Dr. Babasaheb Ambedkar Technological University
(Established as a University of Technology in the State of Maharashtra)
(Under Maharashtra Act No. XXIX of 2014)
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Detailed Syllabus
for
Second Year B. Tech program in Petrochemical Engineering

With effective from
Academic year July 2018-19
Approved in the 11th meeting of Academic Council 8th June 2018

Teaching and Evaluation Scheme Second Year B. Tech. (Petrochemical Engineering)

Sr. No.	Code	Course title	Weekly Teaching hours			Evaluation Scheme			Credit
			L	T	P	MSE	CA	ESE	
Semester III									
1	BTBSC 301	Engineering Mathematics -III	3	1	-	20	20	60	4
2	BTCHC 302	Chemical Process Calculations	3	1	-	20	20	60	4
3	BTCHC 303	Fluid Flow Operations	2	1	-	20	20	60	3
4	BTCHC 304	Mechanical Operations	2	1	-	20	20	60	3
5	BTBSC 305	Advanced Engineering Chemistry	2	1	-	20	20	60	3
6	BTCHE 306	Elective - I A) Green Technology B) Renewable Energy Sources C) Nanotechnology D) Materials for Engineering Applications	2	1	-	20	20	60	3
7	BTCHM307	Mini Project-I	-	-	2	-	60	40	1
8	BTCHL308	Fluid Flow Operations Lab	-	-	2	-	60	40	1
9	BTCHL309	Mechanical Operations Lab	-	-	2	-	60	40	1
10	BTPCF310	Field Training / Internship/Industrial Training						50	1
11	BTPCC311	Petroleum Geology	2	-	-	-	50	-	Audit
		Total	**16**	**6**	**6**	**120**	**350**	**530**	**24**
Semester IV									
1	BTCHC401	Numerical Methods in Chemical Engineering	3	1	-	20	20	60	4
2	BTCHC402	Chemical Engineering Thermodynamics - I	3	1	-	20	20	60	4
3	BTCHC403	Heat Transfer Operations	3	1	-	20	20	60	4
4	BTHM3401	Basic Human Rights	2	-	-	-	50	-	Audit
5	BTID405	Product Design Engineering	2	-	-	20	20	60	2
6	BTPCC406	Petrochemical Engineering - I	2	1	-	20	20	60	3
7	BTCHM407	Mini Project II	-	-	2	-	60	40	1
8	BTCHL408	Heat Transfer Operations Lab	-	-	2	-	60	40	1
9	BTCHL409	Programming Languages Lab	-	-	2	-	60	40	1
10	BTCHL410	Advanced Engineering Chemistry Lab	-	-	2		60	40	1
11	BTPCF411	Field Training / Internship/Industrial Training (minimum 4 weeks which can be completed partially in I semester and II semester or at one time)	-	-	-	-	-	-	Credits To be evaluated in V Sem
12	BTPCL412	Petrochemical Engineering Lab-I	-	-	2	-	60	40	1
		Total	**15**	**4**	**10**	**100**	**450**	**500**	**22**

Detailed Syllabus of Individual Courses
Semester III

(BTBSC301) Engineering Mathematics-III

Unit I: Laplace Transform [07 Hours]

Definition – conditions for existence ; Transforms of elementary functions ; Properties of Laplace transforms - Linearity property, first shifting property, second shifting property, transforms of functions multiplied by t^n, scale change property, transforms of functions divided by t, transforms of integral of functions, transforms of derivatives ; Evaluation of integrals by using Laplace transform ; Transforms of some special functions- periodic function, Heaviside-unit step function, Dirac delta function.

Unit II: Inverse Laplace Transform [07 Hours]

Introductory remarks ; Inverse transforms of some elementary functions ; General methods of finding inverse transforms ; Partial fraction method and Convolution Theorem for finding inverse Laplace transforms ; Applications to find the solutions of linear differential equations and simultaneous linear differential equations with constant coefficients.

Unit III: Fourier Transform [07 Hours]

Definitions – integral transforms ; Fourier integral theorem (without proof) ; Fourier sine and cosine integrals ; Complex form of Fourier integrals ; Fourier sine and cosine transforms ; Properties of Fourier transforms ; Parseval's identity for Fourier Transforms.

Unit IV: Partial Differential Equations and Their Applications [07 Hours]

Formation of Partial differential equations by eliminating arbitrary constants and functions; Equations solvable by direct integration; Linear equations of first order (Lagrange's linear equations); Method of separation of variables – applications to find solutions of one dimensional heat flow equation $\left(\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}\right)$, and two dimensional heat flow equation (i.e. Laplace equation : $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$).

Unit V: Functions of Complex Variables (Differential calculus) [07 Hours]

Limit and continuity of f(z); Derivative of f(z) ; Analytic functions; Cauchy- Riemann equations in Cartesian and polar forms; Harmonic functions in Cartesian form; Mapping: Translation, magnification and rotation, inversion and reflection , bilinear transformation; Conformal mapping.

Unit VI: Functions of Complex Variables (Integral calculus) [07 Hours]

Cauchy's integral theorem; Cauchy's integral formula; Residues; Cauchy's residue theorem (All theorems without proofs).

Text Books

1. Higher Engineering Mathematics by B. S. Grewal, Khanna Publishers, New Delhi.
2. Advanced Engineering Mathematics by Erwin Kreyszig, John Wiley & Sons, New York.
3. A Course in Engineering Mathematics (Vol III) by Dr. B. B. Singh, Synergy Knowledge ware, Mumbai.
4. A Text Book of Applied Mathematics (Vol I & II) by P. N. Wartikar and J. N. Wartikar, Pune Vidyarthi Griha Prakashan, Pune.
5. Higher Engineering Mathematics by H. K. Das and Er. Rajnish Verma, S. Chand & CO. Pvt. Ltd., New Delhi.

Reference Books

1. Higher Engineering Mathematics by B. V. Ramana, Tata McGraw-Hill Publications, New Delhi.
2. A Text Book of Engineering Mathematics by Peter O' Neil, Thomson Asia Pte Ltd. Singapore.
3. Advanced Engineering Mathematics by C. R. Wylie & L. C. Barrett, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi.
4. Integral Transforms and Their Engineering Applications by Dr. B. B. Singh, Synergy .Knowledge ware, Mumbai. Integral Transforms by I. N. Sneddon, Tata McGraw-Hill, New York.

General Instructions:

1. The tutorial classes in Engineering Mathematics-III are to be conducted batch wise. Each class should be divided into three batches for the purpose.
2. The internal assessment of the students for 20 marks will be done based on assignments, surprise tests, quizzes, innovative approach to problem solving and percentage attendance. The minimum number of assignments should be eight covering all topics.

(BTCHC302) Chemical Process Calculations

Unit I: **[07 Hours]**

Introduction to Chemical Engineering: Historical evolution of Chemical Engineering and Chemical Process Industries, Chemistry to Chemical Engineering, Revision of Units and Dimensions., Mathematical techniques, Introduction to use of calculators.

Unit II: **[07 Hours]**

Mole concept, composition relationship and stoichiometry.

Unit III: **[07 Hours]**

Material Balances: Basic Material Balance Principles, Material balance problems without and with chemical reactions, Recycle Bypass and Purge.

Unit IV: **[07 Hours]**

Gases, Vapours and Liquids: Ideal Gas Law, Real Gas relationships, Vapour pressure, Vapour-Liquid Equilibrium calculations, Partial saturation & Humidity, Humidity chart, Material balances involving condensation and vaporization.

Unit V: **[07 Hours]**

Energy Balances: Heat Capacity, Calculation of enthalpy changes, Energy balances without chemical reactions, Enthalpy changes of phase changes, Heat of solution and mixing, Energy balances accounting for chemical reactions - Standard heat of reaction, formation and combustion, Hess Law, Effect of temperature, Adiabatic flame temperature.

Unit VI: **[07 Hours]**

Un-steady state mass balances.

Texts / References:

1. B. I. Bhat and S. M. Vora, "Stoichiometry" Tata McGraw-Hill, New Delhi

2. R.M. Felder and R.W.Rousseau, "Elementry Principles of Chemical Processes" 3rd Edition,Wiley 2005
3. D.M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 6th Edition, Prentice Hall of India, 1997.
4. V. Venkataramani, N. Anantharaman and K.M. Meera Sheriffa Begum, "Process Calculations" 2nd edition, Prentice Hall of India, 2015

(BTCHC303) Fluid Flow Operations

Unit I: **[06 Hours]**

Continuity equation for compressible and incompressible fluids, Bernoulli equation, Euler equation, Equation of motion.

Unit II: **[06 Hours]**

Types of flow, steady and unsteady, laminar and turbulent flows, relationship between shear stress and pressure gradient, Hagen Poiseuille equation. Prandtl mixing length theory and eddy diffusivity, losses in pipes and fittings.

Unit III: **[06 Hours]**

Darcy-Weisbach equation for frictional head loss, friction factor, Moody diagram. Velocity profile and boundary layer calculations for turbulent flow. Flow through packed and fluidized beds.

Unit IV: **[06 Hours]**

Pumps and compressors for handling different fluids, valves, pipe fittings and their standards, power requirement for flow. Piping layout and economical pipe diameter.

Unit V: **[06 Hours]**

Flow measuring devices: orificemeter, venturimeter, rotameter, pitot tube, anemometer etc. Flow through constrictions such as notches, weirs, nozzles.

Unit VI: **[06 Hours]**

Mixing and agitation, calculation of power numbers and mixing indices. Liquid-liquid and liquid solid mixing. Vacuum producing devices. Introduction to non-Newtonian flow and two phase flow.

Texts / References:

1. W. L. McCabe and J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering 4th ed. McGraw Hill 1985.
2. S. K. Gupta, Momentum Transfer Operations, Tata McGraw Hill, 1979.
3. J. M. Coulson and J. F. Richardson, Chemical Engineering Vol. I Pergamon Press, 1970.
4. A. S. Foust, L. A. Wenzel, C. W. Clump, L. B. Andersen. Principles of Unit Operations, 2nd ed. John Wiley, New York, 1980.

(BTCHC304) Mechanical Operations

Unit I: **[06 Hours]**

Introduction: Unit operations and their role in chemical industries; Types of mechanical operations;

Unit II: **[06 Hours]**

Properties and handling of particulate solids: Characterization of solid particles, Properties of masses of particles, Mixing of solids, Size reduction, Ultrafine grinders.

Unit III: **[06 Hours]**

Screening: Screening equipment, Screen capacity.

Unit IV: **[06 Hours]**

Cake filters: Centrifugal filters, Filter media, Principles of cake filtration, Washing filter cakes. Clarifying filters: Liquid clarification, Gas cleaning, Principles of clarification.

Unit V: **[06 Hours]**

Cross flow filtration: Types of membranes, Permeate flux for ultrafiltration, Concentration polarization, Applications of ultrafiltration, Diafiltration, Microfiltration.

Unit VI: **[06 Hours]**

Sedimentation: Gravity sedimentation processes, Centrifugal sedimentation processes. Agitation and mixing of liquids: Agitated vessels, blending and mixing, Suspension of solid particles, Dispersion operations, Agitator selection and scale up, Power Number, Mixing Index.

Text / Reference:

1. McCabe W. L., Jullian Smith C. and Peter Harriott - Unit operations of Chemical Engineering, 7th Edition, McGraw-Hill international edition, 2005.
2. Coulson J.M., Richardson J.F, Chemical Engineering, Vol. II, 4th Edition, Elsevier India, 2006.

(BTBSC305) Advanced Engineering Chemistry

Unit I: Corrosion and its Control **[06 Hours]**

Introduction, Fundamental reason, Electrochemical Corrosion, Direct Chemical Corrosion, Factors affecting the rate of corrosion, types of corrosion-Galvanic, Pitting Corrosion, Stress corrosion, methods to minimise the corrosion- Proper design, Cathodic and Anodic protection.

Unit II: Photochemical and Thermal Reactions **[06 Hours]**

Introduction, Laws of Photochemistry, Measurement of absorbed intensity, Quantum yield or efficiency, Jablonski Diagram, Photosynthesis reaction of Hydrogen Bromide, Brief discussion on Thermal Reactions- Cope Rearrangement

Unit III: Polymers **[06 Hours]**

Introduction, Nomenclature of polymers, types of polymerisation, molecular weight determination by osmotic pressure and viscosity method. Plastic and its classification, Constituents of Plastic and Moulding of plastic by Injection method.

Unit IV: Reaction Mechanism and Reaction Intermediates **[06 Hours]**

Introduction of reaction mechanism, Brief introduction of reactivity of substrate (Inductive effect, Mesomeric effect, Electromeric Effect, Hyperconjugative effect), Bond fission: Homolytic and Heterolytic bond fission, Reaction Intermediates: Carbocation(Structure, Stability and applications), Carbanion (Structure, Stability and applications).

Rearrangement reactions:

Intramolecular Rearrangement: Isomerisation, Beckmann Rearrangement, Benzidine Rearrangement
Intermolecular Rearrangement: Orton Rearrangement, Diazoamino Rearrangement.

Unit V: Spectroscopy **[06 Hours]**

Brief introduction to spectroscopy, UV – Visible Spectroscopy: Laws of absorption, instrumentation and application. IR spectroscopy: introduction, theory, instrumentation and application. Brief discussion on NMR Spectroscopy, AAS (Atomic Absorption Spectroscopy)

Unit VI: Instrumental Methods of Analysis **[06 Hours]**

Introduction to Chromatography, Types of Chromatography (Adsorption and partition chromatography), Thin Layer Chromatography, Gas Chromatography – introduction, theory, instrumentation. Brief discussion of Thermo gravimetric analysis (TGA).

Text books:

1. Bhal and Bhal Advance Organic Chemistry, S. Chand & Company, New Delhi, 1995
2. Jain P.C & Jain Monica, Engineering Chemistry, Dhanpat Rai & Sons, Delhi, 1992.
3. Bhal & Tuli, Text book of Physical Chemistry (1995), S. Chand & Company, New Delhi.
4. Instrumental Methods of analysis by Chatwal Anand, Himalaya Publication.
5. Text Book of Organic Chemistry by Rakesh K. Parashar, V.K. Ahluwalia.

Reference books:

1. Finar I.L., Organic Chemistry (Vol. I & II), Longman Gr. Ltd & English Language Book Society, London.
2. Barrow G.M., Physical Chemistry, McGraw-Hill Publication, New Delhi.
3. Shikha Agarwal, Engineering Chemistry- Fundamentals and applications, Cambridge Publishers - 2015.
4. O. G. Palanna, Engineering Chemistry, Tata McGraw-Hill Publication, New Delhi.
5. WILEY, Engineering Chemistry, Wiley India, New Delhi 2014.
6. Instrumental Methods of analysis by Willard, Dean, Merrit, McGraw - Hill.
7. Physical Chemistry, Glasstone.
8. Physical Chemistry, Peter Atkins, W.H. Freeman & Co. 9th Edition, 2009.

(BTCHE306) Elective I
(A) Green Technology

Unit I: **[06 Hours]**

Principles and concepts of Green Chemistry: Introduction, Sustainable Development and Green Chemistry, Atom Economy, Atom Economic Reactions, Rearrangement Reactions, Addition Reactions, Atom Un-economic Reactions, Substitution Reactions, Elimination Reactions, Wittig Reactions, Reducing Toxicity, Measuring Toxicity

Unit II: **[06 Hours]**

Waste- Production, Problems and Prevention: Introduction, Some Problems Caused by Waste, Sources of Waste from the Chemical Industry, The Cost of Waste, Waste Minimization Techniques, The Team Approach to Waste Minimization, Process Design for Waste Minimization, Minimizing Waste from Existing Processes, On-site Waste Treatment, Physical Treatment, Chemical Treatment, Bio-treatment

Plants, Design for Degradation, Degradation and Surfactants, DDT, Polymers, Some Rules for Degradation, Polymer Recycling, Separation and Sorting, Incineration, Mechanical Recycling, Chemical Recycling to Monomers.

Unit III: **[06 Hours]**

Measuring and controlling environmental performance: The Importance of Measurement, Lactic Acid Production, Safer Gasoline, Introduction to Life Cycle Assessment, Green Process Metrics, Environmental Management Systems, The European Eco-management and Audit Scheme, Eco-labels, Legislation, Integrated Pollution Prevention and Control. Catalysis and green chemistry: Introduction to Catalysis, Comparison of Catalyst Types, Heterogeneous Catalysts, Basics of Heterogeneous Catalysis, Zeolites and the Bulk Chemical Industry, Heterogeneous Catalysis in the Fine Chemical and Pharmaceutical Industries, Catalytic Converters, Homogeneous Catalysis, Transition Metal Catalysts with Phosphine Ligands, Greener Lewis Acids, Asymmetric Catalysis, Phase Transfer Catalysis, Hazard Reduction, C–C Bond Formation, Oxidation Using Hydrogen Peroxide, Bio-catalysis, Photo catalysis.

Unit IV: **[06 Hours]**

Organic solvents, Environmentally benign solutions: Organic Solvents and Volatile Organic Compounds, Solvent-free Systems, Supercritical Fluids, Supercritical Carbon Dioxide, Supercritical Water, Water as a Reaction Solvent, Water-based Coatings, Ionic Liquids, Ionic Liquids as Catalysts, Ionic Liquids as Solvents, FluorousBiphase Solvents. Renewable resources: Biomass as a Renewable Resource, Energy, Fossil Fuels, Energy from Biomass, Solar Power, Other Forms of Renewable Energy, Fuel Cells, Chemicals from Renewable Feedstocks, Chemicals from Fatty Acids, Polymers from Renewable Resources, Some Other Chemicals from Natural Resources, Alternative Economies, The Syngas Economy, The Biorefinery, Chemicals from renewable feed stocks.

Unit V: **[06 Hours]**

Emerging Greener technologies and Alternative energy solutions: Design for Energy Efficiency, Photochemical Reactions, Advantages of and Challenges Faced by Photochemical, Processes, Examples of Photochemical Reactions, Chemistry Using Microwaves, Microwave Heating, Microwave-assisted Reactions, Sonochemistry, Sonochemistry and Green Chemistry, Electrochemical Synthesis, Examples of Electrochemical Synthesis. Designing greener processes: Conventional Reactors, Batch Reactors, Continuous Reactors, Inherently Safer Design, Minimization, Simplification, Substitution, Moderation, Limitation, Process Intensification, Some PI Equipment, Examples of Intensified Processes, In-process Monitoring, Near-infrared Spectroscopy.

Unit VI: **[06 Hours]**

Industrial case studies: A Brighter Shade of Green, Greening of Acetic Acid Manufacture, EPDM Rubbers, Vitamin C, Leather Manufacture, Tanning, Fatliquoring, Dyeing to be Green, Some Manufacturing and Products Improvements, Dye Application, Polyethene, Radical Process, Ziegler–Natta Catalysis, Metallocene Catalysis, Eco-friendly Pesticides, Insecticides. An integrated approach to a greener chemical industry: Society and Sustainability, Barriers and Drivers, The Role of Legislation, EU White Paper on Chemicals Policy, Green Chemical Supply Strategies.

Text / Reference:

1. Mike Lancaster, Green Chemistry, Royal Society of Chemistry, 2010.
2. Paul T. A. John C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, 2000.
3. Jay Warmke, Annie Warmke, Green Technology, Educational Technologies Group, 2009.

(B) Renewable Energy Sources

Unit I: **[06 Hours]**

Sources of energy: Energy sources and their availability, renewable energy sources. Energy from Biomass: Introduction, Biomass as a source of energy, Biomass conversion technologies, Biogas generation, classification of biogas plants, Biomass gasification.

Unit II: **[06 Hours]**

Solar Energy: Sun and solar energy, solar radiation and its measurement, solar energy collectors, solar energy storage, Photovoltaic systems, Application of solar energy

Unit III: **[06 Hours]**

Wind Energy: Wind as an Energy source, Basic principles of wind energy conversion, Types of Wind machines, Components of wind energy conversion system, Performance of wind machines, application of wind energy.

Unit IV: **[06 Hours]**

Geothermal Energy: Introduction, Origin and distribution of geothermal energy, types of geothermal resources, Hybrid geothermal power plant, Application of geothermal energy.

Unit V: **[06 Hours]**

Energy from the Oceans: Introduction, Ocean Thermal Electric Conversion (OTEC), Energy from Tides, Ocean Waves.

Unit VI: **[06 Hours]**

Hydrogen energy: Introduction, Hydrogen production, Hydrogen storage, Hydrogen transportation. Chemical Energy Sources: Introduction, Fuel cells, Batteries.

Text / Reference:

1. Rai, G.D, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, 2010.
2. Rajesh Kumar Prasad, T.P. Ojha, Non-Conventional Energy Sources, Jain Brothers, 2012.
3. Sukhatme S.P and J. Nayak, Solar energy – Thermal Collection and storage, 3rd Edition, Tata McGraw Hill Education Pvt Ltd., 2008.
4. MM. EI – Wakil, Power Plant Technology, Tata McGraw Hill, New York, 1999.

(C) Nanotechnology

Unit I: **[06 Hours]**

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nano sizes and properties comparison with the bulk materials, different shapes and sizes and morphology.

Unit II: **[06 Hours]**

Fabrication of Nanomaterials: Top Down Approach, Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Micro emulsion Approach, Colloidal

Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Unit III: **[06 Hours]**

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH. Carbon Nanomaterials: Synthesis of carbon buckyballs, List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nanocones Difference between Chemical Engineering processes and nanosynthesis processes.

Unit IV: **[06 Hours]**

Characteristics of quantum dots, Synthesis of quantum dots, Semiconductor quantum dots, Introduction - Nanoclay Synthesis method, Applications of nanoclay.Nanomaterials characterization: Instrumentation Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential Microscopy's SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy

Unit V: **[06 Hours]**

Applications in Chemical Engineering: Self-assembly and molecular manufacturing : Surfactant based system Colloidal system applications, ZnO,TiO_2, Silver Nanoparticles Functional materials Applications, Production Techniques of Nanotubes, Carbon arc, bulk synthesis, commercial processes of synthesis of nanomaterials, Nanoclay, Commercial case study of nano synthesis - applications in chemical engineering, Nano inorganic materials - $CaCO_3$ synthesis, Hybrid wastewater treatment systems, Electronic Nanodevices, sensor applications.

Unit VI: **[06 Hours]**

Nanobiology: biological methods of synthesis. Applications in drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nanomaterials, Environmental Impacts, Case Study for Environmental and Societal Impacts.

Text / Reference:

1. Kulkarni Sulabha K., Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., H.F. Tibbals, JoydeepDutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
5. Davies, J.H. 'The Physics of Low Dimensional Semiconductors: An Introduction', Cambridge University Press, 1998.

(D) Materials for Engineering Applications

Unit I: **[06 Hours]**

Materials Science and Engineering Materials, Classification of Materials and Properties: Mechanical, Dielectric, Magnetic and Thermal

Unit II: **[06 Hours]**

Metallurgical Aspects of Materials: Structure of Metals and Alloys, Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals, Significance of micro structural features.

Unit III: **[06 Hours]**

Heat Treatment: effect of cooling and heating rates and ageing materials for mechanical load bearing applications.

Unit IV: **[06 Hours]**

Corrosion Resistant Materials: Some important Metals, Alloys, Ceramics and Polymers

Unit V: **[06 Hours]**

Materials for Electrical Applications: Conductors, Dielectrics, insulators; Materials for Civil Engineering Applications.

Unit VI: **[06 Hours]**

Materials for Biomedical applications: Steels, Ti and its alloys, Ni-Ti alloys, bioceramics, porous ceramics, bioactive glasses, calcium phosphates, collagen, thin films, grafts and coatings, biological functional materials Latex products.

Text / Reference:

1. M.F. Ashby: Engineering Materials, 4th Edition, Elsevier, 2005.
2. M.F. Ashby: Materials Selection in Mechanical Design, B H, 2005.
3. ASM Publication Vol. 20, Materials Selection and Design, ASM, 1997
4. Pat L. Mangonon: The Principles of Materials Selection and Design, PHI, 1999.

(BTCHM307) Mini Project I

The purpose behind the mini project is that the student should be exposed to more hands-on rather than merely theory. It is expected that the student (or a small group say, not more than two in a group, to be confirmed) will undertake to make a working model, a program, etc. which he will benefit from since he /she will be doing it first-hand.

(BTCHL 308) Fluid Flow Operations Lab

List of Experiments:

1. Determination of flow regimes -Reynolds' apparatus
2. Verification of Bernoulli's equation
3. Determination of Fanning friction factor for smooth and rough pipes
4. Determination of equivalent length of pipe fittings
5. Determination of viscosity with capillary tube viscometer.
6. Determination of friction factor for flow through packed bed.
7. Determination of discharge coefficient for venturi meter
8. Determination of discharge coefficient for orifice meter
9. Centrifugal pump characteristic
10. Calibration of Rota meter
11. Flow through a coil

12. Two phase flow
13. Pitot tube
14. Vacuum pump
15. Weirs

(BTCHL 309) Mechanical Operations Lab

List of Experiments:

1. Determination of screen effectiveness
2. Dry screen analysis
3. Wet screen analysis
4. Study of sedimentation
5. Study of air elutriation
6. Study of cyclone separator
7. Study of froth flotation
8. Fluidisation
9. Agitation and Mixing
10. Stoke's Law Experiment
11. To verify laws of crushing and grinding using Jaw crusher
12. To verify laws of crushing and grinding using Ball mill.
13. Study of Vacuum leaf filter.
14. Study of Plate and Frame filter press.
15. Study of Conveyors.
16. Study of Basket Centrifuge.

(BTPCF310) Field Training / Internship/Industrial Training

(BTPCC311) Petroleum Geology

Unit I: **[04 Hours]**

Petroleum Geology and its scope, Origin of Petroleum (emphasis on both techniques and geochemistry), Composition of petroleum, Hetroatoms and metallic trace impurities, Oil and gas traps.

Unit II: **[04 Hours]**

Application of remote sensing in petroleum resource development, Basin and exploration strategies, Instruments used – principles and working; magnetometers, seismogram, radiation counters and gravimeters

Unit III: **[04 Hours]**

Drilling methods (vertical, deviated and horizontal), drilling fluids, platform.

Unit IV: **[04 Hours]**

Casting and cementation, geological formation testing, functions of geologist on drilling well, assessment of potential.

Unit V: **[04 Hours]**

Geochemical concepts in oil exploration, the role of stable isotones, biomarkers and geomicrobiology in petroleum exploration.

Unit VI: **[04 Hours]**

Geochemical prospecting methods, Field reservoir studies (static and flowing bottom pressures, build up curves, draw dawn tests), methods of recovery (Activation and stimulation tests). Case histories of geophysical exploration in India for Petroleum resource development.

References:

1. G. D. Hobson, Modern Petroleum Technology, Volume I
2. A. I. Levorsen , Geology of Petroleum
3. B. G. Deshpande, World of Petroleum
4. P. K. Mukharjee, Text Book of Geology

Semester IV

(BTCHC401) Numerical Methods in Chemical Engineering

Unit I: **[07 Hours]**

Solutions of Linear Algebraic Equations - Gauss elimination and LU decomposition, Gauss-Jordan Elimination, Guass-Seidel and relaxation methods.

Unit II: **[07 Hours]**

Eigen values and Eigen Vectors of Matrices –Faddeev-Leverrier method, Power method, Householder's and Given's method.

Unit III: **[07 Hours]**

Nonlinear Algebraic Equations - Fixed point method, Multivariable successive substitutions, Single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique.

Unit IV: **[07 Hours]**

Function Evaluation - Least-squares curve fit, Newton's Interpolation formulae, Newton's divided difference interpolation polynomial, Langrangian interpolation, Pade approximations, Cubic spline approximations.

Unit V: **[07 Hours]**

Ordinary Differential Equations (Initial value problems) – RungeKutta Methods, Semi-implicit RungeKutta Techniques, Step size control and estimates of error **Ordinary Differential Equations (Boundary value problems) -** Finite difference technique, Orthogonal collocation technique, Orthogonal collocation on finite elements

Unit VI: **[07 Hours]**

Partial Differential Equations – Introduction to finite difference technique; Applications of Numerical methods to Chemical Engineering.

Texts / References:

1. S.K. Gupta, "Numerical Methods for Engineers", Wiley Eastern, 1995.
2. M.E. Davis, "Numerical Methods & Modeling for Chemical Engineers", Wiley, 1984.

(BTCHC 402) Chemical Engineering Thermodynamics I

Unit I: **[07 Hours]**

Introduction : The Scope of thermodynamics; Dimensions and units; Measures of Amount or size; Force; Temperature; Pressure; Work; Energy; Heat. The First Law of Thermodynamics: Joule's Experiments; Internal Energy; The First Law of Thermodynamics; Energy balance for closed systems; Thermodynamic state and state functions; Equilibrium; The phase rule; The reversible process; Constant V and constant P processes; Enthalpy; Heat capacity; Mass and energy balances for open systems.

Unit II: **[07 Hours]**

Volumetric Properties of Pure Fluids : PVT Behaviour of pure substances; the Virial Equation; The Ideal Gas; Application of the Virial Equation; Cubic Equations of State; Generalised Correlation's for gases; Generalised correlation's for Liquids

Unit III: **[07 Hours]**

Heat Effects: Sensible Heat Effects, Heat Effects Accompanying Phase Changes of Pure Substances. The Standard Heat of Reaction, The Standard Heat of Formation, The Standard Heat of Combustion, Effect of Temperature on the standard Heat of Reaction.

Unit IV: **[07 Hours]**

The Second Law of Thermodynamics : Statement of the Second law : The Heat Engine; Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the Second Law; Entropy balance for open systems; Calculation of ideal work; Lost work; The Third Law of Thermodynamics; Entropy from the Microscopic view point.

Unit V: **[07 Hours]**

THERMODYNAMIC Properties of Fluids: Property Relations for Homogeneous phase; Residual Properties; Residual properties by equations of state; Two phase systems, Thermodynamic diagrams; Tables of Thermodynamic properties; Generalised property correlations for gases.

Unit VI: **[07 Hours]**

Applications of thermodynamics to flow processes: Duct flow of compressible fluids; Turbines (expanders); Compression processes. Refrigeration and Liquefaction : The Carnot Refrigerator; the vapour-compression cycle; The Choice of refrigerant; Absorption Refrigeration; The heat pump; Liquefaction Processes.

TEXT BOOK:

1. Smith J.M, Van Ness H.C and Abbott M.M. - Introduction to Chemical Engineering Thermodynamics - 6th Edition, McGraw Hill International (2001).

REFERENCE BOOKS:

1. Rao, Y.V.C. - Chemical Engineering Thermodynamics - Universities Press (India) Ltd., 1997
2. Narayanan, K.V. - Chemical Engineering Thermodynamics - Prentice Hall of India Pvt. Ltd. – 2001
3. Hougen O.A, Watson. K.M and Ragatz R.A - Chemical Process Principles (Part - II)- 2nd edn., Asia Publishing House.

(BTCHC403) Heat Transfer Operations

Unit I: **[07 Hours]**

Conduction through a single homogeneous solid, thermal conductivity of solids, liquids and gases. Conduction through several bodies in series. Contact resistances. Unsteady state heat conduction, lumped heat capacity system, transient heat flow in a semi-infinite solid.

Unit II: **[07 Hours]**

Heat transfer by Convection: Forced convection, Laminar heat transfer on a flat plate Laminar and turbulent flow heat transfer inside and outside tubes. Film and overall heat transfer coefficients. Resistance concept, Coefficients for scale deposits, L.M.T.D. in heat exchangers with co and counter current flow. Heat exchanger design, Effectiveness – NTU method in finned tube heat exchangers.

Natural convection: Heat transfer from plates and cylinders in verticals and horizontal configuration, natural convection to spheres.
Heat transfer with phase change, i. e. heat transfer in Boiling and condensation, Single and multiple effect evaporators**.**

Unit III: **[07 Hours]**

Heat Transfer by Radiation: Black and grey body radiations, view factor, luminous and non-luminous gases. Combined heat transfer, i.e. conduction, convection and radiation together, Concept of critical insulation thickness.

Unit IV: **[07 Hours]**

Combined natural and forced convection: Fluid flow and heat transfer across cylinders and spheres. Combined natural and forced convection heat transfer in horizontal circular conduits. Heat transfer in extended surfaces such as fins, conduction convection heat transfer, forced convection heat transfer in circular conduits with longitudinal fins. Heat transfer in non-Newtonian fluids.

Unit V: **[07 Hours]**

Heat exchanger design: Design of single and multi-pass shell and tube type exchangers using LMTD and effectiveness – NTU methods. Spiral coil and plate type heat exchangers. Single and multi-phase condenser. Design of Reboilers, vapourisers. Kettle type and Thermosiphon reboilers, forced circulation vaporizers.
Heat transfer in agitated vessels both, jacketed and with coil, Determination of overall heat transfer coefficient, transient heating or cooling.

Unit VI: **[07 Hours]**

Heat transfer in packed and fluidized beds.

Texts / References:

1. J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol. 1 ELBS, Pergamon press, 1970
2. Geoffrey Hewitt, G.L.Shires and T.Reg Bott , "Process Heat Transfer" CRC press,1994
3. J.P.Holman, "Heat Transfer" 10th Editon,Tata McgrawHill publishing ltd.2011
4. J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergamon press, 1970
5. W. L. McCabe J. C. Smith and P. Harriot, "Unit Operations of Chemical Engineering", 4th ed. McGraw Hill 1985.
6. D. Q. Kern, "Process Heat Transfer", McGraw Hill, 1950.

(BTHM3401) Basic Human Rights

Unit I: **[04 Hours]**

The Basic Concepts: Individual, group, civil society, state, equality, justice. Human Values, Human rights and Human Duties: Origin, Contribution of American bill of rights, French revolution. Declaration of independence, Rights of citizen, Rights of working and exploited people

Unit II: **[04 Hours]**

Fundamental rights and economic program: Society, religion, culture, and their inter-relationship. Impact of social structure on human behaviour, Social Structure and Social Problems: Social and communal conflicts and social harmony, rural poverty, unemployment, bonded labour.

Unit III: **[04 Hours]**

Workers and Human Rights: Migrant workers and human rights violations, human rights of mentally and physically challenged. State, Individual liberty, Freedom and democracy.

Unit IV: **[04 Hours]**

NGOs and human rights in India: Land, Water, Forest issues.

Unit V: **[04 Hours]**

Human rights in Indian constitution and law

i) The constitution of India: Preamble
ii) Fundamental rights.
iii) Directive principles of state policy.
iv) Fundamental duties.
v) Some other provisions.

Unit VI: **[04 Hours]**

Universal declaration of human rights and provisions of India. Constitution and law. National human rights commission and state human rights commission.

References:

1. Shastry, T. S. N., "India and Human rights: Reflections", Concept Publishing Company India (P Ltd.), 2005.
2. C.J. Nirmal, "Human Rights in India: Historical, Social and Political Perspectives(Law in India)", Oxford India.

(BTID405) Product Design Engineering

Unit I: **[04 Hours]**

Creating Simple Products and Modules

Unit II: **[04 Hours]**

Document Creation and Knowledge Sharing

Unit III: **[04 Hours]**

Self and Work Management

Unit IV: **[04 Hours]**

Team Work and Communication

Unit V: **[04 Hours]**

Managing Health and Safety

Unit VI: **[04 Hours]**

Data and Information Management

References:

1. Model Curriculum for "Product Design Engineer – Mechanical", NASSCOM (Ref. ID: SSC/Q4201, Version 1.0, NSQF Level: 7)
2. Eppinger, S., & Ulrich, K.(2015). Product design and development. McGraw-Hill Higher Education.
3. Green, W., & Jordan, P. W. (Eds.).(1999).Human factors in product design: current practice and future trends. CRC Press.
4. Sanders, M. S., & McCormick, E. J. (1993). Human factors in engineering and design. McGRAW-HILLBook Company.
5. Roozenburg, N. F., &Eekels, J. (1995). Product design: fundamentals and methods (Vol. 2). John Wiley & Sons Inc.
6. Lidwell, W., Holden, K., & Butler, J. (2010). Universal principles of designs, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design. Rockport Pub.

(BTPCC406) Petrochemical Engineering-I

Unit I: **[06 Hours]**

Brief review of Petroleum, its formation and composition of crude oil.

Unit II : **[06 Hours]**

Characterization of crude oil, pretreatment of crude, removal of moisture, salts etc., General refinery set – up and function of various units, refinery flow diagram, equipment and tank yard layout.

Unit III : **[06 Hours]**

Types of refineries such as simple, intermediate and complex, preflashing distillation principles, atmospheric distillation, column types, vacuum distillation, pressure distillation.

Unit IV: **[06 Hours]**

Major petroleum products and their specifications like LPG, Gasoline, Industrial solvents, naphtha, Kerosene, aviation turbine fuel (ATF), high speed diesel (HSD), LDO, furnace fuel, lubricants, base oil, tar and bitumen.

Unit V: **[06 Hours]**

Blending of various petroleum fractions to meet require specification, molecular rebuilding processes, eg. Gas to liquid processes. Methane, natural gas, CNG, rebuilding of hydrocarbons.

Unit VI : **[06 Hours]**

Statistical information on Indian petroleum and petrochemical industry, future trends and developments.

Text Books / Reference Books:

1. Hobson G.D., 'Modern Petroleum Technology, Volume – II' John Wiley & Sons 1986
2. Speight J.H., 'The Chemistry and Technology of Petroleum Hydrocarbons' Mercel Dekker, Inc,1982
3. Sarkar G.N., 'Advanced Petroleum Refining' Khanna Publishers, New Delhi,2006

(BTCHM 407) Mini project II

The purpose behind the mini project is that the student should be exposed to more hands-on rather than merely theory. It is expected that the student (or a small group say, not more than two in a group, to be confirmed) will undertake to make a working model, a program, etc. which he will benefit from since he /she will be doing it first-hand.

(BTCHL408) Heat Transfer Operations lab

List of Experiments

1. To determine thermal conductivity of given metal rod
2. Study of Double Pipe Heat Exchanger (steam -water)
3. Study of Double Pipe Heat Exchanger (steam -air)
4. Study of Shell and Tube Heat Exchanger
5. Study of Study of emissivity of circular discs with and without black coating.
6. Study of Stefan-Boltzman's constant
7. To determine the surface heat transfer coefficient for a vertical tube losing heat by natural convection.
8. Solar Heater
9. Plate heat exchanger
10. Heat transfer from a finned tube
11. Unsteady state heat transfer
12. Single and double effect evaporator
13. Thermosiphon reboiler
14. Heat transfer coefficient of melting ice.
15. Pool boiling
16. Heat transfer in fixed/fluidized bed

(BTCHL409) Programming Languages Lab

Unit I: **[04 Hours]**
Problem solving techniques – algorithms. Introduction to computers - Basics of C++ - Number representation, Basic data types - int, float, double, char, bool, void.

Unit II: **[04 Hours]**
Flow of Control - Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

Unit III: **[04 Hours]**
Functions - user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion.

Unit IV: **[04 Hours]**
Arrays - Single, Multi-Dimensional Arrays, initialization, accessing individual elements, passing arrays as parameters to functions. Pointers and Dynamic Arrays - Multidimensional Dynamic Arrays, creation and deletion of single and multi-dimensional arrays.C Strings, Standard String Class

Unit V: **[04 Hours]**

I/O Streams, stream flags, stream manipulators, formatted I/O, binary I/O, Character I/O, File I/O - Opening, closing and editing files.

Unit VI: **[04 Hours]**

Structures and Classes - Declaration, member variables, member functions, access modifiers, inheritance, function overloading, overriding, redefinition, virtual functions, operator overloading, polymorphism - compile time and runtime binding.

Text / Reference:

1. Walter Savitch, Problem Solving with C++, Sixth Edition, Pearson, 2007
2. Cay Horstmann, Timothy Budd, Big C++, Wiley, Indian Edition, 2006.

Laboratory Practice:

1. Simple gauss elimination method
2. Partial pivoting
3. LU decomposition method
4. Newton Raphson method.
5. Bisection method
6. Trapezoidal Rule
7. Successive substitution method
8. Least square method
9. Runge-Kutta method
10. Function approximation method
11. Finite difference method

(BTCHL410) Advanced Engineering Chemistry Lab

List of Experiments: (Perform any 10 Experiments)

1. To determine λmax of given solutions.
2. To Verify Beer's Lambert's law.
3. Experiments on Paper and Thin Layer Chromatography. (two experiments)
4. Determination of rate of corrosion of metal.
5. Experiments related with Organic Chemistry. (three experiments)
6. Experiments on pH metry.
7. Experiments on Conductometry
8. Experiments on Flame Photometry.
9. Experiments on Solvent Extraction.
10. Estimation of Metals from Solution/ Alloys. (two experiments)
11. Synthesis of materials by various techniques. (two experiments)

Reference Books:

1. Systematic experiments in Chemistry, A. Sethi, New Age International Publication, New Delhi.
2. Practical Inorganic Chemistry, A. I. Vogel, ELBS Pub.
3. Practical in Engineering Chemistry, S. S. Dara.
4. Practical Organic Chemistry, A. I. Vogel, ELBS Pub.

(BTPCF411) Field Training / Internship/Industrial Training (minimum 4 weeks which can be completed partially in I semester and II semester or at one time)

(BTPCL412) Petrochemical Engineering Lab. - I

List of Experiments

1. To determine the Density, Specific gravity and API gravity of given petroleum and petroleum fraction.
2. To determine cloud point and of pour point given petroleum and petroleum fraction.
3. To determine the flash point and fire point of given petroleum fraction.(two experiments)
4. To determine the Reid Vapor Pressure of given petroleum product
5. To determine the aniline point of given petroleum fraction
6. To determine the carbon residue of given petroleum fraction by Ramsbottom Method.
7. To determine the carbon residue of given petroleum fraction by Conradson Method.
8. Detection of copper strip corrosion by petroleum product using copper strip tarnish test.
9. To determine the smoke point of given petroleum product.
10. To determine the viscosity of given petroleum product by different viscometers(two experiments)
11. To determine the penetration index of given grease sample.
12. To Determine the vaporization characteristics of given petroleum product (Gasoline) by ASTM –D 086 distillation.
13. To Determine the vaporization characteristics of given petroleum product (Diesel) by ASTM –D 086 distillation