooking, Solar drying, Solar distillation and solar refrigeration, Active and passive heating and cooling of buildings, Solar Chimney, Solar drying Solar thermal power generation - Energy Storage - Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds. Solar pond. Energy in wind- wind energy applicable to Indian standards –Variables in wind energy conversion systems – wind power density – power in a wind stream– wind turbine efficiency – Forces on the blades of a propeller – Solidity and selection curves. HAWT, VAWT– tower design-power duration curves- wind rose diagrams- study of characteristics-wind turbine circuits. Biomass - Sources and Classification - Chemical composition, properties of biomass - Energy plantations. Size reduction, Briquetting, Drying, Storage and handling of biomass. Biogas technology - Feedstock for biogas, Microbial and biochemical aspects - operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waste water treatment. Incineration- Processing for liquid fuel production. Pyrolysis - Effect of particle size, temperature, and products obtained. Gasification - Effect of pressure, temperature, steam and oxygen. Bio-ethanol and bio-diesel technology Production of fuel ethanol by fermentation of sugars, gasohol as a substitute for petrol. Trans-esterification of oils to produce bio-fuels, Pyrolysis and gasification of biomass, Thermo- chemical conversion lignocelluloses biomass. Combustion of biomass and co-generation systems Environmental aspects of biofuel utilization - Techno  economic features of bio  fuels – Co-generation in biomass processing industries.

**References:**
1. Goswami D.Y., Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2ndEdition, Taylor & Francis, 2000, Indian reprint, 2003
2. Anderson E.E, "Fundamentals for solar energy conversion", Addison Wesley Publ. Co., 1983.
3. Duffie J. A and Beckman, W .A., "Solar Engineering of Thermal Process", John Wiley,1991. 4. G. N. Tiwari and M. K. Ghosal,

"Fundamentals of Renewable energy Sources", NarosaPublishing House, New Delhi, 2007

4. Sukhatme S. P, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hil, New Delhi, 1996
5. Wind energy Handbook, Edited by T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, John Wiley & Sons, 2001
6. Mukund & Patel R., Wind and Solar Power Systems., 2nd Edition, Taylor & Francis, 2001
7. Freris B. L .L., Wind Energy Conversion Systems, Prentice Hall, 1990.
8. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing Co, 1989.
9. Mital K.M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd., 1996.
10. Rezaiyan. J and Cheremisinoff N. P., "Gasification Technologies, A Primer for Engineers and Scientists", Taylor & Francis, 2005
11. Samir Kumar Khana Bioenergy and Biofuel from Biowastes and Biomass , ASCE Publications, 2010

## CHE 4071: RISK AND SAFETY MANAGEMENT IN PROCESS INDUSTRIES [3 0 0 3]

Safety in plants: Hazard analysis, damage minimisation, fires, fire extinguishers, handling, contamination removal, reduction methods, personal protective devices, Plant and personal safety. Pressure vessels, handling and transportations of liquids and gases under high pressure, explosive chemicals and handling. Safety administration, safety committee, safety education. First aid principles and methods, plant inspection. Engineering design for safety considerations. Hazards in work places, workers exposure to hazardous chemicals, threshold limit values of chemicals, engineering control of hazards and accidents due to fire and explosives and natural causes in different industries. Safety management, safety performance, motivation of employees, supervisors, managers and management, legal aspects of safety. Case studies: Major explosions in Chemical Industry: Bhopal disaster, Flixborough disaster, Seveso disaster, Philips disaster, Texas disaster.

**References:**
1. Roland P.Blake, Industrial safety, (2e), Prentice Hall Inc, New York, 1953
2. Muir G.D, Hazards in Chemical Laboratory, (2e), The Chemical Society, London, 1980
3. Judson and Brown, Occupational Accident Prevention, John Wiley, New York, 1980
4. Handley W., Industrial Safety Hand Book, McGraw Hill, London, 1969

## CHE 4072: SYSTEM IDENTIFICATION [2 1 0 3]

Introduction to Identification and models for linear Deterministic systems: Motivation, Incentives in model developments, Benefits, System identification –Terminology and notation, types of models, System identification procedure. Modeling example using MATLAB. Mathematical description of process models: Definition of model, classification of models, Input excitation trypes, Criteria for input excitation. Sampling and discretization: Sampled data system, zero order hold, sampler, sampling criteria. Examples using MATLAB. Models for discrete Time LTI systems: Transfer function operator and transfer function, Convolution models, Response models- Finite Impulse Response (FIR) Model, Step Response Models, state space descriptions, Forma of state space representation, controllability, observability, example in MATLAB for estimating LTI models. Stability of linear discrete systems. Examples using MATLAB. Models for Random Process: Introductory remarks, Random variables, Random signals and processes, Application of time series analysis, Time domain analysis, Models for linear stationary processes, MA, AR models. Examples using

MATLAB. Estimation Methods: Least square estimators, linear least square, weighted least square, output error models, and equation error models, Predictions: one step ahead predictor, L-step ahead predictor. Identification of time series parametric models: ARX, ARMAX. Examples using MATLAB.

**References:**
1. Tangirala A. K., Principles of System Identification: Theory and Practice, CRC Press, 2005
2. Ljung L., System Identification: Theory for the users (3e), Prentice Hall, 2005.
3. Astrom K. J. and Wittermark B., Computer-Controlled Systems: Theory and Design (3e), Prentice Hall, 1996
4. Seborg D.E., Edgar T.F., Mellichamp, Process dynamics and control (2e), John Wiley & sons, 2004
5. Harmon Ray W., Babatunde Ogunnaike. Process dynamics, modeling and control, Oxford University press. 1994
6. Ogata K., Discrete Time Control systems (2e), Pearson Education, 2005.

## CHM 4051: ANALYTICAL TECHNIQUES AND INSTRUMENTATION [3 0 0 3]

Spectroscopic methods of analysis – Introduction to spectroscopy – Energy concepts, properties of EMR, General features of spectroscopy, Types of molecular spectra, Interaction of EMR with matter, Instrumentation, Application. Microwave spectroscopy, Raman spectroscopy, Infrared spectroscopy, UV-visible spectroscopy, NMR spectroscopy.

Chromatographic Techniques – General concepts, Classification, Column chromatography, HPLC, Instrumentation, Applications, Thin layer chromatography, Experimental techniques, Applications, Advantages and disadvantages, Gas chromatography, principles, instrumentation and applications

Electroanalytical methods– Conductometric titrations – basic principles, Applications in titrations involving weak and strong acids and bases, Potentiometric titrations- Fundamental principles, Applications involving neutralization, redox, precipitation and complexation types

**References:**
1. Skoog D.A., Holler J., Nieman F.T.A., Principles of Instrumental Analysis, (5e), Saunders, Philadelphia, 1992
2. Skoog D. A., West D. M. and Holler F. J., Fundamentals of Analytical Chemistry, (5e), Saunders College Publishing, Philadelphia, 1988.
3. Jeffery G.H., Vogel's Textbook of Quantitative Chemical Analysis, (5e), John Wiley & Sons Inc, 1989
4. Chatwal G, Anand. S. , Instrumental Methods of Chemical Analysis, Himalaya Publishers, Bombay, 1996
5. Ewing G.W., Instrumental Methods of Chemical Analysis, Mc-Graw-Hill, 1989
6. Banwell C.N., McCash C.N., Fundamentals of Molecular Spectroscopy, McGraw-Hill, London, 1972

## OPEN ELECTIVES

## CHE 4301: INDUSTRIAL POLLUTION CONTROL [3 0 0 3]

Symbiosis between man and environment, Nutrient and hydrologic cycles, Types of pollution, Legislation to environmental pollution, Phases involved in establishment of plant monitoring and control system, Evaluation and characterization of wastewater, Treatment methods, Concept of Zero Liquid Discharge, Sludge treatment and disposal , Solid waste management, Noise pollution and control, E-waste – sources and effects, e-waste management, Ambient air and stack gas sampling, Analysis of air pollutants, Plume behaviour, Meteorological factors affecting air pollution, Equipment for control and abatement of air pollution, Pollution from automobiles – control mechanisms.

**References:**
1. Mahajan S.P., Pollution Control in Process Industries, Tata McGraw Hill, 1990
2. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern, 1992.
3. Noel De Nevers, Air pollution Control Engineering, (2e), McGraw-Hill, 1999
4. Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, (2e), McGraw-Hill, 2002.

## CHE 4302: RISK AND SAFETY MANAGEMENT IN INDUSTRIES [3 0 0 3]

Safety in plants: Hazard analysis, damage minimisation, fires, fire extinguishers, handling, contamination removal, reduction methods, personal protective devices, Plant and personal safety. Pressure vessels, handling and transportations of liquids and gases under high pressure, explosive chemicals and handling. Safety administration, safety committee, safety education. First aid principles and methods, plant inspection. Engineering design for safety considerations. Hazards in work places, workers exposure to hazardous chemicals, threshold limit values of chemicals, engineering control of hazards and accidents due to fire and explosives and natural causes in different industries. Safety management, safety performance, motivation of employees, supervisors, managers and management, legal aspects of safety.

**References:**
1. Roland P.Blake, Industrial safety, (2e), Prentice Hall Inc, New York, 1953
2. Muir G.D, Hazards in Chemical Laboratory, (2e), The Chemical Society, London, 1980
3. Judson and Brown, Occupational Accident Prevention, John Wiley, New York, 1980
4. Handley W., Industrial Safety Hand Book, McGraw Hill, London, 1969

## CHE 4303: WATER TREATMENT TECHNOLOGY [3 0 0 3]

Water demand per capita, drinking water standards (BIS and WHO), drinking water treatment–flow-chart. Aeration, sedimentation, filtration, disinfection, softening, removal of taste, odour, desalination, reverse osmosis, Nalagonda process. Water distribution networks, Sanitary and storm sewerage systems, Intake structures and pumping installations. Wastewater treatment quality and quantity estimation, Wastewater characteristics, Preliminary treatment, primary treatment Softening, Biological treatment processes, microbial kinetics, nitrification and denitrification, trickling filters and rotating biological contactors, advanced treatment processes, concept of zero liquid discharge, wastewater disposal in receiving bodies, Industrial wastewater treatment, Case studies for industrial wastewater treatment

**References:**
1. Garg S.K., Water supply Engineering, Khanna Publishers 2017
2. Metcaff and Eddy, Wastewater Engineering: Treatment and Reuse (5e), McGraw Hill, 2007.
3. Edwards J. D., Industrial Waste Water Treatment: A Guide Book (1e), CRC Press, 1995.
4. Patwardhan A. D., Industrial Waste Water Treatment, Prentice Hall India, 2008.
5. Ranade V. V., Bhandari V. M., Industrial Wastewater Treatment, Recycling and Reuse (2e), Prentice Hall India, 2017.
6. Droste R. L., Theory and Practice of Water and Wastewater Treatment, John Wiley & Sons, 2005.
7. Hammer, M.J., (1986), Water and Wastewater Technology –SI Version, (2e), John Wiley and Sons.

## MCA 4301: INTRODUCTION TO DATABASE SYSTEMS WITH MYSQL [ 3 0 0 3 ]

Modeling and Designing Databases, Database Design Process, Entity-Relationship Model, Basic Concepts, Constraints, Design of ER database schema, Reduction of ER to schema, Relational model, Super, candidate, primary ,foreign key, Schema Diagram, Relational Database design, Functional dependencies, Normal forms, Creating a MySQL Database, Table, Modifying table, constraints, indexes, Basic SQL, Inserting Data, Selecting Data, Updating Data, Deleting Data, MySQL Functions, Numeric, String, Date /Time, Advanced Queries, Sorting, Multiple tables, Inner Join, Left Join, Right Join, Natural Join, Nested queries, Generating summaries, COUNT(), MIN(), MAX(), SUM(), AVG(), Group By, Statistical techniques, Calculating Descriptive statistics, Per-Group Descriptive Statistics, Generating frequency distribution, Calculating correlation coefficients, assigning ranks, Stored routines, stored procedure, stored function, Triggers, Events to schedule Database actions, Managing users and privileges, Importing and Exporting data, importing data with LOAD data and mysql import, importing csv files, exporting query results, tables, importing XML.

### References:
1. Paul Dubois, MySQL Cookbook, O'REILLY, First Edition, 2007.
2. Larry Ullman, Visual Quick Start guide MySQL, Pearson Education, 2nd Edition, 2007.
3. Seyed M. M, Saied Tahaghoghi and Hugh Williams, Learning MySQL, O'Reilly, 2006.
4. Russell J.T. Dyer, MySQL in a Nutshell, O'REILLY, 2nd Edition, 2008.

## MCA 4302: INTRODUCTION TO VR AND AR TECHNOLOGIES [3 0 0 3]

Introduction: Input Devices, Output Devices, Displays, Computing Architectures for VR, The Rendering Pipeline, PC Graphics Architecture, Workstation-Based Architectures, Distributed VR Architectures, Modeling, Geometric Modeling, Physical Modeling, Behavior Modeling, Model Management, VR Programming and other Toolkits. Introduction to Unity 3D Engine, 2D Game concepts and basic scripting, 3D Game concepts and environment creation, Advanced game concepts. Introduction to Unity AR: Foundation and Vuforia, working with Vuforia in Unity, ARCore in unity, Mini project on AR. Introduction to VR, Unity for Google cardboard, Basic VR app development for Cardboard, Develop for a specific VR platform.

### References:
1. Jonathan Linowers, Krystian Banbilinski, Augmented Reality for Developers,Packt Publishers, 2017.
2. Edward Lavieri, Getting started with Unity 5, Packt publishing, 2015.
3. Grigore C. Burdea, Philippe Coiffet, Virtual Reality Technology, Wiley-IEEE Press, 2003.
4. Sherman, W.R. & A. Craig, Understanding, Virtual Reality: Interface, Application and Design, Morgan Kaufmann, San Francisco, CA, 2003.
5. Philippe Fuchs, Guillaume Moreau, Pascal Guitton, Virtual Reality: Concepts and Technologies, CRC, Taylor and Francis, 2011.

## MCA 4303: INTRODUCTION TO LINUX AND SHELL SCRIPTING [3 0 0 3]

Introduction to UNIX/LINUX Operating System: OS concepts, Linux overview, key features of Linux, pros and cons of Linux. Processes: Processes and Files, I/O redirection and pipes, process creation, process attributes standard process file descriptors. File and Process commands. File systems: Files and directories, file naming and wildcards, file attributes, file permissions. Regular Expressions & filters: find, grep, cut, sort, grep patterns. AWK and SED. Shell and Shell Scripting: The need for shell, types of shells, interactive uses of shell, using shell for creating user commands, functions. Bash shell features: Statements, data structure, built-in commands, environment customization primitives. Linux Editors.

### References:
1. Richard Blum and Christine Bresnahan, Linux Command Line Shell Scripting BIBLE, 3rd Edition, Wiley, 2015.
2. Mark Sobel. A Practical Guide to Linux commands Editor and shell programming, Prentice Hall, 2nd Edition, 2010.
3. Stephen G. Kochan. Unix Shell Programming, 3rd Edition, SAMS Publications, 2003.
4. Bash Reference Manual Download able from GNU Project.
5. Brian W Kerningham and Rob Pike. The Unix Programming Environment, PHI Learning Pvt. Ltd., 2009.

## MCA 4304: INTRODUCTION TO DATA ANALYTICS [3 0 0 3]

Introduction - data science, need for analytics, steps in data analysis projects, Data- sources of data, data sets, data warehouses, data types, privacy and confidentiality, samples vs. population. Data summarization and visualization – tables and graphs. Data Preprocessing- cleaning, transformation, dimensionality reduction. Data Analysis and Visualization – descriptive, inferential statistics, uni-variate and multi-variate analysis. Grouping – Cluster Analysis- distance measures, partitioning, hierarchical, density based methods. Market Basket Analysis, Association Analysis, Market Basket Analysis. Classifiers-Bayesian, k-nearest neighbor, neural network, Support Vector Machine, Decision Trees. Prediction- Regression models, Evaluating Classification and Predictive performance, ensemble methods. Anomaly Detection. Forecasting models.

### References:
1. Glenn J. Myatt, Wayne P. Johnson, Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining, 2nd Edition, John Wiley & Sons Publication, 2014.
2. Glenn J. Myatt, Wayne P. Johnson, Making Sense of Data II: A Practical Guide to Data Visualization, Advanced Data Mining Methods, and Applications, John Wiley & Sons Publication, 2009.
3. Galit Shmueli, Nitin R. Patel, and Peter C. Bruce, Data Mining for Business Intelligence, John Wiley & Sons, 2014.
4. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann, 2011.
5. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Introduction to Data Mining, Pearson Addison Wesley, 2005.

**Minor Specialization: Computational Mathematics**

### MAT 4051: APPLIED STATISTICS AND
### TIME SERIES ANALYSIS [2 1 0 3]

Stochastic and deterministic dynamic mathematical models – forecasting and control, transfer function models, models for discrete control systems. Basic ideas in model building- linear and multiple linear regression. Basic concepts in stochastic processes and Markov chains, Mean square distance, mean square error prediction, prediction of covariance stationary process, ergodic theory and stationary process, applications of ergodic theory, spectral analysis of covariance stationary processes, Gaussian systems, stationary point processes, level crossing problems. ARIMA models, Autoregressive models, moving average models, duality, model properties, parameter estimates, forecasts.Volatility models: ARCH and GARCH modelling, testing strategy for heteroscedastic models, volatility forecasts, Black Scholes model.

**References:**

1. G.E.P. Box, G. M. Jenkins, G. C. Reinsel and G M Ljung, *Time Series Analysis-Forecasting and Control*, (5e), Wiley Series, 2016.
2. Anderson T W, *The Statistical Analysis of Time Series*, John Wiley, New York, 1994
3. Samuel Karlin, Howard M Taylor, *First Course in Stochastic process*, Academic Press, New York,
4. C. Chatfield, *The Analysis of Time Series – An Introduction*, Chapman and Hall / CRC, (4e), 2004
5. David Ruppert, *Statistics in Finance*, Springer Publications, 2004

### MAT 4052: COMPUTATIONAL LINEAR ALGEBRA [2 1 0 3]

Matrix Analysis: Basic Ideas from Linear algebra, vector norms, matrix norms, orthogonality and SVD, Projections and CS decomposition, the sensitivity of square linear systems. General Linear Systems: Triangular systems, The LU factorization, Round off analysis of Gausian elimination, Pivoting, Improving and estimating accuracy. Orthogonalization and least squares: Householder and Givens matrices, The QR factorization, The full rank LS problem, Other orthogonal factorizations, The rank deficient LS problem, Weighing and iterative improvement, square and underdetermined systems.The symmetric Eigen value problem: Eigen values properties and decompositions, Power iterations, the symmetric QR algorithm, Jacobi methods, Tridiagonal Methods, Computing the SVD, some generalized eigen value problems.

**References:**

1. Gene H. Golub and Charles F. Van Loan, *Matrix Computations*, (4e), Johns Hopkins University Press, 2013.
2. Gilbert Strang, *Linear Algebra and its applications*, (4e), Wellesley Cambridge press, 2009.
3. David S. Watkins, *Fundamentals of Matrix Computations*,(3e), Wiley, New York, 2010.
4. Roger a Horn, *Matrix Analysis*, (2e), Cambridge University Press, 2013.

### MAT 4053: COMPUTATIONAL PROBABILITY AND
### DESIGN OF EXPERIMENTS [2 1 0 3]

Sampling and sampling distributions, Most powerful tests, Uniformly most powerful tests, Likelihood ratio tests, The sequential probability ratio test, Randomized Designs, Inferences about the differences in Means, Paired Comparison Designs, Inferences about the variance of normal distributions, Monte Carlo estimation methods.The analysis of variance, RCBD, LSD and Related Designs, The Graeco - Latin square Design, Balanced Incomplete Block Designs, PBIBD    Introduction to Factorial Designs, The Two Factor factorial design, Blocking in a factorial design, $2^k$ Factorial Design, Blocking and Confounding in the $2^k$ Factorial Design, Partial Confounding. Two level fractional factorial designs, three level and mixed level factorial and fractional factorial designs, $3^k$ Factorial Design, Confounding in the $3^k$ Factorial Design, Fractional replication of the $3^k$ Factorial Design, Factorials with mixed levels.

**References:**

1. Robert V Hogg and Allen Craig, *Introduction to Mathematical Statistics*, (4e), Macmillan
2. M N Murthy, *Sampling Theory and Methods*, Statistical Publishing Society, 1967
3. C Radhakrishna Rao, *Linear Statitical Inference and its applications*, (2e), Wiley Series.
4. Douglas C Montgomery, *Design and Analysis of Experiments*, (8e), Wiley Series, 2012,
5. D D Joshi, Linear Estimation and Design of Experiments, New Age International Publishers, 2009

### MAT 4054: GRAPHS AND MATRICES [2 1 0 3]

Graphs and subgraphs, walks, paths and connectedness, distance as a metric, degrees, regular graphs, cubic graphs, bipartite graphs, self-complementary graphs, operations on graphs, extremal graphs, cut points, bridges and blocks, block graphs and cut point graphs.Trees and their characterizations, centres and centroids, block-cut point trees, spanning trees, independent cycles and cocycles, connectivity and line connectivity, graphical variations of Menger's theorem. Traversability: Eulerian graphs and Hamiltonian graphs. Line graphs and total graphs. Line graphs and traversability, coverings and independence, critical points and lines. Planarity: Plane and planar graphs, outer planar graphs, Kuratowski's theorem, vertex colouring.Incidence Matrix: Rank, minors, path matrix, 0-1 incidence matrix. Adjacency Matrix: Eigen values of some graphs, determinant, bounds, energy of a graph, antiadjacency matrix of a directed graph, non-singular trees. Laplacian Matrix: Basic properties, computing Laplacian eigen values, matrix tree theorems, bounds for Laplacian spectral radius, edge-Laplacian of a tree.

**References:**

1. F. Harary, *Graph Theory*, Narosa Publishers, 1988.
2. J.A Bondy and U.S.R Murthy, *Graph Theory with Applications*, (5e), Elsevier Publishing Co., 1982.
3. D.B. West, *Introduction to Graph Theory*, Pearson Education, Inc., 2001.
4. R.B Bapat, *Graphs and Matrices*, Hindustan Book Agency, 2010.
5. Lowell W Beineke and Robin J Wilson, *Topics in Algebraic Graph Theory*, Cambridge University Press, 2005.

## OPEN ELECTIVES
### MAT 5301: APPLIED GRAPH THEORY [2 1 0 3]

Graphs and applications of the theorems by Havel and Hakimi,  Erdos and Gallai.  Cut points, bridges and blocks, block graphs and cut point graphs. Trees and their characterizations, centre and centroids, block-cut points  trees, spanning trees, independent cycles and cocycles, connectivity and  line connectivity, Whitney's theorem. Traversability-Eulerian, Hamiltonian, line graphs and total graphs. Traversability, coverings and independence, theorem of Gallai, critical points and lines. Planarity, genus, thickness, crossing number. Colorability, chromatic number and its bounds, Nordhaus Gaddum theorems, the four and five colour theorems, chromatic polynomial. Matrix Representation -Incident matrix, Adjacency matrix, cycle matrix, cutset matrix, path matrix, Digraphs, Matrix - tree theorem on number of spanning trees. Tournament. Graph theoretic Algorithms: Computer representation of graphs-Input and output, Algorithms for connectedness, Spanning Tree, Fundamental Circuits, Directed Circuits and Shortest paths.

**References:**

1. F. Harary, *Graph theory*, Narosa Publishers
2. Narsingh Deo, *Graph theory with applications to Engineering and Computer Science*, Prentice Hall.
3. Robin J.Wilson, *Introduction to Graph theory*, Logman

### MAT 5302: APPLIED LINEAR ALGEBRA [2 1 0 3]

Finite dimensional vector spaces, subspaces, linear independence, basis and dimension. Sum and intersection of subspaces. Algebra of linear transformations, range and null space of a linear transformation, Inner-product spaces, metric spaces and banach spaces, Gram Schmidt orthogonalization, linear operators and their adjoint, self adjoint, unitary and normal transformations, polar decomposition. Matrix algebra, simultaneous equations, Eigen values, characteristic vectors, Cayley-Hamilton theorem, minimal polynomial, Application of eigen values to solve simultaneous difference and differential equations. Quadratic forms and their classification, constrained optimization. Somecomputational methods of linear algebra.

**References:**

1. Gantmocher F.R., *The Theory of Matrices*, Cheisea.
2. Gilbert Strang , *Linear Algebra and its applications*,Thomson learning
3. David C. Lay, *Linear Algebra and its applications*, Pearson Education

### MAT 5303:APPLIED NUMERICAL METHODS [2 1 0 3]

Matrix Algebra : Solution for linear system of equations – Direct methods: Gauss elimination method, Gauss Jordon method, Crouts (LU decomposition) method. Iterative methods, Jacobi Gauss Seidal and successive over relaxation methods. Computation of inverse of a matrix: Jordan method, Triangularization method, Choleski's method, partition method. Eigen value & Eigen vectors: Given's method for real symmetric matrices, Jocobi's method for real symmetric matrices, Power method. Numerical Solution of Ordinary Differential Equations: Single step methods, Runge- Kutta method, Adam Bashforth's predictor corrector method, Milne's predictor and corrector method. Numerical Solution of Partial Differential Equations: Finite difference approximation to derivatives of Parabolic, Elliptic. Explicit finite difference method, implicit method.

**References:**

1. Jain, Iyengar and Jain: *Numerical methods for Scientific and Engineering Computations*, New Age Publishers
2. Carnahan, Luther and Wikes: *Applied Numerical Methods*, John Willey
3. Conte S.D and Be Door, *Introduction to Numerical analysis*, McGraw Hill.

### MAT 5304:MATHEMATICAL MODELLING [2 1 0 3]

Introduction, Techniques, classification and characteristics of mathematical models, mathematical modeling through algebra, ordinary differential equations of first order. Mathematical modeling through systems of ordinary differential equations of first order, Prey- Predator model Mathematical modeling through systems of ordinary differential equations, modeling in medicine A model for diabetic mellitus. Modelling on population dynamics Mathematical modelling through difference equations. Some simple models. Modelling of economics and finance through difference equations, population dynamics and generation of models through difference equations, modeling in probability theory, examples. Optimization models: Mathematical modeling through linear programming. Mathematical modelling through graphs: elements of graphs, digraphs. Mathematical models for blood flow. Mathematical model for Peristaltic transport of two layered.

**References:**

1. J N Kapur, *Mathematical Modelling*, New age international publishers,(2e), 2015.
2. J N Kapur *Mathematical Models in biology and medicine*, East- West press.
3. J N Kapur *Mathematical models of environment*, INS Academy, New Delhi

### MAT 5305:OPTIMIZATION TECHNIQUES [2 1 0 3]

Formulation, Linear programming-simplex method, Penalty coase methods, 2-phase method. Dual Simplex method. Duality theory .Transportation problem-Volgel's approximation method, MODI method, Assignment problem-Hungarian method.Project Management - Networks, Project planning and control using PERT and CPM. Project crashing. Game theory - 2persons zero sum games, Minimax principle, games with mixed strategies. Dominance theory, solution using Linear programming.

**References:**

1. Bronson Richard - *Theory and Problems of Operations Research*- Schaum series- MGH
2. P.K.Gupta& Man Mohan - *Operations Research* - Sultan Chand & Sons
3. HamdyA.Taha - *Operations Research* PHI

### MAT 5306: STOCHASTIC PROCESSES AND RELIABILITY [2 1 0 3]

Static probabilities: Review and prerequisites generating functions, difference equations.Dynamic probability: definition and description with examples. Markov chains, transition probabilities, Chapmen Kolmogrov equations. Classification of states, chains of Markov process. Stability of Markov systems, limiting behaviour, random walk. Poisson Processes : assumptions and derivations, related distributions, birth and death processes. Queueing System, general concepts, Model M/M/1 and M/M/S, steady state behaviour, transient behaviour. Wiener processes and Gaussian processes. Differential equations of a wiener process, Kolmogrov equations, Ornstein – Unlenbeck Process. White note. Reliability Theory : Definition of Reliability, types of failure, Hazard rate, Laws of failure - normal, exponential & Weibull failure laws - System reliability - in series, in parallel series - parallel system, Paralled - series system & related problems.

**References:**

1. Medhi. J., *Stochastic Processes*, Wiley Eastern.
2. Bhat U R, *Elements of Applied Stochastic Processes*, John Wiley.
3. A Papoulis, *Probability, Random Variables and Stochastic Procesess*, McGraw Hill.

## Minor Specialization: Business Management

### HUM 4051: FINANCIAL MANAGEMENT [2 1 0 3]

Introduction and objectives of financial management, Evolution of corporate finance, responsibilities. Types of accounts, Golden rules of accounting, Preparation of Journal, Ledger, Trial balance and final accounts. Sources of long term finance, Characteristics of equity capital, Preference capital, Debenture capital & Term loans. Valuation of securities, Concepts, Bond valuation and related models, Bond value theorems, Yield to maturity. Equity valuation; Dividend capitalization approach, Leverage, Operating leverage, Financial leverage, Total leverage, Indifference point analysis. Working capital management, Capital budgeting: appraisal criteria, pay-back period, Average rate of return, Net present value, Benefit cost ratio and Internal rate of return. Risk analysis in capital budgeting, Cost of capital: introduction, cost of debt capital, Preference capital and Equity capital, Weighted average cost of capital, Determination of proportions, Cash management, Dividend decisions.

**References:**

1. Prasanna Chandra., Fundamentals of Financial Management, Tata McGraw Hill Education Pvt Ltd., New Delhi, 2006.
2. I M Pandey, Financial Management, Vikas Publishing House Pvt Ltd.,, New Delhi, 2015.
3. N Ramachandran & Ram Kumar Kakani, Financial Accounting for Management, 3/e, Tata McGraw Hill Education Pvt Ltd., New Delhi, 2011.
4. Eugene F Brigham & Michael C E, Financial Management: Theory and Practice. 12e, Cengage Learning, India, 2008.
5. Maheshwari S.N., Financial Management, Sultan Chand & Co., New Delhi, 2002.

### HUM 4052: HUMAN RESOURCE MANAGEMENT [2 1 0 3]

Introduction, Scope of HRM, Objectives of HRM, Functions, Activities, Roles, HRD organization and responsibilities. Evolution of HRM, Influence of various factors on HRM. Human resource planning: Introduction, Strategic considerations, Nature and scope, Human Resources Inventory, Job analysis, Job design, Job description, Job specification and Job evaluation. Employee Recruitment & Selection: Policy, Process, Tests, modern methods, Interview, Provisional selection, Medical/Physical examinations, Placement, Induction programs and socialization. Training and development: Basic concepts, Employees training Process, Planning, Preparation of trainees, Implementation, Performance evaluation and Follow-up training. Competency Mapping and Career development programmes. Performance appraisal and Merit rating, Promotion, transfers and separations, Wages and salaries administration, Discipline and grievances. Industrial and labour relations and Trade Unionism Overview: Collective bargaining and maintaining Industrial health.

**References:**

1. Michael Armstrong ., A Handbook of Human Resource Management Practice: 10th Edition, New Delhi, Kogan Page India,2006
2. Gary Dessler& BijuVarkey .,Human Resource Management:12th Edition Dorling Kindersley(India),Noida,2011
3. T.V. Rao and Pereira D F., Recent experiences in Human Resources Development, Oxford and IBH Publishing, 1986.
4. Subbrao A., Essentials of Human Resource Management and industrial Relations, Himalaya Publishing House, 1999.
5. Aswathappa K,Human ResourceManagement,Text&Cases McGrawHill 7th Edition,2006
6. N G Nair and Latha Nair., Personnel Management and Industrial Relations, S. Chand Company, 1995.

### HUM 4053: MARKETING MANAGEMENT [2 1 0 3]

Marketing definition, scope and concepts, Adapting marketing to the New Economy, Marketing strategic planning. Market Demand, Marketing Environment, Marketing Information System, Marketing Research. Segmentation, Targeting and Positioning, Buying Behaviour: Consumer Markets and Business Markets, Competition: Identifying competitors, analysing competitors. Product Life Cycle: Product life-cycle marketing strategies. New Market Offerings: New product development and challenges, Branding. Designing and Managing Services, Price Strategies, Retailing, Wholesaling, Integrated Marketing Communications, Digital Marketing and Trends, International Marketing

**References:**

1. Philip Kotler, Kevil Keller, Abraham Koshy & Mithileshwar Jha, Marketing Management – A South Asian Perspective, Pearson Education Inc, New Delhi, 2012.
2. Arun Kumar & N Meenakshi, Marketing Management, Vikas Publishing House Pvt Ltd, New Delhi, 2011.
3. Varshney R L and Gupta S L., Marketing Management, Sultan Chand & Sons, New Delhi, 2004.
4. Adrian Palmer., Principles of Marketing, Oxford University Press, New York, 2000.

### HUM 4054: OPERATIONS MANAGEMENT [2 1 0 3]

Introductions to operations management – process view and supply chain view, types of production activities, competitive priorities and capabilities. Break-even analysis, evaluating services or products, evaluating processes - make or buy decision, decision making under risk, and decision trees. Introduction to forecasting, importance and uses of forecasting, demand patterns, demand management options, judgement methods, causal methods - linear regression, time series method – naïve method, moving average, weightage moving average, and exponential smoothing curve. Planning long-term capacity, measures of capacity and utilization, economies of scale, diseconomies of scale, capacity timing and sizing strategies, sizing capacity cushions, timing and sizing expansion – expansionist strategy, wait and see strategy, and a systematic approach to long term capacity decision. Levels inoperations planning and scheduling across the organization, sales and operation planning strategies- chase strategy, level strategy, operations planning using linear programming technique, scheduling job and facility scheduling, and work for scheduling. Theory of constraints, managing bottle necks in manufacturing and service processes, identifying bottle necks, relieving bottle necks, drum buffer rope system, and managing constraints in a line system. Supply chain design across the organization, supply chains for services and manufacturing, measures of supply chain performance - inventory measures, financial measures, inventory and supply chains - pressures for small inventories, pressures for large inventories, types of inventory, inventory reduction tactics, and inventory placement. Costs of quality, total quality management, acceptance sampling, statistical process control - control charts, and process capability. Continuous improvement using lean systems, different types of wastes, strategic characteristics of a lean system, designing lean system layout, and Kanban system.

**References:**

1. Krajewski L. J., Ritzman L. P., Malhotra M., and Srivastava S. K., *Operations Management*, 11th edition, Pearson Education (Singapore) Pvt. Ltd., Delhi, 2016.
2. Heizer J. and Render B., *Operations Management*, 11th edition. Pearson Education India, 2016.
3. Khanna R. B., *Production and Operations Management*, 2nd edition, PHI Learning Private Limited, 2015.

## OPEN ELECTIVES

### HUM 4301: COMMUNICATIVE ENGLISH [3 0 0 3]
(Offered for Lateral Entry Students only)

Common Errors in English: Subject Verb Agreement; Uses of Tenses / Sequence of Tense; Prepositions; Articles; Special Usages; Creative Writing Essay: Types of Essays, Argumentative Essay, Descriptive/ Expository/Narrative Essays; Reading Comprehension; Dynamic text; Critical Evaluation; Group Discussions; Presentation Skills; Essay writing.; Audio texts/speeches -Practice listening skills- summary, commentary, listening exercises. Video Speeches -Theme based speeches - motivational, informative, technical, and persuasive, discussions. Speech - Elements of a good speech, types of speeches, model speech, Speech exercises, individual presentations, peer and facilitator feedback. Formal/Informal communication. Communication Styles- formal and informal, standard English and variations in usages, examples and analysis of faulty usages; Correspondence: formal/informal letters and emails .

**References:**

1. Green David., *Contemporary English Grammar, Structures and Composition* Chennai: Macmillan Publications.

2. Thompson AJ & Martinet AB., *A Practical English Grammar*, OUP.

3. Turton N D , Heaton J B., *Longman Dictionary of Common Errors*, 1998.

4. Meenakshi Raman & Sangita Sharma., *Technical Communication; Principles and Practice*, Oxford University Press, 2011.

### HUM 4302: FILM STUDIES [2 1 0 3]

History of invention of motion pictures - Daguerre, Muybridge, Edison, SkaldanowskyBrothers,Lumieres; Evolution of film – Lumieres, Melies, Porter, Griffith, Basic techniques – Mise-en-scene, Mise-en-shot, Deepfocus Photography, Longtake, Continuity, Editing, Montage, German Expressionism; French Impressionism; Soviet Montage cinema; Hollywood cinema, Italian Neo-realism; French Nouvelle Vague, Documentary, Directors – Eisenstein, Kurosawa, Godard, Chaplin, Bergman; Mohsen Makmalbakf, Majid Majidi, Keislowski, Zhang Yimou, Kim Ki Duk, "New Wave" Cinema in India - Bengali; Malayalam; Kannada; Hindi, To be screened- Bicycle Thieves, The 400 blows, Rashomon, Wild strawberries, Battleship Potemkin, Cabinet of Dr.Caligari, The kid, Children of heaven, Hero, Ghatashraddha, PatherPanchali, Mathilukal.

**References:**

1. Bordwell, David and Thompson, Kristin., *Film Art: an Introduction, 7th ed*. New York: McGraw-Hill Co., 2004.

2. Kawin, Bruce., *How Movies Work*. Berkeley and Los Angeles: University of California Press, 1992.

3. Cook, David A., *A History of Narrative Film*, 4th ed. New York: W.W. Norton & Co., 2004.

### HUM 4303:GERMAN FOR BEGINNERS [3 0 0 3]

Text selections, dialogue and exercises which have been designed to give the absolute beginner grounding in the rudiments of the German language, as well as providing background information about the history, life and culture in Germany.Introduction to the German alphabet and the German language – dialogues & conversations – pronunciation, basic vocabulary lists - key points of grammar  - background information about the history and culture of Germany - exercises on vocabulary, grammar and German culture - reading & listening comprehension.

**References:**

1. Sally Johnson, Natalie Braber., *Exploring the German Language*, (2E), Cambridge University Press. 2008.

2. Charles Russ., *The German Language Today: A Linguistic Introduction*, Routledge. 1994.

### HUM 4304: BUILDING BRIDGES: INDO-EUROPEAN INTERCULTURAL DYNAMICS [3 0 0 3]

The challenges of Intercultural communication - interacting in a diverse world, understanding cultures, alternative views of reality, cultural stereotyping. Foundational Theories in Intercultural Communication - Edward Hall, Samovar, G Hofstede, Understanding cultural Dimensions and  Cultural Stereotyping- collectivism/ individualism, power distance, masculine/feminine, cultural metaphors, Intercultural Business Communication Competence - The Role of Language in Intercultural Business Communication , Nonverbal Language in Intercultural Communication, Cultural influence on interpersonal communication, Intercultural Dynamics in the multicultural organizations.

**References:**

1. Dodd, Carley H. *Dynamics of Intercultural Communication*, McGraw-Hill, Boston. 1998.

2. Gannon M J and Pillai R. *Understanding Global Cultures*, Sage Publications, California. 2010.

3. Hall, E. T. *The dance of life: The other dimension of time*, Random House, New York. 1983.

4. Hofstede, Geert., *Cultures' Consequences, Comparing Values, Behaviors, Institutions, and Organizations across Nations*, Sage Publications, Thousand Oaks, CA. 2001.

5. Martin, J.N. & Nakayama, T.K., *Intercultural communication in contexts*. 4th Edition. Mountain View, CA: Mayfield. 2007.

6. Samovar, L A and Porter, R., *Communication between Cultures*, Cengage Learning, Wadsworth, CA. 2007.

### HUM 4305: INTERPRETATION OF LITERARY TEXTS [3 0 0 3]

Texts-static, dynamic, cryptic and delphic ; Language of literature; Form and structure; Literature verses popular fiction; Text and discourse; Authors and critics; Theories and approaches to literary texts; Formalism, Structuralism, Marxism, Feminism, Deconstruction; Ideational functions and textual Functions; Class, gender and texuality; Race and nationality; Genre, phonological deviations –sound patterns and figures of speech ; Pragmatic approach to literature; Understanding syntax, Lexical and syntactic analysis of literary texts; Point of  view in literary texts and foregrounding; Prediction and making sense of a text; Stylistic analysis of a novel; Kinds of meaning, Rhetorical structure; Pragmatics and   discourse analysis; Interpreting cohesive devices and complex functional values; Stylistic approach to literature ; Elements of literary style; Stylistic analysis of selected short stories, Poems, Novels and Plays; Genre, the plot setting,  characterization, tone and themes; Stylistics and its implications on narrative techniques; Intertextuality and conceptual blending; Identifying patterns in the texts; Meaning making process in literature; Imagery, metaphor as a mode of thought; Coherence and Cohesion; Context, turn taking and Adjacency Pair; Pro-forms, Discourse markers, Lexical cohesion and presupposition; Recognizing text organization; Critical texts, Shared assumptions on critical texts; The role of schema and the concept of speech acts in literary texts.

**References:**

1. Austin, J.L., *How to do Things with Words*, Longman, London, 1992.

2. Barthes. R., *Introduction to the Structural Analysis of Narratives*, Fontana, London, 1977.

3. Blake.N.F, *An Introduction to the Language of Literature*, Macmillan, London. .1990.

4. Carter, R. (ed.)., *Language and Literature: An introductory Reader in Stylistics*, Allen and Unwin, London, 1982.

5. Cook, G., *Discourse and Literature*, Oxford University Press, London, 1994.

6. Harold, C.M.(ed.)., *Style in Prose Fiction*, Columbia University Press, New York.

7. Leech, G.N., *A Linguistic Guide to English Poetry*, Longman, London, 1969.

## HUM 4306: PUBLIC SPEAKING [3 0 0 3]

Public Speaking -Introduction to Public speaking- Voice modulation, Sounds/accent (basics), Articulation, Anxiety management, Logical arguments, Concept of purpose, Audience, Smart use of Body language. Types of speech-Informative speeches - designing and delivery-Persuasive speeches – designing and delivery- Impromptu speeches – designing and delivery -Special occasion speeches- designing and delivery, Presentations - planning and execution -Types of presentation - Informative-Planning and delivery - Persuasive - Planning and delivery - Motivational - Planning and delivery, Other forms of speaking – Debates, Seminars, Panel Discussion, Group Discussion, Tall Tales, Turn Coat, Art of Evaluation-Providing feedback- planning, designing and delivering constructive feedback - Receiving feedback – making use of relevant feedback -Techniques of providing feedback- Speech analysis –Role of the Evaluator.

**References:**

1. Duarte Nancy., *Resonate: Present Visual Stories that Transform Audiences*, John John Wiley and Sons, 2010.
2. Minto Barbara., *The Pyramid Principle: Logic in writing, thinking and Problem Solving*, Financial Times Prentice Hall, 2002.
3. Berkun Scott., *Confessions of a Public Speaker*, O'Reily Media, 2009.
4. Goodale Malcolm., *Professional Presentations*, Cambridge University Press, 2005.
5. Carnegie Dale., *The Art of Public Speaking*, 1905.

## HUM 4307: INTRODUCTION TO PSYCHOLOGY [3 0 0 3]

Psychology - Meaning, Nature and Scope, Defining Psychology, Meaning of the term Behavior, Nature of Psychology, Scope of Psychology: Branches and fields of Psychology. Development of Psychology - Historic Sketch of Psychology, Modern Age of Psychology, Gestalt Psychology, Psycho Analysis, Contemporary Psychology. Systems of Psychology- The Nervous System, Nature V/s Nurture, Sensation and perception, States of Consciousness. Methods of Psychology - Classical Conditioning, Introspection Method, Naturalistic Method, Experimental Method, Differential Method, Clinical Method, Psycho Physical Method. Personality- Personality types, Personality Disorders, Abnormal psychology, Treatment of personality disorders. Thinking - Nature of Thinking, Types of Thinking, Language and Intelligence. Discussion, Presentation and Assignments.

**References:**

1. Boring, E.G., Langfield,H.S. &Weld,H.P., *Foundations of Psychology, Asia* Publishing House, Calcutta, 1963.
2. Carson, R.C., Butcher, J.N. & Coleman, J.C., *Abnormal Psychology & Modern Life*, (8th ed) Scoff, Foresman&Co. 1988.
3. Lahey, B.B.,Psychology: *An Introduction*, 6th Ed., Tata McGraw Hill, New York, 1965.
4. Olson, M.; Hergenhahn, B.R., *Introduction to the Theories of Learning*, Prentice-Hall India, 2009.

## HUM 4308: INTRODUCTION TO PHILOSOPHY, RELIGION AND CULTURE [3 0 0 3]

Notions of Philosophy; The Origin and Development of Philosophy; Ancient Philosophy; Medieval Philosophy; Modern Philosophy; Contemporary Philosophy; Indian Philosophy; Comparative Religion; Western Philosophy; The Relevance of Philosophy; Branches of Philosophy; Methods of Philosophy; Philosophy and other Branches of Study; Some Problems of Philosophy; Themes of Philosophy; Mind and Body, and the Problem of Universal; Change/Movement time and place; Existence of God and Evolution; Indian Culture; Social Ethics; Logic and Scientific Methods; Philosophy of Language.

**References:**

1. Aquinas, Thomas., *On Being and Essence. Trans. Armand Maurer*. Canada: Pontifical Institute of Mediaeval Studies, 1968.
2. John-Terry, Chris., *For the Love of Wisdom: An Explanation of the meaning and Purpose of Philosophy*. New York: Alba House, 1994.
3. Maritain, Jacques., *An Introduction to Philosophy*, London: Sheed and Ward. 1979.
4. Radhakrishnan, S. (Ed)., *History of Philosophy Eastern and Western Vol.II* George Allen and Unwin Ltd., London, 1953.
5. Wallace, William., *The Elements of Philosophy*. New York: Alba House, 1990.

## HUM 4309: CREATIVE WRITING [3 0 0 3]

Various literary/prose forms and their characteristics; techniques and strategies for reading; nuances of language and meaning in reading and writing; Writing Exercises - techniques and strategies of writing creatively; Critical Concepts and Terms in Literary Writing; Writing Exercises; creative writing output.

**References:**

1. Milan Kundera ., *The Art of the Novel*.
2. The Art of Fiction: Illustrated from Classic and Modern Texts, David Lodge

## HUM 4310: GRAPHIC NOVELS: HISTORY, FORM AND CULTURE [3 0 0 3]

Part I:The History of Comic Books, Part 1: Developing a Medium Defining comic books as a medium-Relationships between comic books and other forms of sequential art-The (continental) roots of comics as an art form -The ways in which comic strips and pulps contributed to the emergence of the comic book. The History of Comic Books, Part 2: The Maturation of the Medium-Influence of underground movement, ways in which mainstream publishers began to address more relevant topics, proliferation of independent comics, the increase in the profile and prominence of the medium due to ambitious projects. Part II: Creating the Story: Graphic Storytelling and Visual Narrative-Some narrative structures commonly found in comic books -The types and techniques of encapsulation-The nature of the relationship between the pictorial and linguistic elements of comic books Experiencing the Story: The Power of Comics -    About diegetic images that show the world of the story-About interpretive images that comment on the story-The impact art style has on the emotional reactions of the reader; and  how the    meaning of each image is affected by the relationship to other images in that particular book, in other texts, and in the reader's personal experience-Part III: Comic Book Genres-the definition of genre and the role it plays in shaping the creation of comics products- the characteristics of genres, including character types, narrative patterns, themes, and other conventions-how the example genres of teen humor, romance, funny animals, horror, and memoir developed in comics, and what characterizes each-how the hybridization of genres helps experimentation and expansion of narrative possibilities.

**References:**

1. Roger Sabin., *Comics, Comix and Graphic Novels*.
2. Robert Petersen, Allan Moore., *Comics, Manga and Graphic Novels: A History of Graphic Narrative3. Comics as Performance*, Fiction as Scalpel.
3. JeetHeer, Kent Worcester., *Arguing Comics: Studies in Popular culture*.

**HUM 4311: MANAGEMENT INFORMATION SYSTEMS [3 0 0 3]**

Management information system: Introduction to management, information and system. System concepts, general model of a system and types of systems. Evolution of MIS, models and resources used in the MIS model. Structure of MIS, operating elements of an information system, synthesis of the structure. Information systems for different applications: Transaction processing systems, Human resource management systems and Marketing-application areas. Production planning and Office automation systems. Role of management information in decision making: Concepts of decision making, Decision making process and information needs at different levels of management. Herbert. A. Simon model. Phases in the decision making process, Programmed vs non-programmed decisions, General model of human as an information processor, Allen Newell Simon model. Decision support systems -structure, elements and working. Information as a strategic resource. MIS as a technique for making programmed decisions: Behavioral models of the decision maker and methods. MIS support for decision making. Role of MIS in Organizations -recent trends and e-commerce applications. Development of customized management information system approaches: SDLC -phases in SDLC, Strategic and project planning for MIS, conceptual design and detailed design phases: general business planning and MIS response. MIS Planning and planning cycle. Conceptual system design and Detailed System design. MIS System Implementation, and Pit falls: Pit Falls in MIS development, Fundamental weaknesses, soft spots in planning, design problems and review.

**References:**

1. Gordon B. D. and Margrethe H. O., (2005), "Management Information Systems", McGraw-Hill, New York.
2. Kenneth L. and Price J. P., (2003), "Management Information Systems", Macmillan.
3. Jawadekar W. S., (2000) "Management Information System", Tata McGraw Hill.
4. Senn J. A., (2003), "Analysis & Design of Information System", McGraw Hill International Student Edition.
5. Mudrick; Ross (1997) "Information Systems for Modern Management " Prentice Hall of India.
6. James A. O.Brien (1995)"Management Information Systems, Galgotia Publications.

**HUM 4312: ENTREPRENEURSHIP [3 0 0 3]**

Entrepreneur: Meaning of entrepreneur, evolution of the concept, functions of an entrepreneur, types of entrepreneur, and intrapreneur. Concept of entrepreneurship - evolution of entrepreneurship, development of entrepreneurship, stages in entrepreneurial process, role of entrepreneurs in economic development, entrepreneurship in India, barriers for entrepreneurship. Small scale industry: Definition, characteristics, need and rationale. Objectives, scope, role of Small Scale Industries (SSI) in economic development, advantages of SSI, steps to start an SSI - government policy towards SSI, different policies of SSI, impact of liberalization, privatization, and Globalization. Effect of WTO/GATT and supporting agencies of government for SSI. Institutional support: Different Schemes: TECKSOK, KIADB; KSSIDC; KSIMC; DIC Single Window Agency: SISI, NSIC, SIDBI, and KSFC, New schemes and support for start-ups and new venture under Govt. of India. Preparation of Business plan and project report: components of a successful plan. Meaning of project, project identification, project selection, project report, need and significance of report, contents, formulation, guidelines by planning commission for project report. Network analysis, errors in project report, project appraisal. Identification of business opportunities, market feasibility study, technical feasibility study, financial feasibility study and social feasibility study and documentation and evaluation.

**References:**

1. Vasant Desai., Dynamics of Entrepreneurial Development & Management, Himalaya Publishing House, 2007.
2. David H. Holt Entrepreneurship: New Venture Creation, Published by prentice Hall,1991.
3. Poornima. M. Charantimath., Entrepreneurship Development, Pearson Education, 2006.
4. S.S. Khanka., Entrepreneurship Development, S.Chand& Co, 2007.

**PHY 4051: PHYSICS OF LOW DIMENSIONAL MATERIALS [3 0 0 3]**

**Thin films:** Thick and Thin Film Materials, preparation by physical and chemical methods. Thickness measurement techniques. Theories of nucleation - Capillarity and atomistic theory, effect of deposition parameters on nucleation and growth of thin films. Epitaxial growth. Reflection and Transmission at interface between isotropic transparent media. Reflectance and Transmittance in thin films. Antireflection coatings. Electrical conduction in discontinuous metal films - Quantum mechanical tunneling model. Conduction in continuous metal and semiconducting films. Thermoelectric power in metal films. thin film resistors, thermopiles. Quantum well devices.

**Nanomaterials:** Chemical Synthesis of Nanoparticles: Bottom up approach. Functionalized nanoparticles in different medium. Size control. Self assembly. Nanoparticle arrays. Semiconductor nanoparticles- synthesis, characterization and applications of quantum dots. Magnetic nanoparticles- assembly and nanoastructures. Manipulation of nanoscale biological assemblies. Carbon nanotubes and fullerene as nanoclustures. Nanostructured films. Physical Methods of Nanostructure Fabrication: Top down approach. Nanopatterning-Lithography- Optical, X-ray and Electron beam lithography. Ion- beam lithography.

**References:**
1. Chopra K. L., *Thin Film Phenomena*, Mc Graw Hill, 1969
2. Milton Ohring, *Materials Science of Thin Films*, Elsevier, 2001
3. Heavens  O. S., *Optical Properties of Thin Solid Films*, Dover, 1955
4. Liz-Marzan L. M. and Kamat P. V. (Eds), *Nanoscale Materials*, Kluwer, 2003
5. Nalwa H. S. (Ed), *Nanostructured Materials and Nanotechnology*, Academic, 2002

**PHY 4052: PHYSICS OF PHOTONIC AND ENERGY STORAGE DEVICES [3 0 0 3]**

**Semiconductors:** Direct and indirect band gaps. Carrier concentrations at thermal equilibrium. Fermi level. Degenerate and non-degenerate semiconductors. Semiconductor Crystal growth techniques Contact phenomenon- semiconductor-semiconductor, metal-semiconductor contacts. Schottky and Ohmic contacts. Preparation of semiconductor devices. IC technology, elements of lithography.

**Photonic Devices:** LED and semiconductor lasers: Radiative and non-radiative transitions, diode laser, population inversion, laser operating characteristics, efficiency, photoconductor, photodiode, avalanche photodiode, phototransistor, material requirement for solar cells, theory and types of solar cells.

**Fuel cells:** Hydrogen energy – merits as a fuel – production of hydrogen, Hydrogen Fuel cells – introduction – difference between batteries and fuel cells, components of fuel cells, principle of working of fuel cell, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages and disadvantages of fuel cell power plant. Types of fuel cells. Application of fuel cells – commercially available fuel cells.

**References:**
1. Neamen Donald A., *Semiconductor Physics and Devices, basic principles*, Tata McGraw-Hill, 2002
2. Sze S. M., *Physics of Semiconductor Devices*, John Wiley & Sons, 2007
3. Larminie J. and Dicks A., *Fuel Cell Systems Explained*, Wiley, 2003
4. Xianguo Li, *Principles of Fuel Cells*, Taylor and Francis, 2005
5. S. Srinivasan, *Fuel Cells*: From Fundamentals to Applications, Springer, 2006

**PHY 4301: FUNDAMENTALS OF ASTRONOMY AND ASTROPHYSICS [3 0 0 3]**

Introduction to astronomy and astrophysics. Properties of ordinary stars: Brightness of starlight; the electromagnetic spectrum; Colours of stars; stellar distances; absolute magnitudes; HR diagram. Stellar evolution: Formation of star; the main sequence; stellar structure; evolution off the main sequence; planetary nebulae; white dwarfs. The death of high mass stars: Supernovae; neutron stars; pulsars; stellar black holes. Normal Galaxies: Types of galaxies; Dark matter in galaxies. Cosmology: The scale of universe; expansion of the universe; open or closed universe; the big bang; the cosmic background radiation; big bang nucleosynthesis. Astronomical instruments.

**References:**
1. Marc L Kutner, *Astronomy: A physical Perspective (2e)* Cambridge University Press,2003
2. BaidyanathBasu, *An Introduction to Astrophysics (2e)*, PHI Learning Pvt. Ltd, 2011.
3. Michael Zeilik, *Introductory Astronomy and Astrophysics (4e)*, Saunders College Pub. 1992.

**PHY 4302: PHYSICS OF ENGINEERING MATERIALS [3 0 0 3]**

Types of magnetism, ferromagnetic domains, soft and hard magnetic materials, ferrites, magnetic storage, Superconducting materials, Applications of superconductors, Nano-materials, bottom-up and top-down methods, Quantum dots and nano-carbon tubes, Composite materials, micromechanics of composites - Density, Mechanical and Thermal properties, Semiconductors, Metals, semiconductors and insulators, Direct and indirect band-gap semiconductors, Intrinsic and extrinsic semiconductors, Diffusion and drift processes, Crystal growth techniques, Preparation of semiconductor devices.

**References:**
1. William F. Smith, *Principles of Materials Science and Engineering (2e)*, McGraw-Hill International Edition, 1990.
2. Nalwa H.S., *Nanostructured Materials and Nanotechnology (2e)*, Academic, 2002.
3. Chawla K. K. *Composite Materials- Science & Engineering (3e)*, Springer-Verlag, 2012.
4. Streetman Ben G. and Banerjee Sanjay Kumar, *Solid State Electronic Devices (6e)* PHI learning Private Limited, 2012.

**PHY 4303: RADIATION PHYSICS [3 0 0 3]**

Radiation Sources: Fast electron sources-Heavy charged particle sources-Sources of electromagnetic radiation-Neutron sources. Radiation Interaction: Photoelectric and Compton process -pair production. Interaction of heavy charged particles-stopping power-Energy loss characteristics- Bragg curve-Particle range-range straggling- stopping time-energy loss in thin absorbers-Interaction of fast electrons-absorption of beta particles-interaction of gamma rays-gamma ray attenuation-Interaction of neutrons-neutron cross section-neutron induced nuclear reactions. Radiation Detectors and Instrumentation: Semiconductors diodes-JFET-MOSFET-Integrated Circuits-OPAMP and their characteristics-Differential Amplifier-Operational amplifier systems-Pulse Amplifiers. Principles of radiation detection and measurements-Gas filled detectors-Ionisation chambers-Proportional counters-GM counters-Scintillation detectors-Semiconductor detectors-Thermo luminescent Dosimeters-Radiation spectroscopy with scintillators-Gamma spectroscopy-Multichannel pulse analyzer-Slow neutron detection methods-Reactor instrumentation. Industrial uses of nuclear measurements: Radiation detection in industrial environments-Measuring systems for industrial problems-Determination of physical material characteristics by nuclear measurements-Level height determination-Density measurements-Quantity measurements-Thickness measurement-coating thickness measurement.

**References:**
1. Knoll G. F., *Radiation Detection and Measurement (3e)*, Wiley 2010
2. Boylestad R. L., *Electronic Devices and Circuit theory (11e)*, Pearson Education 2016
3. Malvino A. P., *Electronic Principles (7e)*, TMH 2010
4. Foldiak G., *Industrial Applications of Radioisotopes*, Elsevier Science Ltd 1986

## PHY 4304: SOLID STATE PHYSICS [3 0 0 3]

Review of Crystal structure: Lattice, basis and unit cell, crystal system, symmetry, crystal planes and miller indices, reciprocal lattice, Bragg's law, experimental methods of x-raydiffraction, types of crystal binding, analysis of stress and strain in crysals. Electrical conduction: Free electron gas model, Sommerfield quantum theory, Fermi energy, parameters of free electron gas at absolute zero, electrical conductivity, Drude-Lorentz theory and Sommerfield theory of electrical conductivity, Band theory of solids, electrical conduction in metals, insulators and semiconductorsDielectrics: Static dielectric constant, polarization and polarizability, local field, ferro electricity, piezo electricity, frequency dependence of polarizability (electronic, ionic and dipolar), dielectric losses, requirements of insulating materials, applications of dielectric materialsMagnetism: Classification of magnetic materials, classical theory of diamagnetism and paramagnetism, Weiss theory of ferromagnetism, ferrites, hard and soft magnetic materials, garnets, magnetic bubbles, ceramic magnets, applications of magnetic materials

**References:**
1. Kittel C., *Introduction to Solid State Physics (7e)*, Wiley 1996.
2. Rao A., *A first course Solid State Physics*, Asiatech publications 2000.
3. Pillai S.O., *Solid State Physics (6e)*, New age international publications 2006.
4. Wahab M. A., *Numerical problems in Solid State Physics*, Alpha science international publications 2011.
5. Gupta H. C., *Solid State Physics*, Vikas publishing house Pvt. Ltd. 1996.

## PHY 4305: MODERN OPTICS [3 0 0 3]

Optics: Review of geometrical and physical optics, Dual nature of light, Electromagnetic spectrum, Optical devices, mirrors, lenses, prisms, grating, beam splitters, zone plate, polaroids. Light sources, emission profile. Elements of lasers: Basic requirements in a laser, characteristic properties of lasers. Q-switched and mode locked lasers. CO2, Nd: YAG lasers.  Applications. Introduction to Non-linear optics. Optoelectronic devices and its application: Photo diodes, solar cells, LED, and diode lasers. DBR and DFB lasers, CCD. Optical Communication: Conceptual picture of the optical communication system, Modulation and Detection Schemes, properties of optical fibers, discussion on device requirements, OEICS. Optical storage devices: Data recording and read out from optical discs. Holographic data storage systems.

**References:**
1. Ghatak A., *OPTICS (4e)*, Tata McGraw Hill Publishing Company Ltd. 2009.
2. Singh J., *Optoelectronics: An Introduction to Materials and Devices*, TATA McGraw- Hill Companies, Inc. 2014.
3. Wilson & Hawkes, *LASERS*, Prentice-Hall of India Pvt. Ltd. 1987.
4. Hugh Bennett, *Understanding Recordable & Rewritable DVD*, OSTA.org.
5. Hugh Bennett, *Understanding CD-R & CD-RW*, OSTA.org.

## PHY 4306: INTRODUCTORY QUANTUM MECHANICS [3 0 0 3]

Review of certain basics : Limitations of classical physics, wave-particle duality, De Broglie's hypothesis, matter as wavepacket, Heisenberg's uncertainty principle, Mathematical Formalism : operators; commutation relation; orthonormal functions; eigenvalues and eigenfunctions; the Dirac notation; the postulates of quantum mechanics.The Schrödinger Equation : Introduction, wavefunctions , time dependent Schrödinger equation, conservation of probability, expectation values, Ehrenfest's theorem, time independent Schroedinger equation, stationary states, Schroedinger equation in one dimension : the infinite square potential well; the finite square potential well; the potential barrier; tunneling; the harmonic oscillator.Quantum mechanics in three dimensions: Schrödinger equation in spherical coordinates, separation of variables, the angular equation, the radial equation, Applications (energy eigenvalues and eigenfunctions): the rigid rotator; the hydrogen atom; angular momentum.  Identical Particles.Some applications of quantum mechanics in nuclear physics, condensed matter physics, and spectroscopy: alpha decay, nanostructures, STM, vibrational and rotational spectra of molecules etc.

**References:**
1. Verma H.C., *Quantum Physics (2e)*, Surya Publications. 2016.
2. Gasiorowicz S., *Quantum Physics (3e)*, Wiley India Pvt Limited. 2007.
3. Jain M. C., *Quantum Mechanics: A Textbook for Undergraduates*, PHI Learning Private Limited 2012.
4. Griffiths D. J., *Introduction to Quantum Mechanics (2e)*, Pearson Education.
5. Eisberg R. and Resnick R., *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles (2e)*, Wiley-India Pvt Limited. 2009.

### CHM 4051: CHEMICAL BONDING [3 0 0 3]

Introduction to bonding, Classification. Ionic bond- Lattice energy, Born Haber cycle, Radius-ratio rules, Properties of ionic compounds, Covalent character in ionic bonds. Covalent bond-Covalency, Valence bond theory, Sigma and pi bond, Hybridization, VSEPR Theory, Molecular orbital theory, Bond order, Properties of covalent compounds. Coordination bond - Primary and Secondary valencies, ligands, Valence bond theory of complexes, Crystal field theory of octahedral and tetrahedral complexes, Low and high spin complexes. Metallic bond-Band theory of metals, Conductors, semiconductors and insulators. Secondary bonding- Hydrogen bonding, London forces and dipole-dipole interactions.

**References:**

1. J D Lee, "Concise Inorganic chemistry", Wiley India, 2012
2. B R Puri , L R sharma and K C Kalia, "Principle of Inorganic chemistry", Vishal Publishing Co., Punjab, 2017.
3. D F Shriver, P W Atkins, "Inorganic chemistry", Oxford India, 2014
4. A F Cotton, "Basic Inorganic chemistry", Wiley Publishers, 2007

### CHM 4052: CHEMISTRY OF CARBON COMPOUNDS [3 0 0 3]

Introduction to Organic Compounds: Classification, Nomenclature; Alkanes: Homologous series, Preparation; Cycloalkanes: Ring size and strain, Applications; Alkenes: Markovnikov and anti-Markovnikov addition reactions, Reduction, applications; Alkynes: Acidity, preparation, Reduction of alkynes, applications; Alkyl halides: SN1, SN2, E1 and E2 reaction mechanisms; Alcohols: Classification, Acidity, organo-metallic reagents; Aromatic compounds: Electrophilic and nucleophilic substitution reactions; Mechanism of some named reactions; Carbonyl compounds: aldehydes and ketones, carboxylic acids and carboxylic acid derivatives; Heterocyclic compounds: Nomenclature, synthesis and reactivity of thiophene, pyrrole and furan; Carbon materials: Fullerenes, carbon thin films, nanotubes and carbon fibers; Carbon nanotubes: SWNT, MWNT, synthesis, properties and applications; Carbon nanomaterials applications.

**References:**

1. B S Bahl and Arun Bahl, "Advanced Organic Chemistry", S Chand, New Delhi, 2012.
2. Robert T. Morrison and Robert N. Boyd, "Organic Chemistry", Pearson, New Delhi, 2016.
3. P.S. Kalsi, "Organic Reactions and Their Mechanisms", New Age International Private Limited, New Delhi, 2017.
4. Ashutosh Tiwari and S. K. Shukla, "Advanced Carbon Materials and Technology", John Wiley & Sons, 2013.
B. Bhushan ed., "Springer Handbook of Nanotechnology", Springer Publishers, Berlin, 2004.

## OPEN ELECTIVES

### CHM 4301: ANALYTICAL METHODS AND INSTRUMENTATION [3 0 0 3]

Spectroscopic methods of analysis: Properties of EMR, General features of spectroscopy, Types of molecular spectra, Interaction of EMR with matter, Instrumentation, Applications, Theory, Instrumentation and applications of Microwave, Raman, Infrared, UV-Visible, NMR spectroscopic techniques. Chromatographic Techniques: General concepts, Classification, Principles, Experimental techniques of CC, HPLC, TLC, GC and their applications. Electroanalytical methods: Basic principles and applications of conductometric, potentiometric titrations.

**References:**

1. D.A. Skoog, J. Holler, F.T.A. Nieman, *Principles of Instrumental Analysis*, 5thEdn, Saunders, Philadelphia, 1992
2. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, 5thEdn, Saunders College Publishing, Philadelphia, 1988
3. *Vogel's Textbook of Quantitative Chemical Analysis*, GH Jeffery, John Wiley & Sons Inc, 5thEdn, 1989

### CHM 4302: FUNDAMENTALS OF INDUSTRIAL CATALYTIC PROCESSES [3 0 0 3]

Adsorption & Catalysis: Physisorption and chemisorption, Adsorption isotherms, Factors influencing adsorption, Adsorption of gases by solids, Adsorption from solution, Introduction to catalysis, Energetics, Catalytic cycles Solutions & Solubility: Ideal and non-ideal solutions, Raoult's law, Thermodynamics of ideal solutions, Vapor pressure and boiling point composition curves, Distillation behaviour of completely miscible & immiscible liquid systems, Azeotropes Colligative Properties: Determination of molar masses from vapor pressure lowering, Osmotic pressure, Boiling point elevation and Depression of freezing point, Vant Hoff's factor Colloids: Types, Preparation and purification of sols, General properties, Optical, Electrical & Kinetic properties of sols, stability of sols, Application of colloids, Emulsions & Gels- Types, Preparation, Properties and their applications.

**References:**

1. *Principles of Physical Chemistry*, B.R. Puri, L.R. Sharma, M.S. Pathania, Vishal Publications, New Delhi, (23e), 2008
2. *Principles of Physical Chemistry*, S.H. Maron, C.F. Prutton, IBH Publishing co. New Delhi, (4e), 1985
3. *Fundamentals of Analytical Chemistry*, D.A. Skoog, D.M. West, F.J. Holler, R. Crouch, (4e),Thomson-Brooks, 2007

### CHM 4303: SUSTAINABLE CHEMICAL PROCESSES AND PRODUCTS [3 0 0 3]

Introduction and principles of green chemistry, Examples, Atom economy, carbon efficiency, life cycle analysis, sustainable products, process and synthesis catalysis and green chemistry, examples of fine and bulk chemicals production, catalysts for clean technology. Application of ecofriendly approach to waste treatment. Cleaner production processes, clean synthesis in lab Scale, industrial examples, use of ecofriendly energies. Bio-pesticides, polymers & pharmaceutical products. Electrochemical synthesis, Alternate reaction media using water and other green solvents, ionic liquids & supercritical fluids; phase transfer catalysis.

**References:**

1. P.T. Anastas, J. C. Warner, *Green Chemistry: Theory and Practice*, Oxford Univ. Press, Oxford, 2008
2. A.S. Matlack, *Introduction to Green Chemistry*, Marcel Dekker, New York, 2001
3. P. T. Anastas, R. H. Crabtree, *Handbook of Green Chemistry and Catalysis*, Wiely-VCH, Weinheim, 2009

# Inter Institute Open Electives

## Centre for Creative and Cultural Studies (CCCS), Manipal

### IIE 4301: ART APPRECIATION [3 0 0 3]

How to read a visual, how to enjoy or feel an art form, what is Creative Thinking? Indian Art: Heritage & Culture; Art Appreciation: Western Art, Artist & Art Movements: Raja Ravi Verma, Tagore, Da Vinci, Van Gogh; Aesthetics: Beauty, Feel & Expression; Art & Science; Art & Film; Art: Freedom & Society, to be an art literate. A journey to immerse in the world of Art.

### IIE 4302: INDIAN CULTURE AND CINEMA - AN INTRODUCTION [3 0 0 3]

Introduction to Idea of Culture, Identity and tradition, Indian Cultural History, Indian cultural history, Time and space, Indian Art and heritage, Indus valley civilization – Indian Independence, Post-colonial India, Modern India, Indian Cinema, Body, language and feel, Film and culture, Evolution, Interpretation and Reflection, Indian Cinema, Media and the medium, Pioneers and classical films, Culture and art of cinema, Culture, Cinema and Society, Revolutions, ideas, innovations, Culture, Cinema and Peace, Message, purpose and the challenge.

## Manipal Institute of Management, Manipal

### IIE 4304: CORPORATE FINANCE [3 0 0 3]

Introduction to Corporate Finance, Financial Goal, Agency Problems, Managers vs Shareholders Goals, Concepts of Value and Return, Capital Budgeting Decisions, Cost of Capital, Calculation of the Cost of Capital in Practice, Financial and Operating Leverage, Capital Structure, Relevance of Capital Structure, Irrelevance of Capital Structure, Relevance of Capital Structure, Dividend Theory, Dividend Relevance, Dividend Relevance, Dividend and Uncertainty, Dividend Irrelevance, Principles of Working Capital Management.

**References:**
1. Brealey, R., Myers, S., Allen, F., & Mohanty, P. (2014). Principles of Corporate Finance (11e). New Delhi : Mc Graw Hill Education (India) Private Limited,.
2. Pandey, I. M. (2014). Financial Management (10e). New Delhi: Vikas publishers.
3. Ross, S. A., Westerfield, R. W., Jaffe, J., & Kakani, R. K. (2014). Corporate Finance (10e). New Delhi: Mc Graw Hill Education (India) Private Limited.
4. Parasuraman, N. R. (2014). Financial Management - A Step-by-Step Approach (1e.). New Delhi: Cengage Learning India Private Limited.

### IIE 4305: INTERNATIONAL BUSINESS MANAGEMENT [3 0 0 3]

Historical perspective of international business, International business environment, Modes of entering international business, Cross-Culture and dynamic market understanding, Differences in Culture, Theories of international business, World Bank, World trade organization, Multinational Corporations and their involvement in International Business, Tariffs and quotas, Balance of Payment Account.

**References:**
1. Hill Charles, W. L., & Jain Arun, K. (2011). International Business: Competing in the Global Marketplace. (8e), Tata McGraw Hill.
2. Kumar, S. P., & Sanchari, S. (2012). International Business Management-A Global Perspective. New Delhi: Excel Books.

### IIE 4306: BRAND MANAGEMENT [3 0 0 3]

Introduction to brand management, Developing a brand strategy, Brand resonance and brand value chain, Designing and implementing brand marketing programs to build brand equity, Measuring and interpreting brand performance, Designing and implementing brand architecture strategies, Managing brands.

**References:**
1. Keller, K. L., Parameswaran, M. G., Jacob, I. (2015). Strategic Brand Management (4e). Noida, India: Pearson Prentice Hall Publication.
2. Rowles, D., (2014). Digital Branding (1e.). UK: Kogan Page Limited.
3. Kapferer, J. N., (2012). The New Strategic Brand Management: Advanced Insights and Strategic Thinking (5e). UK: Kogan Page Limited

## Centre for Integrative Medicine & Research (CIMR)

### IIE 4307: YOGA [3 0 0 3]

Aim, Objectives, Meanings and Definitions of Yoga, History of Yoga, Concepts and misconcepts of Yoga, Schools of Yoga, Ashtanga Yoga

## Subjects by Industry Experts

### IIE 4308: HEALTH ECONOMICS [3 0 0 3]

Economics: Understanding Economics, Efficiency, Rational decision making, Opportunity costs, Supply and demand, Price discovery, Health economics: Defining health, Human capital, what does supply and demand mean in the context of health? Arrow on the uncertainty and welfare economics, The Moral hazard, DALY and QALY, Efficiency: The Production possibility frontiers. The production function for health care. Health policy, Defining equity, Standards of healthcare provision Epidemiology, The Healthcare sector, The demand for health, Disease prevalence, The pharmaceuticals market, Cross country case studies.

**References:**
1. Sloan, Frank A., and Chee-Ruey Hsieh. Health economics. MIT Press, 2012
2. Annemans, L. Health economics for non-economists. An introduction to the concepts, methods and pitfalls of health economic evaluations. Academia Press, 2008
3. Jeffery, Roger. The politics of health in India. University of California Press, 1988.

### IIE 4309: DIGITAL MEDICINE [3 0 0 3]

Present day practice of medicine. Limitations of scalability in the present framework. Introduction to computing, algorithms, big data, semantic web, mobility. Communication-WAN/LAN, 3G/4G and 5G. Patient/Electronic Health records. Experience with these records elsewhere Wearables, the physics of data capture. Practical demonstration of wearables Genomics, an introduction. Computational genomics including the software. Imaging –an introduction-ionizing and non-ionizing. Imaging software and science of diagnosis. How all the four 4 pillars-PHR/EHR, Wearables, Genomics and Imaging come together with software as the glue to change the world of medicine.

**References:**
1. David Mount. Bioinformatics: Sequence and Genome Analysis. CSHL, 2001
2. Durbin, Richard, Sean Eddy, Anders Krogh, and Graeme. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press, 1999

## Manipal College of Nursing Manipal

### IIE 4310: MEDICAL EMERGENCY AND FIRST AID [3 0 0 3]

Principles of First Aid, First aid kit and equipment, emergency drugs, scene assessment, safety and identifying hazards, patient assessment, Basic Life Support and AED, triage, extrication/stretchers, ambulance. Describe the causes, signs and symptoms and management of respiratory emergencies, acute gastro-intestinal emergencies, musculoskeletal emergencies, dental, ENT and eye emergencies, renal emergencies, nervous system emergencies, hematological emergencies, endocrine emergencies, toxicological emergencies, environmental emergencies, pediatric emergencies, psychiatric emergencies, obstetrical emergencies

**References:**

1. Pollak, A.N. (2005). Emergency care and transportation of the sick and injured. Massachusetts: Jones and Bartlett publishers.
2. Keen, J. H. (1996). Mosby's Critical Care and Emergency Drug Reference. Missouri: Mosby's year book.
3. Walsh, M. (1990). Accident and emergency nursing. A new approach. Oxford: Butterworth Heinemann Ltd.
4. Sbaih, L. (1992). Accident and emergency Nursing. A nursing model. London: Chapman and Hall.
5. Sbaih, L. (1994). Issues in accident and emergency Nursing. London: Chapman and Hall.
6. Bourg, P., & Rosen, S. P. (1986). Standardized nursing care plans for emergency departments. Missouri: The C. V. Mosby Company.
7. Howard, P.K., &Steinmann, R. A. (2010). Sheehy's Emergency Nursing principles and practice. Missouri: Mosby Elsevier.
8. Sira.S, (2017). First Aid Manual for Nurses (First ed.), New Delhi: CBS Publishers & Distributors Pvt. Ltd.

### IIE 4311: LIFE STYLE MODIFICATION AND COMPLEMENTARY AND ALTERNATIVE THERAPIES [3 0 0 3]

Principles and concepts of life style modification and various complementary and alternative therapies, Demonstrate skill in performing different yoga aasanas, guided imagery/Progressive muscle relaxation, meditation & Pranayama, reflexology, massage therapy, aerobics, laughter therapy

**References:**

1. Bhat Krishna K. The power of yoga. Suyoga publications; DK, 2006
2. M.M.Gore. Anatomy & Physiology of yogic practices; (5e), New age book.
3. K N Udupa. Stress and its management by yoga. (2e). Motilal Banarsidas publishers Pvt. Ltd, Delhi, 2007.
4. Yoga and total health. A monthly journal on the yoga a way of life.
5. Swami Satyananda Saraswati. Dynamics of yoga. (2e), Bihar school of yoga, Bihar 1997.

## Welcomegroup Graduate School of Hotel Administration, Manipal

### IIE 4312: INDIAN CUISINE AND CULTURE PRACTICAL [3 0 0 3]

Introduction to Indian cuisine, Basic Indian gravies, Rice cooking, Preparation of various rice products, Tandoor Cooking, Indian sweets, Comfort Food, Regional and sub-regional cuisine.

### IIE 4313: FOUNDATION COURSE IN BAKING AND PATISSERIE PRACTICAL [3 0 0 3]

Introduction to Patisserie and Baking Principles, Special emphasis placed on the study of ingredient functions, Students will have the opportunity to apply basic baking techniques, Understanding fundamentals of yeast dough production, Emphasis on the application of ingredient functions, product identification and recipe interpretation occurs throughout the course, Pastry Basics and Pie dough, The fundamental production of classical European pastry based desserts are included, Techniques of Cake Making, Techniques of Cookie making, The course emphasizes the preparation and makeup techniques of various cookies.

**References:**

1. Wayne Gisslen – Professional Baking, (5e), John Wiley USA.
2. Haneman L.J. Bakery: Flour Confectionery HEINMAN.
3. Mermaid Books The Book Of Ingredients DOWELL PHILIP.
4. John Wiley Understanding Baking AMENDOLA JOSEPH.
5. New Age International, A Professional Text to Bakery and Confectionery, KINGSLEE JOHN.
6. Virtue And Company Ltd., The New International Confectioner: WILFRED J. FRANCE.
7. Charrette Jacques, Great Cakes and Pastries, TEUBNER CHRISTIAN.
8. Joseph Amendola, Baker's Manual, (5e), NICOLE REES.
9. Joseph Amendola, Understanding Baking, (3e), NICOLE REES.
10. Culinary Institute Of America, Baking and Pastry: Mastering the Art and Craft, JOHN WILEY.

### IIE 4314: GLOBAL CUISINE & CULTURE- PRACTICAL [3 0 0 3]

European Cuisine: Familiarization of ingredients, recipes and preparation of different countries. North American Cuisine: Familiarization of ingredients, recipes and preparation of different countries. South American Cuisine: Familiarization of ingredients, recipes and preparation of different countries. Asian Cuisine: Familiarization of ingredients, recipes and preparation of different countries. Australian Cuisine: Familiarization of ingredients, recipes and preparation of different countries. African Cuisine: Familiarization of ingredients, recipes and preparation of different countries. Molecular Gastronomy: Additives, Tools, and Recipes. Processed Food: Comparison and Critiquing. Mediterranean and European cuisine: Familiarization of ingredients, recipes and preparation of different countries.

**References:**

1. The Professional Chef - The Culinary Institute of America
2. Practical Cookery - Kinton, Ceserani and Foskett
3. Food Production Operation - Parvinder S. Bali
4. Professional Cooking - Wayne Gisslen
5. Cookery for the Hospitality Industry - Dodgshun Peters
6. Modern Cookery - Thangam E Phillips

## School of Communication, Manipal

### IIE 4315: REPORTING AND WRITING [3 0 0 3]

Introduction to news writing news in different media, news, definition of news, news values; types of news other theoretical issues relating to news writing. News Reporting Basic of news writing: structure of news reports; writing the lead; the changes in the composition of the lead; techniques of news gathering; sources of news. Reporting various types of reporting (Objective, Interpretative, Investigative,) General assignment reporting/working on a beat. Reporting for news agency, periodicals and magazines. Interviewing: doing the research, conducting the interview, types and formats of interviews, writing interviews

**References:**

1. Mencher, Melvin (2006): News Reporting and Writing, Mac-Graw Hill, Boston.
2. Scalnan, Christopher (2000): Reporting and Writing: Basics for the 21st Century, Harcourt College Publishers.
3. Harrington Walt (1997) Intimate Journalism: The Art and Craft of Reporting Everyday Life, Sage Publications.
4. Carole, Rich (2007), Writing and Reporting News: A Coaching Method, Thomson Learning Inc.Kamath, K.V. (1993): Journalists' Handbook, Vikas Publishing House.
5. Aggarwal, Vir Bala (2006): Essentials of Practical Journalism, Concept Publishing Company.

## IIE 4316: INTRODUCTION TO ADVERTISING & PUBLIC RELATIONS [3 0 0 3]

Introduction to advertising; Evolution and history of advertising; Influence of advertising on society and ethics. Advertising as part of marketing mix; Structure and types of ad agencies; Advertising planning; creative strategy and implementation (media strategy). The essentials of advertising on different media platforms – print, broadcast, internet and new media; discuss the difference in planning and execution using examples or campaign case studies. Public Relations-scope; definition; evolution; establish difference between PR and advertising; Identifying stakeholders and various Public Relation tools. Steps in developing a PR program/campaign-stating the problem, planning and programming, action and evaluation; Crisis communication; Ethical issues in Public Relations.

**References:**
1. Butterick, K (2012): Introducing Public Relations: Theory and Practice. New Delhi: SAGE Publications India Pvt. Ltd.
2. Cutlip, Center & Broom, (2000): Effective Public Relations.USA: Prentice Hall International.
3. Jaishri Jethwaney and Shruti Jain, (2012): Advertising Management. New Delhi: Oxford University Press
4. Reddi, C.V.N. (2009): Effective Public Relations and Media Strategy. New Delhi: PHI Learning Pvt. Ltd.
5. Sharma, S. & Singh, R. (2009): Advertising Planning and Implementation. New Delhi: PHI Learning Pvt. Ltd.

## IIE 4317: BASIC PHOTOGRAPHY [3 0 0 3]

Photo Journalism: History of Photography and Photo Journalism. Photo Journalism: Definition, Nature, Scope and Functions of Photo Journalism – Qualification and Responsibilities of Photo Journalists, News Photographers and News Value, Types and Sources. Selection, Criteria for News Photographs – Channels of News Pictures – viz., Wire, Satellite, Agency, Stock, Picture Library, Freelancer, Photo Editing, Caption Writing, Photo – Presentation. Legal and Ethical aspects of Photography – Professional Organizations – Camera – Components and Types of Camera – Types of Lens, Types of Films, Types of Filters – Importance of Light and Lighting Equipments – Camera Accessories – Picture appreciation. Digital Camera – Digital Technology and its future – Darkroom Infrastructure – Film developing and Printing

**References:**
1. Basic Photography – Newnes
2. The Hamlyn Basic Guide to Photography – Hamlyn
3. Hamlyn Encyclopedia of Photography – Hamlyn
4. Photographing People – Guglielmezei
5. History of Photography – Cyernshem G R
6. Photo Journalism – Rothsteline
7. Techniques of Photo Journalism – Milten Feinberg
8. Freelance Photography – Jechsend Gedsey
9. Picture Editing – Stanley E Kalish and Clifton C Edom
10. News Photography – Jack Price
11. 1000 Ideas for better News Picture – High Sidley and Rodney Fox

## IIE 4318: MEDIA PRODUCTION TECHNIQUES [3 0 0 3]

Print design elements – typography, colours, spacing, pictures, logos, graphics, principles of layout and design – basic writing skills. Photography – SLR camera, Lenses, Apertures and Shutter speeds, Exposure, Understanding light, Filters and assessories, composing a picture, developing and printing, creating special effects. Digital photography – digital camera – digital technology and its future. Television – Introduction to AV Media-pre-production, production, post-production. Show packaging-Camera-characteristics, parts and functions; Mounting accessories and movements. Shots-Types and Uses; Basic composition. Practical video recording process. Radio – Introduction to Radio-Microphone types, characteristics and uses; Cables and Connectors. Recording device-Types and Characters, Audio editing, Programme formats-news, drama, feature and PSA's and Advertising.

**References:**
1. Gerald Millerson, "Effective TV production"
2. Peter Jarvis, "The Essential TV director's Handbook
3. Hamlyn "Basic guide to photography"
4. Ralph Milton "Radio programming – a basic training manual"
5. Tomlinson Holman "Sound for film and television"
6. Reporting and writing by Melwin Mencher

## IIE 4319: GRAPHIC & SKETCHING [3 0 0 3]

Basic Art Principles: Element of Art & Design, Contour Drawing, Composition Principles, Pencil shading, creating geometry model and shading. Basic Perspective: Still life sketching & Drawing, Styles of shading, Introduction to colors, color still life painting, Layout Design, Creating concepts for Design. Skeleton System, Body Proportions, Upper Body, Lower Body, Back, Hands and Legs. Text: Human Anatomy by Victor Perard, Dynamic Anatomy by Burne Hogarth. Gesture Drawing Tips, Line of Action, Dynamic Poses, Body Weight and Gravity, Clothing. Text: Figure Drawing by Anthony Ryder.

**List of Practical's:**
- 10 Drawings of Human Anatomy Study In Pencil
- 50 Drawings of Gesture Drawing In Pencil
- 5 Contour Drawing
- 2 Still Life Pencil Shading
- 2 Color Still Life
- 2 Layout Design

**References:**
1. Mastering Composition: Techniques and Principles to Dramatically Improve Your Painting (Mastering (North Light Books)) Hardcover – 25 Jan 2008 by Ian Roberts
2. Layout Essentials: 100 Design Principles for Using Grids (Design Essentials) Paperback – 1 by Beth Tondreau
3. Pencil Drawing: Learn how to develp drawings from start to finish with techniques for shading, contrast, texture, and detail (Artist's Library) Paperback – 1 Jan 1988 by Gene Franks
4. Drawing the Head and Figure – Jack Hamm
5. Dynamic Anatomy – Burne Hogarth
6. The artists complete guide to Human figure Drawing – Anthony Ryder
7. Human Anatomy – Victor Perard