CHEMICAL ENGINEERING DEPARTMENT
M. M. M. UNIVERSITY OF TECHNOLOGY
GORAKHPUR

Overall Credit Structure for B.Tech. Programme

Credit Courses			
Undergraduate Core (UC)		**Undergraduate Electives (UE)**	
Category	**Min. credits**	**Category**	**Min. credits**
Basic Sciences &Maths (BSM)	36	Program Electives (PE)	16
Engineering Fundamentals (EF)	24	Open Electives (OE) (Other Departments)	3
Department Core (DC)	78	Humanities & Social Science Electives (HSSE)	3
Management (M)	6		
Humanities & Social Science Core (HSSC)	4		
Project (P)	10		
Total	**158**	**Total**	**22**
		Grand Total	**180 (min.)**
Audit Courses			
Audit Courses (Other Departments)			16 (min.)
Seminar			3
Industrial/Practical Training (IT)			1
		Grand Total	**20 (min.)**

Credit Structure of B. Tech. Chemical Engineering with Specialization in Sugar and Alcohol Technology

Category Semesters	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
Basic Sciences & Maths (BSM)	14	14	9	-	-	-	-	-	**37**
Engineering Fundamentals (EF)	7	7	6	6	-	-	-	-	**26**
Department Core (DC)	-	-	9	13	18	20	13	5	**78**
Management (M)	-	-	-	3	3	-	-	-	**6**
Humanities & Social Science Core (HSSC)	4	-	-	-	-	-	-	-	**4**
Project (P)	-	-	-	-	-	-	5	5	**10**
Program Electives (PE)	-	-	-	-	-	4	4	8	**16**
Open Electives (OE)	-	-	-	-	-	-	-	4	**4**
Humanities & Social Science Electives (HSSE)	-	3	-	-	-	-	-	-	**3**
	25	**23**	**24**	**22**	**21**	**24**	**22**	**22**	**184**

Freshman Year, Semester-I

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	BSM	BAS-01	Engineering Mathematics-I	3	1	0	4
2.	BSM	BAS-02	Engineering Physics-I	3	1	2	5
3.	BSM	BAS-15	Applied Engineering Chemistry	3	1	2	5
4.	EF	BEE-01	Principles of Electrical Engineering	3	1	2	5
5.	HSSC	BAS-03	Professional Communication	3	1	0	4
6.	EF	BCE-10	Engineering Graphics	0	0	4	2
7.	AC		Audit Subject				
			Total	**15**	**5**	**10**	**25**

Freshman Year, Semester-II

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	BSM	BAS-07	Engineering Mathematics-II	3	1	0	4
2.	BSM	BAS-08	Engineering Physics-II	3	1	2	5
3.	BSM	BAS-09	Engineering Chemistry	3	1	2	5
4.	EF	BCS-01	Introduction to Computer Programming	3	1	2	5
5.	HSSE	BAS-**	Humanities and Social Science Electives	2	1	0	3
6.	EF	BME-10	Workshop Technology	0	0	4	2
7.	AC		Audit Subject				
			Total	**13**	**5**	**10**	**24**

Sophomore Year, Semester-III

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	BSM	BAS-31	Advanced Mathematics & Statistics	3	1	0	4
2.	BSM	BCT-11	Chemical Engineering Fluid Mechanics	3	1	2	5
3.	EF	BCT-12	Materials in Chemical Engineering	3	1	0	4
4.	DC	BCT-13	Chemical Engineering Process Calculations	3	1	0	4
5.	DC	BCT-14	Chemical Engineering Mechanical Operations	3	1	2	5
6.	EF	BAS-20	Communication Skills	0	0	4	2
7.	AC		Audit Subject				
			Total	**18**	**6**	**10**	**24**

Sophomore Year, Semester-IV

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	M	MBA-01	Industrial Management	2	1	0	3
2.	DC	BCT-15	Transport Phenomena	3	1	0	4
3.	DC	BCT-16	Sugar Technology	3	1	0	4
4.	DC	BCT-17	Heat Transfer Operation	3	1	2	5
5.	EF	BCT-18	Chemical Engineering Thermodynamics-I	3	1	0	4
6.	EF	BEE-20	Simulation Techniques	0	0	4	2
7.	AC		Audit Subject				
			Total	**17**	**6**	**6**	**22**

Junior Year, Semester-V

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	M	MBA-02	Engineering and Managerial Economics	2	1	0	3
2.	DC	BCT-26	Chemical Technology	3	1	0	4
3.	DC	BCT-27	Mass Transfer-I	3	1	0	4
4.	DC	BCT-28A	Chemical Reaction Engineering - I	3	1	2	5
5.	DC	BCT-29	Chemical Engineering Thermodynamics-II	3	1	2	5
6.	AC						
			Total	**17**	**6**	**4**	**21**

Note: The student is required to complete 10 days industrial training in Sugar Industries after V Semester.

Junior Year, Semester-VI

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	DC	BCT-31	Alcohol Technology	3	1	2	5
2.	DC	BCT-32	Mass Transfer-II	3	1	2	5
3.	DC	BCT-33	Process Dynamics, Control & Instrumentation	3	1	2	5
4.	DC	BCT-34A	Chemical Reaction Engineering-II	3	1	2	5
5.	PE1	BCT-51	Process Integration	3	1	0	4
6.	AC	BCT-30	Seminar				-
			Total	**15**	**5**	**8**	**24**

Note: The student is required to complete 50-65 days industrial training in Process Industries after VI Semester and both training will be evaluated in Semester VII.

Senior Year, Semester-VII

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	DC	BCT-41	Process Equipment Design	3	1	2	5
2.	DC	BCT-42	Energy Resources & Applications	3	1	0	4
3.	DC	BCT-43	Chemical Control in Sugar Plant	3	1	0	4
4.	PE2	BCT-**	Program Elective-2	3	1	0	4
5.	P	BCT-40	Project Part-I	0	0	10	5
6.	AC	BCT-45	Industrial/Practical Training				-
			Total	**12**	**4**	**12**	**22**

Senior Year, Semester-VIII

S.N.	Category	Paper Code	Subject	L	T	P	Credit
1.	DC	BCT-46	Chemical Engineering Design	3	1	2	5
2.	PE3	BCT-**	Program Elective-3	3	1	0	4
3.	PE4	BCT-**	Program Elective-4	3	1	0	4
4.	OE	BOE-**	Open Elective	3	1	0	4
5.	P	BCT-50	Project Part-II	0	0	10	5
			Total	**12**	**4**	**12**	**22**

Humanities & Social Science Electives

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
1.	BAS-11	Human Values & Professional Ethics	-	2	1	0	3
2.	BAS-12	Industrial Psychology	-	2	1	0	3
3.	BAS-13	Industrial Sociology	-	2	1	0	3

Engineering Fundamentals & Department Core (Chemical Engineering with Specialization in Sugar and Alcohol Technology)

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
		Year-I					
1.	BCT-01	Applied Engineering Chemistry	-	3	1	0	4
		Year-II					
2.	BCT-11	Chemical Engineering Fluid Mechanics	-	3	1	2	5
3.	BCT-12	Materials in Chemical Engineering	-	3	1	0	4
4.	BCT-13	Chemical Engineering Process Calculations	-	3	1	0	4
5.	BCT-14	Chemical Engineering Mechanical Operations	-	3	1	2	5
6.	BCT-15	Transport Phenomena	-	3	1	0	4
7.	BCT-16	Sugar Technology	-	3	1	0	4
8.	BCT-17	Heat Transfer Operation	-	3	1	2	5
9.	BCT-18	Chemical Engineering Thermodynamics-I	-	3	1	0	4
		Year-III					
10.	BCT-26	Chemical Technology	-	3	1	0	4
11.	BCT-27	Mass Transfer-I	-	3	1	0	4
12.	BCT-28A	Chemical Reaction Engineering - I	-	3	1	2	5
13.	BCT-29	Chemical Engineering Thermodynamics-II	-	3	1	2	5
14.	BCT-31	Alcohol Technology	-	3	1	2	5
15.	BCT-32	Mass Transfer-II	BCT-27	3	1	2	5
16.	BCT-33	Process Dynamics, Control & Instrumentation	-	3	1	2	5
17.	BCT-34A	Chemical Reaction Engineering-II	-	3	1	2	5
		Year-IV					
18.	BCT-40	Project Part-I	-	0	0	10	5
19.	BCT-41	Process Equipment Design	-	3	1	2	5
20.	BCT-42	Energy Resources & Applications	-	3	1	0	4
21.	BCT-43	Chemical Control in Sugar Plant	-	3	1	0	4
22.	BCT-45	Industrial/Practical Training	-	0	0	2	1
23.	BCT-46	Chemical Engineering Design	-	3	1	2	5
24.	BCT-50	Project Part-II	BCT-40	0	0	10	5

Program Electives (Chemical Engineering)

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
		PE-1 (VI Semester)					
1.	BCT-51	Process Integration	-	3	1	0	4
2.	BCT-52	Piping Design	-	3	1	0	4
3.	BCT-53	Statistical Design of Experiments	-	3	1	0	4
4.	BCT-54	Process Flow Sheet Simulation	-	3	1	0	4
5.	BCT-55	Food Technology	-	3	1	0	4
		PE-2 (VII Semester)					
1.	BCT-61	Fertilizer Technology	-	3	1	0	4

2.	BCT-62	Nuclear Engineering	-	3	1	0	4
3.	BCT-63	Computational Fluid Dynamics	BCT11	3	1	0	4
4.	BME-55	Total Quality Management	-	3	1	0	4
		PE-3 & PE-4 (VIII Semester)					
1.	BCT-71	Heterogeneous Catalysis & Multiphase Reactor Design	BCT34	3	1	0	4
2.	BCT-72	Petroleum Engineering	-	3	1	0	4
3.	BCT-73	Polymer Science & Technology		3	1	0	4
4.	BCT-74	Optimization Techniques in Chemical Engineering	-	3	1	0	4
5.	BCT-75	Standardization & Quality Assurance in Chemical Industry	-	3	1	0	4
6.	BCT-76	Industrial Safety & Hazard Management	-	3	1	0	4
7.	BAS-22	Nano Technology	-	2	1	0	3
8.	BCT-77	Project Engineering & Management	-	3	1	0	4
9.	BCT-78	Bioprocess Engineering Principles	-	3	1	0	4
10.	BCT-79	Nuclear Reactor Technology	-	3	1	0	4

Audit Courses for B. Tech. (Chemical Engineering) Students

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
		Year-I					
1.	BAS-04	Environmental Chemistry	-	3	1	0	4
2.	BAS-05	Environment & Ecology	-	2	1	0	3
3.	BME-02	Fundamentals of Mechanical Engineering	-	3	1	2	5
4.	BME-03	Manufacturing Processes		3	1	0	4
5.	BEC-01	Fundamentals of Electronics Engineering	-	3	1	2	5
6.	BAS-06	Space Sciences	-	2	1	0	3
		Year-II					
1.	BAS-32	Polymer Chemistry	-	3	1	0	4
2.	BME-56	Energy Management	-	3	1	0	4
3.	BEE-16	Electromechanical Energy Conversion	-	3	1	2	5
4.	BEE-15	Introduction to Microprocessors	-	3	1	2	5
5.	MAS-109	Foreign Language-French	-	2	1	0	3
6.	MAS-110	Foreign Language-German	-	2	1	0	3
7.	MAS-111	Foreign Language-Spanish	-	2	1	0	3
		Year-III	-				
1.	BCS-73	Neural Network & Fuzzy Systems	-	3	1	0	4
2.	BCE-21	Environmental Impact Assessment & Management	-	3	1	0	4
3.	BCS-15	Database Management System	-	3	1	2	5

BCT-11: CHEMICAL ENGINEERING FLUID MECHANICS

Course Category	:Departmental Core (DC)
Pre-requisite Subject	:NIL
Contact hours/week	:Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected to: o apply basics equation to fluid flow operations o understand compressible, incompressible fluids and liquid mixing o understand fluid flow measurement device and calculations of pressure drop in pipelines o select device for pumping of fluids

Syllabus

UNIT 1: Fluid Flow Basics

Fluid flow phenomena,Types of fluids, Basic equations of fluid flow: Macroscopic momentum balance, Macroscopic balance in potential flow: Bernoulli theorem and its application.

[9 Lectures]

UNIT 2: Compressible and Incompressible Fluids

Flow of incompressible fluids in pipes and closed channels, Process of compressible fluids, Liquid Mixing: Types of mixing patterns, mixing mechanism and mixing equipment's.

[9 Lectures]

UNIT 3: Fluid Flow Measurements

Measurement of Pressure Devices, Fluid flow measurement using Pitot tube, orifice meter, nozzle, venturimeter, variable area meters, notch or weir, ultrasonic flowmeters. Calculation of Pressure Drop in a Pipe, Minor Losses in Fittings. Concept of hydrodynamic boundary layer, growth over a flat plate, different thickness of boundary layer, types of fluidization.

[9 Lectures]

UNIT 4: Pumping of Fluids

Hydraulic pumps: Positive Displacement Pumps, Reciprocating Pumps, Rotary Pumps and Screw Pumps. Centrifugal Pumps, Characteristic Curves of Centrifugal Pumps, NPSH. Centrifugal pumps verses Reciprocating pumps pump losses and Efficiencies, Multistage pumps, Work and power Input. **[9 Lectures]**

Books

1. McCabe W., Smith J., "Unit Operations of Chemical Engineering", 7th Edition, McGraw Hill Education (2017).
2. Gupta V., Gupta S. K., "Fluid Mechanics and its Applications", Wiley Eastern, New Delhi (1984).
3. Shames I. H., "Mechanics of Fluids", 4th Edition, McGraw-Hill, Inc (2002)

4. Coulson J. M., Richardson J. F., "Chemical Engineering: Volume-I", 4th Edition, Pergamon Press (1990).
5. Jain A. K., "Fluid Mechanics including Hydraulic Machines", Khanna Publishers, Delhi (2007).
6. Geankoplis C. J., "Transport Processes and Unit Operations", 4th Edition, Prentice-Hall Inc (2004).

CHEMICAL ENGINEERING FLUID MECHANICS LAB

1. To find the flow rate using a V notch.
2. To find the friction losses in a Straight and bend pipe.
3. Study of Pipe fittings and Valves.
4. To study the Reynolds apparatus and verify experimentally.
5. To study the working principle of a reciprocating pump and to determine the percentage of slip.
6. To study the working principle of a centrifugal pump and determine its efficiency experimentally.
7. To find out the flow profile of water from hook's gauge and determination of coefficient of velocity, coefficient of discharge, coefficient of resistance, coefficient of contraction.
8. To determine the pressure drop in a packed bed by Leva's and Ergun's equation and verify experimentally.
9. To determine the minimum fluidization velocity in a fluidized/tapered fluidized bed and verify experimentally.
10. Determination of discharge coefficient with Reynolds Number in case of an orifice meter and a venturi meter.
11. Study and verification of the flow pattern in a Bernoulli's apparatus.
12. Determination of the mixing, fluidization and segregation index of the given sample of bed materials in a fluidized bed.

BCT-12: MATERIALS IN CHEMICAL ENGINEERING

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory test.
Course Outcome	Students are expected to: o Select materials for design and construction. o understand the different metals and their alloys o understand characterization/ analytical techniques for the nano/micro structures o understand typical engineering materials like glass, ceramics etc

Syllabus

UNIT 1: Introduction and basic principals

Introduction to materials and their principle properties, structure property relationships in materials, ASTM methods for property determination, testing of materials, destructive and nondestructive tests, structure of atom and chemical bonds, crystal structures and their influence on material properties, deformation and slip processes. **[9 Lectures]**

UNIT 2: Metals and their alloys

Iron – Carbon diagram, Ferrous and nonferrous alloys, mild steel, special steels, stainless steels, brasses, aluminum alloys and titanium alloys, high and low temperature material, insulation, refractories. Heat Treatments: Methods for fabrication, rolling, bending, central punching, riveting, and welding. [**9 Lectures]**

UNIT 3: Experimental Techniques

Electron Microscopes, scanning electron microscopy (Basics, Principal Elements, working), transmission electron microscopy (Basics, Principal Elements, working). Scanning probe microscopes; scanning tunneling microscopy, atomic force microscopy, other kinds of microscopes; X-ray diffraction, Surface area analyzer, FTIR. **[9 Lectures]**

UNIT 4: Typical Engineering Materials

Ferrous metals, nonferrous metals and alloys: aluminum, copper, lead, tin, zinc, alloys for high temperature service, ceramic materials: structure, Polymorphism, mechanical, electrical and thermal properties of ceramic phase, smart materials, biomaterials, nanomaterials.

[9 Lectures]

Books:

1. Hajra Choudhary S. K. "Material Science and Processes", Indian Book Distributing Co. (1982).

2. Raghavan V., "Material Science and Engineering - A First Course", 3rd Edition, Prentice Hall: India Pvt. Ltd., New Delhi (1996).
3. Callister W. D., "Material Science and Engineering: An Introduction", 7th Edition, John Wiley & Sons (2006)
4. Van Vlack, H. L., "Elements of Materials Science", 2nd Edition, Addision-Wesly Publishing Company, NY (1964)
5. Gupta R. C., "Principles of Materials Science and Engineering", Dhanpat Rai & Co.

BCT-13: CHEMICAL ENGINEERING PROCESS CALCULATIONS

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory test.
Course Outcome	Students are able to o perform basic unit conversions and calculations o perform material and energy balance calculations without and with chemical reaction o perform energy balance calculations o apply material and energy balance calculations to unit operations

Syllabus

UNIT 1: Mathematical Principles

Dimensions and system of units, Fundamental and derived units, Dimensional consistency, Dimensional equations, Different ways of expressing units of quantities and physical constant, Unit conversion and its significance. Calculations for mole, molecular weight, equivalent weight, etc., Composition of gaseous mixtures, liquid mixtures, solid mixtures, etc., Ideal gas law & other equations of state and their applications, Dalton law, Raoult's law, Henry's law, Solutions and their properties. **[06 Lectures]**

UNIT 2: Material Balance for Physical and Chemical Systems

Concept, material balance calculations, recycling and bypassing operations, introduction to unsteady state processes with examples like batch reactor, accumulation of inert components electrochemical reactions, recycling and By-passing Operations. **[12 Lectures]**

UNIT 3: Energy Balance

Concept, energy and Thermo chemistry, energy balances, heat capacity of pure substances and mixtures, latent heats, enthalpy of pure substances and mixtures, absolute enthalpy, heat of reaction, adiabatic reactions, thermo chemistry of mixing processes, dissolution, liquid-liquid mixtures, gas-liquid systems. **[10 Lectures]**

UNIT 4: Stoichiometry and Unit Operations

Distillation, humidification, absorption and stripping, extraction and leaching, crystallization, Psychrometry, drying, evaporation, introduction to stoichiometry and industrial problems.

[**08 Lectures]**

Books:

1. Bhatt, B. L., Vora, S. M., "Stoichiometry", 4th Edition, Tata McGraw-Hill (2004).
2. Hougen, O. A., Watson, K. M and Ragatz, R. A., "Chemical Process Principles Part-I", John Wiley and Asia Publishing (1970).

3. Himmelblau, D. M., “Basic Principles and Calculations in Chemical Engineering”, Fourth Edition, Prentice Hall Inc. (1982).
4. Whitwell J. C., Tone R. K., “Conservation of Mass and Energy ", McGraw-Hill (1973).
5. Process Calculation for Chemical Engineering, Second Revised Edition, Chemical Engineering Education Development Centre, I.I.T., Madras, 1981.
6. Narayanan K. V., Lakshmikutty B., “Stoichiometry and Process Calculations” PHI Learning Pvt Ltd., New Delhi (2016).

BCT-14: CHEMICAL ENGINEERING MECHANICAL OPERATIONS

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students expected to: o understand properties of particles and the separation techniques for solid particles o select suitable equipment for size reduction of solids and conveying system for transportation of solids o select suitable type of filter for slurry filtration, thickeners and clarifiers o understand concept of fluidization

Syllabus

UNIT I: Screening and size reduction of solids

Properties of solids, Performance of screening equipment/testing sieves, U.S.sieve series, Tyler standard sieve series, sieve shaker, types of screen analysis.Necessity of size reduction, crushing efficiency, energy requirement calculations by using crushing laws. Classification of size reduction equipment: Crushers, Grinders, Ultrafine grinders, Cutters. Dry versus wet grinding. Open and closed-circuit grinding. **[10 Lectures]**

UNIT 2: Settling, sedimentation and fluidization

Motion of particle in fluid, drag force, drag coefficient. Gravity settling methods, Terminal falling velocity, Stoke's law and Newton's law of settling. Gravity sedimentation operations, Sedimentation test, Kynch theory, Determination of thickener area and depth of thickener, Classification, Types of classification equipment.

[11 Lectures]

UNIT 3: Mixing and agitation

Types of fluidization, fluidized bed systems, determination of minimum fluidization velocity, flow through packed bed, applications of fluidized bed.

[7 Lectures]

UNIT 4: Filtration and Conveying of Solids

Classification of filtration and filters. Theory of filtration-equations. Filter media and filter aids. Batch and continuous filters. Plate and frame filter press. Storage of solids, characteristics of bulk solids, Conveyors: Principle, Construction and Working. Advantages, Disadvantages and design calculations of Belt Conveyors, Screw conveyors, Chain & Flight conveyors, Bucket elevators and Pneumatic conveyors. cyclone separator, electrostatic separator, fabric filter.

[9 Lectures]

Books:

1. McCabe W., Smith J., "Unit Operations of Chemical Engineering", 7th Edition, McGraw Hill Education (2017)
2. Coulson & Richardson, "Chemical Engineering: Volume II", Pergamon Press (2002)
3. Coulson & Richardson, "Chemical Engineering: Volume I", Pergamon Press (2002)

MECHANICAL OPERATIONS LAB

1. Determination of average particle size of a mixture of particles by sieve analysis.
2. Study and operation of Jaw crusher and thereby verification of Ritinger's constant.
3. Determination the viscosity of fluid in falling ball viscometer
4. Determination of the effect of no of balls on grinding in a Ball mill and comparison of its critical speed with the operating speed.
5. To determine minimum fluidization velocity.
6. Determination of the effectiveness of a gyratory sieve screen.
7. Study and operation of a Gyratory Crusher and thereby finding its reduction ratio.
8. To find the cake and filter medium resistance of Plate and Frame Filter press.
9. To find the filter medium resistance of a press and frame Filters.
10. To find out the efficiency of separation of cyclone separator.

BCT-15: TRANSPORT PHENOMENA

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: Fluid Mechanics (BCT-11)
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory test.
Course Outcome	Students are able to o understand concept of viscosity, thermal conductivity and diffusivity o apply shell momentum, heat and mass balances to chemical engineering problems o understand concept of interphase momentum, heat and mass transport

Syllabus

UNIT 1: Momentum Transport

Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Shell momentum balance and its application, boundary conditions, equation of continuity, equation of motion. **[09 Lectures]**

UNIT 2: Heat Transport

Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Shell energy balance, boundary conditions and its application, equation of motion for forced and free convection.

[09 Lectures]

UNIT 3: Mass Transport

Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity, Shell mass balance and its applications. **[09 Lectures]**

UNIT 4: Interphase Transport

Introduction to the concept of heat and mass transfer coefficients. Interphase mass transfer, various coefficient of mass transfer and their determination, resistance concept, controlling phase concept, Mass transfer in turbulent flow, Analogies of mass transfer, Empirical equations. Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory. **[08 Lectures]**

Text Book:

1. Bird R. B., Stewart W.E., Lightfoot E.N., "Transport Phenomena" 2nd Edition, John Wiley & Sons (2002)
2. Beek W. J., Muttzall K. M. K., Heuven J. W. V., Transport Phenomena., 2nd Edition, John Wiley & Sons (2000)
3. Plawsky J. L., "Transport Phenomena Fundamentals", 3rd Edition, Marcel Dekker, New York (2014)
4. Brodkey R.S., Hershey H.C., "Transport Phenomena: A Unified Approach" McGraw-Hill (1989)

BCT-16: SUGAR TECHNOLOGY

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory test.
Course Outcome	Students are able to o sugar production o juice processing and alcoholic beverages o manufacturing of cabonated beverages and confectionery o manufacturing of miscellaneous products from sugar

UNIT I: Sugar Production

Raw Materials: Sugarcane and beet, Manufacture and properties of Granulated and Liquid sugars, Invert sugar and their characteristics, Specialty products of Sugar Industry, Black strap Molasses, Sugar production process Energy and material balance. **[9 Lectures]**

UNIT II: Juice Processing and alcoholic beverages

Extraction of juice, drying, Bagasse, juice purification, Clarification: Lime addition, pH control, treatment, evaporation, vacuum pans, crystallization, washing of sugar crystals and centrifugal separation. Sugar: refining, analysis, recovery, balance, energy conservation, plant sanitation. Technology for Alcoholic Beverages: manufacture of beer, wine and champagne, quality characteristics for manufacture of distilled beverages: whisky, brandy, rum and gin.

[**9 Lectures]**

UNIT III: Cabonated Beverages and Confectionery

Carbonated beverages and confectionery: Manufacture, quality aspects, sugar-free, sugar-less carbonated beverages. Confectionery manufacture: high boiled sweets, Ingredients, center filled, lollipops, coextruded products: gums and jellies. **[9 Lectures]**

UNIT IV: Miscellaneous products from Sugar

Miscellaneous Products: Caramel, Toffee, fudge, Liquorice paste and aerated confectionery, Lozenges, sugar pannings and Chewing gum, Countlines. **[9 Lectures]**

Reference Books

1. Jackson E. B., "Sugar Confectionery Manufacture", 2nd Edition, Aspen Publishers Inc., (1999)
2. Shachman M, "Soft Drinks Companion: A Technical Handbook for the Beverage Industry", CRC Press (2005)
3. Minifie B. W., "Chocolate, cocoa and confectionery-Science and Technology", 3rd Edition, Aspen Publishers Inc. (2010)

BCT-17: HEAT TRANSFER OPERATION

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and one practical test.
Course Outcome	Students are able to o understand concept of conduction, convection and radiations o able to do design heat exchanger o understand concept of evaporation operation

Syllabus

UNIT 1: Conduction

Modes of heat transfer, Thermal conductivity, thermal insulation, units and dimensions. General differential equation of conduction, Steady state heat conduction, Contact resistance, heat transfer between surfaces and surrounding, critical thickness of insulation. Heat transfer through extended surfaces of uniform cross section. Enhanced heat transfer: concept of fins, Fin efficiency. **[8 Lectures]**

UNIT 2: Convection

Natural and forced convection, principal heat balance equation in laminar flow Empirical equations for convection heat transfer in turbulent flow through tubes, through annulus and over a flat plate. Dimensional analysis, dimensional groups used in heat transfer. Condensation: Modes and features, Nusselt's equation, condensation on vertical and horizontal plate Boiling: Pool boiling of saturated liquid, types of boiling, concept of critical heat flux.

[11 Lectures]

UNIT 3: Radiations

Thermal radiation, black body radiation, properties of radiation, laws of radiation. The radiation shape factor, various cases of radiation between two surfaces, radiation shields.

[9 Lectures]

UNIT 4: Heat Exchangers and Evaporators

Basic types of heat exchangers, overall heat transfer coefficient, fouling factor. Double pipe heat exchanger design by LMTD and effectiveness-NTU methods calculations of overall heat transfer coefficient and area), Shell and tube heat exchangers

Introduction, types of evaporators, material and energy balance, boiling point elevation, capacity and economy, multiple effect evaporators. **[8 Lectures]**

Books:

1. McCabe, W. L., Smith, J.C., Harriott, P. "Unit Operations of Chemical Engineering", 7th Edition, McGraw-Hill (2017)
2. Holman, J. P., "Heat Transfer", McGraw-Hill (1996)
3. Coulson, J. M. & Richardson, J. F., "Chemical Engineering: Vol-1", Butterworth – Heinemann (2002)
4. McAdams W. H., "Heat Transmission", 3rd Edition, Krieger Pub Co (1985).
5. Kern D. Q., "Process Heat Transfer", McGraw-Hill (1950).

6. Badger W. L. & Bancharo J. T., “Introduction to Chemical Engineering”, Tata McGraw Hill (1955).
7. Rudramoorthy R. and Mayilsamy K. “Heat and Mass Transfer”. Pearson (2010)

HEAT TRANSFER LAB

Experiments can be planned as per the following list;

1. To study heat transfer through lagged pipe.
2. To find out the thermal conductivity of liquid.
3. To study heat transfer in composite wall and find equivalent thermal conductivity.
4. To find out the convective heat transfer co-efficient of vertical cylinder in natural convection.
5. To determine convective heat transfer coefficient in forced convection.
6. To find out the overall heat transfer co-efficient of a double pipe heat exchanger.
7. To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger.
8. To study the heat transfer coefficient during drop wise and film wise condensation.
9. To study the heat transfer coefficient in a vertical and a horizontal condenser.
10. To find out the emissivity of a surface.
11. To find out the Stefan-boltzman constant and compare with the theoretical value.
12. Study and operation of a batch evaporator.

BCT-18: CHEMICAL ENGINEERING THERMODYNAMICS – I

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory test.
Course Outcome	Students are able to o apply the first law of thermodynamics o select appropriate equation of state for representing the P-V-T behaviour of gases o calculate the ideal and actual efficiencies of heat engines and performance of heat pumps o apply concept of laws of thermodynamics

Syllabus

UNIT 1: First law of thermodynamics and basic concept

First law of thermodynamics, thermodynamics state and state functions, equilibrium, phase rule, reversible process, constant PV processes, enthalpy, heat capacity, internal energy. **[10 Lectures]**

UNIT 2: Volumetric properties of fluids

PVT behaviors of pure fluids, equation of state, processes involving ideal gases, equation of state for real gases, heat effects accompanying chemical reactions. **[10 Lectures]**

UNIT 3: Second law of thermodynamics

Second law of thermodynamics, Entropy, Carnot cycle, Clausius inequality, entropy and irreversibility, residual properties, two phase systems, thermodynamic diagram. **[9 Lectures]**

UNIT 4: Application of laws of thermodynamics

Flow processes, refrigeration, liquefaction processes, steam power plant, internal combustion engines and gas turbine power plants. **[7 Lectures]**

Text Book:

1. Smith, J. M., Van Ness H. C., Abbot M. M., 'Introduction to chemical engineering Thermodynamics', 7th Edition, McGraw Hill Education (2009)
2. Koretsky Millo D., "Engineering and Chemical Thermodynamics" John Wiley & Sons (2004)

Reference Books:

1. Bevan O., Juliana Boerio-Goates, Chemical Thermodynamics Principles and Applications, Academic Press (2000).
2. Gopinath Halder, 'Introduction to Chemical Engineering Thermodynamics', PHI Learning Pvt. Ltd. (2009)
3. J. Richard Elliott, Carl T. Lira, 'Introductory Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall, (2012)
4. Thomas Engel, Philip Reid, Thermodynamics, Statistical Thermodynamics and Kinetics, 3rd Edition, Pearson, (2012)
5. Rajaram J., Kuriacose J. C., Chemical Thermodynamics Classical, Statistical and Irreversible, Pearson Education India (2013)

BCT-26: CHEMICAL TECHNOLOGY

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory test.
Course Outcome	Students are able to o pulp & paper and chemicals derived from coal o petrochemicals o sulphur and chloro-alkali industries o petroleum and polymer synthetic fibre

UNIT I: Pulp and paper, Coal chemicals

Pulp and Paper: Raw materials, pulping processes, recovery of chemicals, stock preparation and paper making. Coal Chemicals: Various processes for obtaining coal chemicals, coal tar distillation, F-T and Bergious processes for hydrocarbon production. **[9 Lectures]**

UNIT II: Petrochemicals

Petrochemicals: Manufacturing processes of formaldehyde, acetaldehyde, acetic acid, acetic anhydride, maleic anhydride, nitrobenzene, ethylene oxide, ethylene glycol. Pesticides: Processes for manufacturing of insecticides, fungicides and herbicides. Fuel and Industrial Gases: Technology options of producing producer gas, syn gas, pyrogas, nitrogen, oxygen and carbon dioxide. **[9 Lectures]**

UNIT III: Sulphur and chlro-alkali

Sulphur Industries: Origin and extraction of sulphur, production routes of suphuric acid and oleum. Phosphorous Industries: Manufacturing of phosphorus, phosphoric acid and phosphatic fertilizers. Chlor-Alkali Industries: Production of common salt, caustic soda, chlorine, hydrochloric acid and soda ash. Nitrogen Industries: Manufacturing of ammonia, nitric acid, nitrogenous and mixed fertilizers. Explosive and Propellants. **[9 Lectures]**

UNIT IV: Petroleum, Polymer and synthetic fiber

Petroleum Industry: Origin, occurrence and characteristics of crude oil, crude oil distillation and secondary processing. Polymer and Synthetic Fibre: Introduction to polymerization, commodity polymers, rayon, polyester, polyamide, acrylic fibre and nylons. **[9 Lectures]**

Text Books:

1. Gopala Rao M., Marshall S, 'Dryden's Outlines of Chemical Technology', Affiliated East-West Press Pvt Ltd (1997)
2. Austin G. T.,'Shreve's Chemical Process Industries', 5th Edition, McGraw Hill (1984).
3. Moulijn J.K, Makkee M., van Diepen A, 'Chemical Process Technology', 2nd Edition, Wiley (2013).

BCT-27: MASS TRANSFER-I

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: Basic Thermodynamics, Process calculations
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory test.
Course Outcome	Students are able to o to understand concept of diffusion and theories o able to design absorption column o able to design cooling towers o able to design crystallizer

UNIT 1: Diffusion

Introduction to Mass transfer operation, Diffusion: Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, Diffusion through variable cross-sectional area, Diffusion coefficient: measurement and prediction, Multi component diffusion, Diffusivity in solids and its applications. Introduction to mass transfer coefficient, Equimolar counter-diffusion, Correlation for convective mass transfer coefficient, Correlation of mass transfer coefficients for single cylinder, Theories of mass transfer, Penetration theory, Surface Renewal Theory, Boundary Layer Theory, Interphase mass transfer theory, Overall mass transfer coefficient. **[9 Lectures]**

UNIT 2: Humidification and dehumidification

Humidification & Dehumidification: Vapour liquid equilibrium and enthalpy for a pure substance, vapour pressure temperature curve, Vapour gas mixtures, Definition and derivations of relationships related with humidity Fundamental concept of humidification, Dehumidification and water cooling, Wet bulb temperature, Adiabatic operations, Classification and design of cooling towers. **[9 Lectures]**

UNIT 3: Absorption

Absorption: Introduction, Absorption & Stripping: Equipments, Gas-liquid equilibria, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, HTU, NTU & HETP concepts, Design equations for packed column. Murphee efficiency, plate efficiency. **[9 Lectures]**

UNIT 4: Drying

Drying: Solid-gas equilibria, Different modes of drying operations, Definitions of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, Continuous drying, Crystallization: Equilibrium Yield of Crystallization, Heat and Mass Transfer rates in crystallization, Theories of crystallization. **[9 Lectures]**

Text Books:

1. Treybal R.,'Mass Transfer Operations', 3rdEdition, McGraw-Hill: New York: (1980).
2. Geankoplis, C. J.,'Transport Processes and Unit Operations', 3rdEdition, Prentice Hall. (1993)
3. Coulson & Richardson,'Chemical Engineering Vol. II', Pergamon Press, 2002
4. McCabe, W. L., Smith, J. C., 'Unit Operations of Chemical Engineering',3rdEdition, McGraw-Hill (1976)
5. Banchero J.T., Badger, W.L., 'Introduction To Chemical Engineering', McGraw-Hill Inc.(1955)
6. DuttaB.K., 'Principles of Mass transfer and Separation Processes', Prentice-Hall of India, New Delhi (2007).

BCT-28A: CHEMICAL REACTION ENGINEERING - I

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students expected to: o understand kinetics of homogeneous reactions o design isothermal reactors o understand parallel and multiple reactions o understand fluid-fluid reactions

Syllabus

UNIT 1: Kinetics of Homogeneous Reactions

Rate of Reaction, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, Integral and differential methods for analyzing kinetic data. interpretation of constant volume reactor, zero, first, second and third order reactions, half-life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions. **[9 Lectures]**

UNIT 2: Design of Isothermal Reactor

Design of batch, continuous stirred tank, plug flow reactors, optimization of reactor size, reactors in series/parallel, recycle reactor, reactor design for multiple reactions. **[9 Lectures]**

UNIT 3: Parallel and Multiple Reactions

Design of parallel reactions, Irreversible first order reactions in series, first order followed by zero order reaction, zero order followed by first order reaction, successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions, temperature and pressure effect on single and multiple reactions, choosing right kind of reactor **[9 Lectures]**

UNIT 4: Fluid-Fluid Reactions

Fluid-fluid reactions: kinetics, design, Fluid-particle reactions: kinetics and design **[9 Lectures]**

Text Books:

1. Smith J. M., 'Chemical Engineering Kinetics', 3rd Edition, McGraw-Hill (1990).
2. Levenspiel, O., 'Chemical Reaction Engineering', 3rd Edition, John Wiley (1998).

Reference Book:

1. Keith J. Laidler, 'Chemical Kinetics', 3rd Edition, Pearson (2013)
2. Coulson and Richardson's, 'Chemical Engineering Volume III', 3rdElsevier (2006)

CHEMICAL REACTION ENGINEERING -I LAB (0:0:2)

1. Second order reaction
2. Pseudo First order reaction
3. Batch reactor: Second order reaction
4. Batch reactor: Pseudo first order reaction
5. Study of second order reaction for unequal concentration of reactants
6. Arrhenius Law
7. Continuous stirred tank reactor
8. Plug flow reactor
9. To study operation of an adiabatic batch reactor
10. To study combined Flow Reactor
11. To study cascade Continuous Stirred Tank Reactor

BCT-29: CHEMICAL ENGINEERING THERMODYNAMICS -II

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: Chemical Engineering Thermodynamics-I (BCT-18)
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students are able to o vapor-liquid equilibria and to flash calculations o chemical potential and its applications o activity coefficient, Gibbs Energy and chemical reaction equilibria o multi-phase reactions

UNIT 1: Vapor – Liquid Equilibria

An Introduction to vapour-Liquid Equilibria, qualitative behavior of the vapour-liquid equilibria (VLE), Simple models for vapour liquid, equilibrium, Flash calculations, Solution Thermodynamics, theory fundamental property relation. **[9 Lectures]**

UNIT 2: Chemical Potential

The chemical potential and phase equilibria, Partial properties, ideal gas mixtures, fugacity and fugacity coefficient for pure species, the Lewis/Randall rule, excess properties,the excess Gibbs energy and the activity coefficient, the nature of excess properties. Solution Thermodynamics, Applications Liquid phase properties from VLE data. **[9 Lectures]**

UNIT 3: Activity Coefficient, Gibbs Energy and Chemical Reaction Equilibria

Activity coefficient, Excess Gibbs energy, Models for the excess Gibbs energy, Property changes of mixing, Heat effects of mixing processes, Heats of solution, Enthalpy-Concentration diagrams, Chemical Reaction Equilibria, Relation of equilibrium constants to composition. **[9 Lectures]**

UNIT 4: Reaction Equilibria

Gas-phase and liquid-phase reactions, Equilibrium conversions for single reactions, Single phase reactions, Reactions in heterogeneous systems, Multi reaction equilibria, Fuel cells, VLE from cubic equations of state, Equilibrium and stability, Liquid-liquid equilibrium, Vapour-liquid-liquid equilibrium, Solid-liquid equilibrium, Osmotic equilibrium and osmotic pressure. **[9 Lectures]**

Text Book:

1. Smith, J. M., Van Ness H. C., AbbotM. M.,'Introduction to chemical engineering Thermodynamics', 7th Edition, McGraw Hill Education (2009)
2. KoretskyMillo D., "Engineering and Chemical Thermodynamics" John Wiley & Sons (2004)

Reference Books:

1. Bevan O., Juliana Boerio-Goates, Chemical Thermodynamics Principles and Applications, Academic Press (2000).
2. Gopinath Halder,'Introduction to Chemical Engineering Thermodynamics', PHI Learning Pvt. Ltd. (2009)
3. J. Richard Elliott, Carl T. Lira,'Introductory Chemical Engineering Thermodynamics, 2nd Edition, Prentice Hall, (2012)
4. Thomas Engel, Philip Reid, Thermodynamics, Statistical Thermodynamics and Kinetics, 3rd Edition, Pearson, (2012)
5. Rajaram J., Kuriacose J. C., Chemical Thermodynamics Classical, Statistical and Irreversible, Pearson Education India (2013)

Chemical Engineering Thermodynamics (0:0:2)

1. Determine calorific values of solid, liquid and gaseous fuels. (Bomb calorimeter)
2. Determine the heat capacity ratio at constant volume and constant pressure
3. Determine the ratio of volumes using isothermal process
4. Study of vapor Pressure of Liquids
5. To investigate the effect of sensor on target temperature
6. Concepts of pressure measurement and calibration investigation
7. Throttling Calorimeter
8. Determine the coefficient of performance and other parameters of a refrigerator (Refrigeration cycle unit)
9. Boyle-Marriott's Law Apparatus (Boyles Law Apparatus)
10. Joule-Thomson Coefficient Apparatus

BCT-30: Seminar

Course Category	: Audit Course (AC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 0, Tutorial:0
No of Credits	:4
Course Assessment Methods	: Continuous assessment quality of presentation, understanding, performance and analytical skill sets
Course Outcome	Students will be able to demonstrate: o knowledge of subject o presentation skills o writing skills o organization skills

Syllabus

The seminar may be a review of literature of specific phenomena/new process. Working model to demonstrate the principle, alternatively a small experimentation to investigate chemical engineering data/unit process/ unit operation. Based on this study focused report should be submitted. It is expected that the student collect information from reference books, journals and Internet. The report submitted should reveal the student's internalization of the collected information. Mere compilation from the net and other resources is discouraged.

Seminar report should be prepared based on guidelines provided by Department from time to time.

BCT-31: ALCOHOL TECHNOLOGY

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: Sugar Production (BCT-28)
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students are able to o fermentation basic o synthesis of alcohol from molasses o synthesis of alcohol from substrates and refined chemicals o chemicals from alcohol

UNIT I: Fermentation basic

Chemical and physical properties of alcohol, Classification of alcohols, Uses of alcohol, Alcohol synthesis by fermentation, Preferment design and practices. **[8 Lectures]**

UNIT II: Alcohol from molasses

Raw materials, molasses composition, molasses weighing, molasses dilution practices, pre-clarification of molasses, advantages and drawback, molasses sterilization/pasteurization, alcoholic fermentation- Batch fermentation, efficiency of fermentation, characteristics

Control in fermentation operation, contamination control, preventive measure to avoid alcohol loss. **[10 Lectures]**

UNIT III: Alcohol from Substrates and synthesis of refined chemicals

Substrate: Sugarcane and sugar beet molasses, rice, maize, wheat, apple, etc.

Manufacture of extra neutral alcohol, anhydrous alcohol, fuel, ethanol, reduction, blending and alcoholic beverages. **[9 Lectures]**

UNIT IV: Chemicals from alcohol

Acetaldehyde, Acetic acid, Acetic-Anahydride, Butanol, Ethyl acetate, Butyl acetate, acetone, Ethyl ether, Diethyl oxalate, etc. **[9 Lectures]**

Text Book:

1. Jacques K. A., Lyons T. P., KelsallD. R., 'The Alcohol Textbook', Nottingham University Press, 4thEdition (2003)
2. Satyanarayana Rao, 'Ethyl alcohol alcoholic beverages and alcoholometry', Pandith Publications (1983)
3. Chatterjee A.N., 'Handbook of Fermentation and Distillation',Maharashtra Sugar Research Foundation (1980)
4. Barron H., 'Distillation of Alcohol', Joseph E. Seagram & Sons (1944)
5. Paturao J. M.,'By-products of the Cane Sugar Industry', Elsevier, Amsterdam (1969)

Name of experiments (0:0:2)

1. Determination of residue on evaporation of whisky sample.
2. To carry out distillation of whisky sample
3. Determination of ethyl alcohol content of whisky by specific gravity method
4. Determination of Total acidity as acetic acid of whisky
5. To determine the volatile acidity whisky sample.
6. Determination of Aldehyde (as CH_3CHO) content of spirit (AOAC method)
7. Determination of Ester (as$CH_3COO\ C_2H_5$) content whisky
8. Fuel oil determination in spirit sample
9. Furfural determination in Rectified Spirit (ISI)
10. Determination of Methyl Alcohol (as CH_3OH) content of whisky
11. Reduction/ Blending of the spirit

BCT-32: MASS TRANSFER -II

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: Mass Transfer -I (BCT-27)
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students expected to design o distillation column o liquid-liquid and solid-liquid extraction column o adsorption column

UNIT 1: Distillation

Basics of distillation, Pressure-composition, Temperature-concentration, Enthalpy-concentration diagrams for ideal and non-ideal solutions, Raoult's law, boiling mixtures, volatility, Single Stage Distillation Differential distillation, Flash vaporization, Vacuum, molecular and steam distillation. **[9 Lectures]**

UNIT 2: Continuous distillation of binary mixtures

Multistage contact operations, multistage tower, McCabe Thiele method, PonchonSavarit method, Reflux, reflux, tray efficiency, height and column diameter calculation, Multistage batch distillation, Principles of azeotropic and extractive distillation. **[9 Lectures]**

UNIT 3: Liquid-liquid and solid-liquid

Liquid-Liquid Extraction: Ternary liquid equilibria, Triangular graph, theoretical or ideal stage, Equipment for single stage and multistage continuous operation, analytical and graphical solution of single and multistage operation.

Solid /Liquid Extraction: Leaching, Solid liquid equilibrium, Equipment for solid – liquid extraction, single and multistage cross current contact and counter current operations, concept of ideal stage, overall stage efficiency, number of stages determination. **[9 Lectures]**

UNIT 4: Adsorption

Basics of adsorption, Types of adsorption, Nature of adsorbents adsorption equilibria and adsorption hysteresis, Stage wise and continuous contact adsorption operations, determination of number of stages, Ion exchange, Equipment, Equilibrium relationship, Principle Ion exchange, Phase Equilibrium relationship, Rate of Ion-exchange. **[9 Lectures]**

Text Books:

1. Treybal R.,'Mass Transfer Operations', 3rdEditon, McGraw-Hill:New York, (1980).
2. Sherwood T. K., Pigford R. L. and Wilke P.,'Mass Transfer', McGraw Hill (1975)

Reference Books:

1. Leonard A. Wenzel, Curtis W. Clump, Louis Maus, L. Bryce Andersen Alan S. Foust, 'Principles of Unit Operations',2nd Edition, Wiley Interscience(1980).

2. Geankoplis, C.J. “Transport Processes and Unit Operations”, 3rdEditon, Prentice Hall. (1993)
3. Coulson, J. M. and Richardson J. F., “Chemical Engineering” Vol. I, II, IV & V: Pergamon Press.
4. Phillip C. Wankat, “Separation Process Engineering Includes Mass Transfer Analysis, 3rdEditon, Pearson

MASS TRANSFER LAB (0:0:2)

1. Determination of diffusivity of acetone in air.
2. Determination of diffusivity of acetic acid in water.
3. Determination rate of batch drying of CaCO3 powder.
4. Determination of rate of diffusion of spherical shape Naphthalene ball.
5. Determination of ternary curve for the system acetic acid-water-carbon tetrachloride.
6. Solid-Liquid extraction determine the equilibrium curve of extraction in toluene, acetic acid and water system
7. Determination of adsorption kinetics and isotherm at solid-liquid interface.
8. To find the percentage of oxalic acid leached from feed.

BCT-33: PROCESS DYNAMICS, CONTROL & INSTRUMENTATION

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	:5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students expected to o understand fundamentals of process instrumentation o understand working principals of measuring devices for pressure, temperature, level and flow o understand instrumental methods of chemical analysis o understand the basic principles of process dynamics and control

UNIT 1 Fundamentals of Process Instrumentation

Need and scope of process instrumentation, classification of process variables, measurement problem analysis, basic measurement terms, Functional elements of instruments, static and dynamic characteristics of measuring instruments (zeroth, first, and second-order instruments/ systems), measurement system configuration, transducer elements (types and classification) , digital signal transmission and processing, indicating and recording elements. **[9 Lectures]**

UNIT 2: Measuring Instruments

Instruments for measurements of temperature: thermocouples. Resistance thermometers, expansion thermometers, pyrometers, pressure and strain: hydrostatic type, elastic element type and other types of instruments like pressure gauges, level and flow measurements: variable area and variable head flow meters, volumetric and mass flow meters, linear velocity measurement systems. **[9 Lectures]**

UNIT 3: Instrumental Methods of Chemical Analysis

Introduction, classification, basic components of analytical instruments, viscosity measurement, Refractometry, Chromatographic methods: gas chromatography (GC), liquid chromatography (LC), high performance liquid chromatography (HPLC). Electrochemical methods: measurement of pH, colourimetric, conductometric, potentiometric. **[9 Lectures]**

UNIT 4: Fundamental of Process Dynamics and Control

Introduction to process dynamics (PD), mathematical tools for process, ideal forcing functions, control-relevant theoretical process modeling, transfer function and state-space models, poles and zeros of transfer function and their effect on dynamic response, block diagram representation, studying dynamic behavior of interacting and non-interacting systems.

[9 Lectures]

Text Book:

1. Coughnaowr, D. R., "Process Systems Analysis and Control", McGraw-Hill, Inc.
2. Stephanopolous, G., "Chemical Process Control", Prentice-Hall.
3. Patranabis, D, "Principles of Industrial Instrumentation", Tata McGraw-Hill Publishing Co. Ltd.
4. Johnson, C. D., "Process Control Instrumentation Technology", Pearson Education, Inc.

Reference Books:

1. Seborg, D. E., Edgar, T., and Mellichamp, D. A., "Process Dynamics and Control", John Wiley and Sons.
2. Bequette, B. W., "Process Control: Modeling, Design, and Simulation", Prentice-Hall, Inc.
3. Chidambaram, M., "Computer Control of Processes" Narosa Publishing House Pvt. Ltd., India
4. Beckwith, T. G., Marangoni, R. D. and Lienhard, J. H., "Mechanical Measurements", Addison Wesley.
5. Jain, R. K., "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi

PROCESS DYNAMICS AND CONTROL LAB (0:0:2)

1. Transient response to single tank system with storage & Flow to (a) step change (b) impulse change input (single tank system)
2. Transient response of non-interacting/interacting system in series. (Interacting & Non-Interacting System)
3. Two Tank Non-Interacting System with accessories.
4. Controlling a batch reactor using digital PID controller (characteristics of P.I.D. controller)
5. Two Tank Interacting System
6. Dynamics characteristics of mercury & water manometers (Time Constant of Manometer)
7. Measurement of Level by Capacitance Method
8. Calibration of thermocouple/ Bimetallic thermocouple/Resistance thermocouple (time constant of thermocouple & thermometer)
9. Calibration of Pressure gauge/ Pneumatic pressure recorder/ Differential pressure recorder (Pressure Control Trainer)
10. Calibration of Orifice meter/Venturimeter /Rotameter/ Gas flow meter (Flow Control Trainer).
11. Temperature Control Trainer
12. Calibration of pH meter/ conductivity meter
13. Level Control Trainer

BCT-34A CHEMICAL REACTION ENGINEERING - II

Course Category	: Department Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 1
No of Credits	: 5
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand concept of: o heterogeneous processes o diffusion control reactions o gas-solid and gas-liquid reactions o fluidized bed reactors

Unit - I: Heterogeneous Processes

Global rates of reaction. Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. Adsorption isotherms, Determination of surface area of a catalyst. Classification of catalyst, catalyst preparation. Catalyst deactivation. Langmuir Himshelwood and Eley – Rideal model. Rate equation when surface reaction, adsorption and desorption control. External Diffusion effects on heterogeneous catalytic reaction. Modeling diffusion without reaction **[9 Lectures]**

Unit - II: Diffusion control reactions

External resistance to mass transfer. Mass transfer limited reaction in packed beds. Diffusion and reaction in porous catalyst pellets. Effective diffusivity and effective thermal conductivity. Internal effectiveness factor. Thiele modules. Mass transfer and reaction in a packed bed reactor. Gas- solid non-catalytic reactions. **[9 Lectures]**

Unit - III: Gas – Solid/Gas-liquid reactions

Limitation of shrinking core model. Determination of the rate controlling step. Design of gas solid particle reaction. Gas – liquid reaction. Absorption combined with chemical reaction. Mass transfer coefficients and kinetic constants. Application of film penetration and surface renewal theories. Hatta number and enhancement factor for first order reaction. Tower reactor design. **[9 Lectures]**

Unit IV: Fluidized bed reactors

Phenomena of Fluidization, liquid like behaviour of fluidized beds, advantages and disadvantages of fluidized beds, different types of fluidized beds and its applications. Heat and Mass Transfer in Fluidized Beds: Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes. **[9 Lectures]**

References:

1. J. M. Smith, "Chemical Engineering Kinetics", McGraw Hill College, 3rd Edition (1981)
2. H. S. Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India Pvt Ltd, 4th Edition (2008)

3. O. Levenspiel, “Chemical Reaction Engineering”, John Wiley, 3rd Edition (2006)
4. C. G. Hill, “An Introduction to Chemical Engineering Kinetics & Reactor Design”, John Wiley, 2nd Edition (1994)
5. B. Viswanathan, S. Sivasanker, A. V. Ramaswamy, “Catalysis: Principles and Applications”, Alpha Science International, Ltd (2002)
6. R. A. Van Santen, Piet W. N. M. Van Leeuwen, Jacob A. Moulijn, Bruce A. Averill, “Catalysis: An Integrated Approach”, Elsevier Science, 2nd Edition (1994)
7. D. Kunii, O. Levenspiel, “Fluidization Engineering”, Butterworth-Heinemann, 2nd Edition (1991)

CHEMICAL REACTION ENGINEERING -II LAB (0:0:2)

1. Expanded Course description:
2. To study performance of CSTR connected in series
3. To study performance of PFR & CSTR in Series
4. R.T.D. Studies in Plug Flow Reactor
5. R.T.D. Studies in CSTR
6. R.T.D. Studies in Packed Bed Reactor
7. Semi Bath Reactor
8. Condensation Polymerization Reactor
9. Fluidized Bed Reactor
10. Modeling and simulation of CSTR
11. Modeling and simulation of PFR
12. Modeling of kinetic reactions

BCT-51: PROCESS INTEGRATION

Course Category	: Program Elective (PE1)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students will be able to: o understand of the fundamentals of process integration. o perform pinch analysis. o analyze and design heat exchanger networks. o minimize the water consumption and waste generation.

UNIT 1: Introduction to Process Integration

Areas of application and techniques available for PI, onion diagram, Role of thermodynamics in process design, Concept of pinch technology and its application. **[9 Lecturers]**

UNIT 2: Heat exchanger networks:

Heat exchanger networks analysis, Simple design for maximum energy recovery, Loop Breaking & Path Relaxation, Targeting of energy, area, number of units and cost, Trading off energy against capital. **[9 Lecturers]**

UNIT 3: Network and Mass Integration:

Super targeting, maximum energy recovery (MER), Network for multiple utilities and multiple pinches, Grand Composite curve (GCC). **[9 Lecturers]**

UNIT 4: Heat and Power Integration and Case studies:

Columns, Evaporators, Dryers, and reactors. Case studies: Waste and waste water minimization, Flue gas emission targeting. **[9 Lecturers]**

Text Books:

1. Linnhoff D.W., 'User Guide on Process Integration for the Efficient Use of Energy', Institution of Chemical Engineers (1994).
2. Smith R., 'Chemical Process Design and Integration', John Wiley & Sons(2005).

Reference Books:

1. Shenoy V. U., Heat Exchanger network synthesis, Gulf Publishing (1995).
2. Kumar, A., Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1977)

BCT-52: PIPING DESIGN

Course Category	: Program Elective (PE1)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students will be able to: o understand basic concept of piping engineering o do piping design, line sizing and NPSH calculations o calculate the piping insulation thickness and cost o understand P&ID diagrams, various piping layout

UNIT 1: Introduction to Piping Engineering

Fluid flow, types of fluids and examples, different pipe fittings. Friction factor, pressure drop for flow Newtonian and non-Newtonian fluids, pipe sizing, economic velocity. Pipe line networks and their analysis for flow in branches, restriction orifice sizing. Pressure drop calculations for non-Newtonian fluids. two phase flow, types of two phase flow, two phase flow as encountered in piping for steam, distillation column, pressure drop, vibrations in two phase flow. **[9 Lectures]**

UNIT 2: Piping System Design

Design principles, calculation of pipe diameter, thickness, important system characteristics and design principles related to steam flow at high and low pressures. Design principles and line sizing for vacuum pipelines, slurry pipelines, surge drums and flare stacks, vacuum devices including ejector system. Considerations governing pump selection, analysis of system and pump characteristics in connection with series, parallel flow, and minimum flow and equalizing lines, NPSH, allowable nozzle loads in various codes. Design principles and line sizing of pneumatic conveying of solids, components of conveying systems, dust and fume extraction systems principles. **[9 Lectures]**

UNIT 3: Insulation and Costing of Piping

Purposes of thermal insulation, principles of conductive and convective heat transfer to the extent of application to heat loss / gain through bare pipe surfaces. Critical thickness of insulation, estimating thickness of insulation, optimum thickness of insulation. Insulation for hot and cold materials and their important properties, insulation material selection criteria, typical insulation specification – hot and cold materials. **[9 Lectures]**

UNIT 4: Piping Layout

Introduction to P & I Diagrams, Process flow diagrams, standard symbols and notations. Introduction to various facilities required guidelines for Plot Plan / Plant Layout. Introduction 18 to equipment layout, piping layout, piping isometrics and bill of material. Typical piping system layout considerations for following systems: (i) Distillation columns and heat exchangers, (ii) Reactors, (iii) Pipe racks, (iv) Storage tanks, (v) Pumps **[9 Lecturers]**

Reference Books:

1. Mcketta J. J., 'Piping Design Handbook' Marcel Dekker, Inc, New York.

2. Bausbacher Ed., Hunt R., ‘Process plant layout and piping design’ PTK Prentice Hall Publication
3. Nayyar M., ‘Piping Handbook’, McGraw-Hill Education.
4. Parisher R. A., Rhea R. A., ‘Pipe Drafting and Design’ ASME

BCT-53: Statistical Design of Experiments

Course Category	: Program Elective (PE1)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students will be able to understand: o basic concept of design of experiment o and apply concept of factorial design o concept of regression model and response surface methodology o model effects and design measure

UNIT 1: Introduction to Design of Experiment

Introduction to experimental design principles, simple comparative experiments, introduction to R language and its applications in DOE problems. Single factor experiments, randomized blocks, Latin square designs and extensions, introduction to R language. **[9 Lectures]**

UNIT 2: Factorial Designs

Two levels, 2^k factorial designs, confounding and blocking in factorial designs, applications to manufacturing problems. Fractional factorial designs, two-level, three-level and mixed-level factorials and fractional factorials, applications to quality control problems **[9 Lectures]**

UNIT 3: Regression Models and Response Surface Methodology

Regression models including multiple regression models and its application to transportation scheduling problems. Response surface methodology, parameter optimization, robust parameter design and its application to control of processes with high variability. **[9 Lectures]**

UNIT 4: Model Effects and Design Measures

Random and mixed effects models, nested and split plot and strip plot designs and its application to semiconductor manufacturing problem. Repeated measures design, analysis of covariance and its applications in comparing alternatives. **[9 Lecturers]**

Reference Books:

1. Montgomery D. C., 'Design and Analysis of Experiments', John Wiley & Sons (2001)
2. Dean A. M., Voss D. T., 'Design and Analysis of Experiments' Springer text in Statistics, Springer Science + Business Media (1999)
3. Box G. E. P., Hunter W. G., Hunter J. S., Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building, John Wiley & Sons (1978).
4. Diamond W. J., Practical Experiment Designs for Engineers and Scientists, John Wiley & Sons. Inc. (2001).
5. Jeff Wu C. E., Hamada M. I., Experiments: Planning, Analysis, and Parameter Design Optimization, John Wiley & Sons. Inc. (2000).

BCT-54: Process Flow Sheet Simulation

Course Category	: Program Elective (PE1)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students will be able to: o understand basic concept of process flowsheeting o understand concept of system engineering o select thermodynamic properties o do model and sensitivity analysis

UNIT 1: Introduction to Process Flow Sheeting

Approaches to flow-sheeting, collection and estimation of thermo-physical properties for the chemical species of the system, thermo-physical properties banks, Flow sheet presentation, manual flow sheet calculations, computer aided flow-sheeting, manual calculations with recycle streams, partitioning and tearing a flowsheet. **[9 Lectures]**

UNIT 2: Fundamentals of System Engineering

system definition, system properties, aggregation/decomposition, hierarchies of systems; introduction of canonical modelling concepts: devices, connections, equations, variables; formalizing the modelling process: methods of structuring complex chemical processes, procedures for process modelling; degrees of freedom in a flow sheet. numerical properties of the model equations, numerical methods for steady-state and dynamic systems, Differential Algebraic Equations; Synthesis of reaction systems and synthesis of azeotropic separation systems **[9 Lectures]**

UNIT 3: Thermodynamic properties selection

Overview of physical property system; Property model specifications; Property data requirements and input; Physical property analysis; Example-1: Introducing a non-databank component. Multistage Separation: RADFRAC: Rigorous rating and design fractionation model **[9 Lectures]**

UNIT 4: Model Analysis and Sensitivity

Model Analysis Tools: Sensitivity and case-study runs; Design specifications and calculator blocks; Example-3: VCM flowsheet sensitivity run / design-spec run. Inorganic chemicals and electrolyte modelling; Example-4: sour water systems (CO_2 and H_2S removal for example) **[9 Lecturers]**

Reference Books:

1. Dimian A. C., 'Integrated Design and Simulation of Chemical Processes', Elsevier (2003)
2. Westerberg A. W., Hutchison H. P., Motard R. L. & Winter, P., 'Process Flowsheeting', Cambridge University Press (1979)
3. Kumar, A., 'Chemical Process Synthesis and Engineering Design', Tata McGraw Hill (1981).

4. Hangos K. M., Cameron I. T., ‘Process Modelling and Model Analysis’, Academic Press (2001).
5. Ramirez W. F., ‘Computational Methods for Process Simulation’, 2nd ed., Butterworths (1997)
6. Westerberg A.W., ‘Process Flow Sheeting’, Cambridge University Press (1990)

BCT-55: Food Technology

Course Category	: Program Elective (PE1)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1
No of Credits	:4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test and one major theory and practical test.
Course Outcome	Students will be able to understand: o basic principal of food processing o applications of unit operation in food engineering o concept in packing for various food commodities o importance of food quality assurance

UNIT 1: Principal of Food Processing

Scope and importance of food processing. principles and methods of food preservation freezing, heating, dehydration, canning, additives, fermentation, irradiation, extrusion cooking, hydrostatic pressure cooking, dielectric heating, microwave processing, storage of food, modified atmosphere packaging. Refrigeration, freezing and drying of food, minimal processing, radiation processing **[9 Lectures]**

UNIT 2: Unit Operations in Food Engineering

Unit operation in food engineering processing of food grains, theory of size reduction equipment and effect of size reduction on foods, evaporation extrusion, hot air dehydration, baking, roasting and hot oil frying theory, equipment, applications and effect on food materials for freezing / freeze drying and freeze concentration. **[9 Lectures]**

UNIT 3: Food Packaging

Introduction to packaging. packaging operation, package-functions and design. principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods for prevention, shelf life of packaged foodstuff, methods to extend shelf-life. food containers-rigid containers, corrosion of containers (tin plate). Flexible packaging materials and their properties. food packaging materials and their properties. Food packages-bags, pouches, wrappers, carton and other traditional package, containers-wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks.

[9 Lectures]

UNIT 4: Food Quality Assurance

Objectives, importance and functions of quality control. methods of quality, concepts of rheology, assessment of food materials-fruits, vegetables, cereals, dairy products, meat, poultry, egg and processed food products. food regulations, grades and standards, concept of Codex Almentarious/HACCP/USFDA/ISO 9000 series etc. Food adulteration and food safety, basis, trends and composition of India's foreign trade. **[9 Lecturers]**

Reference Books:

1. Mirajkar M., Food Science and Processing Technology Vol I & II, Kanishka Publishers, New Delhi
2. Heldman, D.R. and Lund, D. B., Handbook of Food Engineering', Marcel Dekker, New York (1992).
3. Ranganna S., 'Handbook of Analysis and Quality Control for Fruits and Vegetable Products', Tata McGraw Hill, New Delhi (1986).
4. Painy F. A., Painy, H.Y., 'A Handbook of Food Packaging', Leonard Hill, Glasgo, UK (1983).
5. Salunkhe D. K., Kadam S. S., 'Handbook of Vegetable Science and Technology, Production, Composition, Storage and processing', Marcel Dekker, New York (1995)

BCT-41: PROCESS EQUIPMENT DESIGN

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 2
No of Credits	: 5
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected to: o design non-pressure and pressure vessels o design tall vessels and support o design shell and tube heat exchangers o mechanical design of distillation and absorptions columns

UNIT I: Design Pressure Vessels

Design of non-pressure storage vessel, tall vertical vessels, unfired pressure vessels with internal pressure, Design of unfired pressure vessels with external pressures, end closures, flat plates, domed ends, torispherical, ellipsoidal, hemispherical and conical ends.

[9 Lectures]

Unit II: Design Tall Vessels and support

Stresses in the shell of a tall vertical vessel, and period of vibration, vessel supports introduction and classification of supports, design of skirt supports considering stresses due to dead weight, wind load, seismic load, design of base plate, skirt bearing plate, anchor bolts, bolting chairs and skirt shell plates Design of saddle supports, ring stiffeners.

[9 Lectures]

Unit III: Design of Heat Exchangers

Classification of shell and tube heat exchanger, material of construction, cleaning of heat exchangers, heat transfer fluid, agitated vessels, description of shell, tubes, bonnet and channel, pass partition plate, nozzle, baffles, tie rods, baffle spacers, flanges, gaskets and expansion joints. Design of heat exchangers: Energy balance, heat duty consideration and process design of double pipe and shell and tube heat exchangers. **[10 Lectures]**

Unit IV: Design of mass transfer equipment

Mechanical design of tall vessels for distillation and absorption columns, packed and tray type towers. Tray Hydraulics: Bubble cap columns, perforated plate columns and packed towers. Process Design: Process design of tray and packed towers. **[10 Lectures]**

References:

1. Kern D. Q., "Process Heat Transfer", McGraw Hill, (2001).
2. Perry's, "Handbook of Chemical Engineering" McGraw Hill, 7th Edition, (1997).
3. Coulson J. M., Richardson R. E., "Chemical Engineering" Vol. 2 and 6, Pergamon Press (1998).

4. Van Winkle M., “Distillation”, McGraw Hill Company, New York (1967).
5. Ludwig E. E., “Applied Process Design for Chemical and Petrochemical Plants”, Vol. 1, 2 and 3, 3rd Edition, Gulf Publishing Company, Houston, (1995).
6. Bhattacharya B. C., “Chemical Equipment Design”, CBS Publisher, (1985).
7. Sinnott R. K., Coulson & Richardson, “Chemical Engineering, Vol.6”, 2nd Edition, Butterworth Heinemann, Oxford, (1998).

Practical:

1. Practice to design any four equipment’s based on syllabus ‘to scale’ using AutoCAD software

2. Prepare specification datasheets for following equipment Vessel data sheet

a. Heat exchanger data sheet
b. Plate heat exchanger data sheet
c. Centrifugal pump data sheet
d. Reciprocating pump data sheet
e. Rotary positive pump data sheet
f. Agitator data sheet

BCT-42: ENERGY RESOURCES & APPLICATIONS

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected to understand concept of: o energy scenario and conservation o alternative sources of energy o hydro and nuclear energy o fossil and processed fuels

Unit I: Energy Scenario and Conservation

Indian and global, energy crisis, Classification of various energy sources, Renewable and non-renewable energy sources, Remedial measures to some energy crisis.

Energy: Biogas plants and their operation, Biomass and its conversion routes to gaseous and liquid fuels. Wind energy, its potential and generation by wind mills **[9 Lectures]**

Unit II: Alternative Sources of Energy

Fuel cell, Solar Energy: Photo thermal and photovoltaic conversion and utilization methods, solar water heating, cooking, drying and its use for other industrial processes, solar cells their material and mode of operation. Direct and indirect methods solar energy storage, sensible heat and latent heat storage materials Solar ponds

Bio energy, biogas plants and their operation, biomass and its conversion roots to gaseous and liquid fuels, wind energy, its potential and generation by wind mills **[9 Lectures]**

Unit III: Hydro and Nuclear Energy

Hydroelectric potential, its utilization & production, Geothermal energy its potential status and production, Nuclear energy: Status, nuclear raw materials, nuclear reactors and other classification, Generation of Nuclear power, Nuclear installations in India and their capacity of generation, Limitations of nuclear energy, Reprocessing of spent nuclear fuel **[9 Lectures]**

Unit IV: Fossil and Processed Fuel

Coal its origin and formation, Coal analysis, Coal classification, Coal preparation, Coal washing and coal blending, Coal carbonization, Treatment of coal gas and recovery of chemical from coal tar, Coal gasification, liquid fuel synthesis from coal, CBM.

Petroleum crude, Types of crude, emergence of petroleum products as energy, Gaseous Fuels: Natural gas, Water gas, producer gas, L.P.G., bio- gas, coke oven gas, blast furnace gas, LNG, CNG, Gas hydrates, GTL Technology. **[9 Lectures]**

References:

1. N. K. Bansal, M. K. Kleeman, "Renewable Sources of Energy and Conversion Systems", McGraw-Hill Education (1989).
2. J. A. Duffie, W. A. Beckman "Solar Engineering of Thermal Processes", Wiley Interscience, 2nd Edition (1991)
3. J. F, Kreider, "Solar Energy Handbook", McGraw Hill (1981)
4. M. A. Green, "Solar Cell: Operating Principles, Technology and System Applications", University of New South Wales (1986)
5. T. Ohta, "Solar Hydrogen Energy Systems", Pergamon Press (1979)
6. D. O. Hall, R. P. Overeed, "Biomass Regenerable Energy", Wiley Interscience (1989)
7. Linden, "Handbook: Batteries and Fuel cell", – (McGraw Hill)
8. L. L. Freris, "Wind energy Conversion Systems", Prentice Hall (1990)
9. J. S. S. Brame, J. G. King, E. Arnold, "Fuel Solid, Liquid and Gases", Wiley Interscience, 4th Edition (2007).
10. S. P. Sukhatme, "Solar Energy - Principles of Thermal Collection and Storage", Tata McGraw- Hill., 2nd Edition (1996).

BCT-43: CHEMICAL CONTROL IN SUGAR PLANT

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected to: o understand concept of dynamic behaviour of simple processes o design of single loop feedback control systems o do stability analysis of feed back systems o understand frequency response and analysis linear processes

UNIT-I: Dynamic behaviour of simple processes

Mathematical modeling of chemical processes, State variables and state equations, Input-Output model, Linearization of nonlinear systems, Types of Forcing functions, dead-time systems, First order systems processes, Dynamic response of first order system to impulse and step inputs, basic concepts of MIMO systems. **[9 Lectures]**

Unit II: Design of single-loop feedback control systems

Second order systems/processes: Damped vibrator, Interacting and Non-interacting systems, Step response of second order system, Characteristics of under-damped system. Classical controllers: P, PI, PD, PID and ON- OFF controllers. Concept of feed-back control system, Servo & Regulatory problem, Block diagram reduction of complicated control systems, and Dynamic behaviour of feed-back control processes. **[9 Lectures]**

Unit III: Stability Analysis of feed-back systems

Stability analysis of feedback control system using Routh-Hurwitz criteria, Root locus. Time Integral performance criteria by ISE, IAE, ITAE, selection of feed-back controller, Controller tuning using process reaction curve by Cohen-coon technique Response of first order system to sinusoidal input, Frequency response characteristics of general linear system, Bode diagrams - First order system, Second order system **[9 Lectures]**

Unit IV: Frequency response analysis of linear processes

Pure capacitive process, dead time system, P, PI, PD & PID, bode stability criteria, Gain margin, Phase Margin, Nyquist Stability criteria, Ziegler Nicholes Tuning technique, Design of controllers with difficult dynamics such as large time-delay systems, inverse response systems. Analysis and design of control systems with multiple loops: cascade, selective, split range control systems, Analysis and design of advanced control systems: feed forward, ratio, adaptive and inferential control systems. **[9 Lectures]**

References

1. G. Stephanopoulos, “Chemical Process Control: An Introduction to Theory and Practice”, Prentice Hall India Learning Private Limited (2008)
2. D. R. Coughanour, “Process System Analysis & Control”, Mc Graw Hill, 3rd Edition (2013)
3. B. Wayne Bequette, “Process Control Modelling, Design & Control”, PHI Publication (2003)
4. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, “Process Dynamics & Control”, Wiley Interscience (1989)
5. Babatunde A. Ogunnaike, W. Harmon Ray, “Process Dynamics, Modeling & Control”, Oxford University Press Inc. (1994)
6. M. Chindambaram, “Computer Control of Processes”, Alpha Science International Ltd. (2002)
7. Bella G. Liptak, “Instrument Engineers Handbook (Process Control)”, CRC Press, 4th Edition (2003)

BCT-61: FERTILIZER TECHNOLOGY

Course Category	: Program Elective (PE-2)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected understand manufacturing and applications: o potassic fertilizer o nitrogenous fertilizer o phosphatic fertilizer o NPK and miscellaneous fertilizer

Unit – I: Overview and Potassic Fertilizer

Role of organic manures and chemical fertiliser, types of chemical fertiliser, growth of fertiliser in India; their location; energy consumption in various fertiliser processes; materials of various fertiliser processes; materials of consumption in fertiliser industry.

Potassic Fertilisers: Methods of production of potassium chloride, potassium schoenite, their characteristics and specifications. **[9 Lecture]**

Unit – II: Nitrogenous Fertilisers

production of ammonia-natural gas, associated gas, coke-oven gas, naphtha, fuel oil, petroleum heavy stock, coal, electricity etc; processes for gasification and methods of production of ammonia and nitric acid; nitrogenous fertiliser-ammonium sulphate, nitrate, urea and calcium ammonium nitrate; ammonium chloride and their methods of production, characteristics and specifications, storage and handling. **[9 Lecture]**

Unit – III: Phosphatic Fertilisers

Raw materials, processes for sulphuric and phosphoric acids, phosphates fertilisers - ground rock phosphate; bone meal-single superphosphate, triple superphosphate, triple superphosphate, thermal phosphates and their methods of production, characteristics and specifications. **[9 Lecture]**

Unit - IV: NPK and Miscellaneous fertilizer

NPK Fertilisers: Methods of production of ammonium phosphate, sulphate diammonium phosphate, nitro-phosphates, urea, ammonium phosphate, mono-ammonium phosphate and various grades of NPK fertilisers produced in the country.

Miscellaneous Fertilisers: Mixed fertilisers and granulated mixtures; bio-fertilisers, nutrients, secondary nutrients and micro nutrients, fluid fertilisers, controlled release fertilisers, controlled release fertilisers. **[9 Lecture]**

References:

1. “Handbook of fertiliser technology”, Association of India, New Delhi, 1977.
2. M. G. Menon, “Fertiliser Industry - An Introductory Survey”, Higginbothams Pvt. Ltd., (1973).
3. V. Sauchelli, “The Chemistry and Technology of Fertilisers, ACS Monograph No. 148”, Reinhold Publishing Corporation, Newyork (1980).
4. A.V. Slack, “Chemistry and Technology of Fertilisers”, Interscience, New York (1966).

BCT-62: NUCLEAR ENGINEERING

Course Category	: Program Elective (PE-2)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected understand fundamentals of: o nuclear physics o nuclear reactor o nuclear fuels o safety o safe dispose of nuclear waste

Unit - I: Nuclear Physics

Nuclear model of an atom-Equivalence of mass and energy-binding- radio activity-half life-neutron interactions-cross sections. **[9 Lectures]**

Unit - II: Nuclear Reactions, Reaction Materials and Reprocessing

Mechanism of nuclear fission and fusion- radio activity- chain reactions-critical mass and composition-nuclear fuel cycles and its characteristics-uranium production and purification-Zirconium, thorium, beryllium.

Reprocessing: nuclear fuel cycles-spent fuel characteristics-role of solvent extraction in reprocessing-solvent extraction equipment. **[9 Lectures]**

Unit - III: Nuclear Reactor

Types of fast breeding reactors-design and construction of fast breeding reactors-heat transfer techniques in nuclear reactors- reactor shielding. Fusion reactors. **[9 Lectures]**

Unit - IV: Safety and Disposal

Safety and disposal: Nuclear plant safety-safety systems-changes and consequences of accident-criteria for safety-nuclear waste-types of waste and its disposal-radiation hazards and their prevention-weapons proliferation. **[9 Lectures]**

References:

1. Thomas J. Cannoly, "Foundation of nuclear Engineering" John Wiley (1978).
2. G. F. Hewitt, J. G. Collier, "Introduction to Nuclear power", CRC Press, 2nd Edition (2000)
3. M. M. El-Wakil, "Power Plant Technology", McGraw-Hill Education (2017).
4. G. Vaidyanathan, "Nuclear Reactor Engineering (Principles and Concepts)", S. Chand & Co. (2013)

BCT-63: COMPUTATIONAL FLUID DYNAMICS

Course Category	: Program Elective (PE-2)
Pre-requisite Subject	: BCT-11
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected to: o understand basic governing equations in fluid mechanics o understand mathematical models for incompressible flow o solve linear differential equation using numerical methods o solve Navior stokes equation using numerical method

Unit- I: Governing equations of fluid mechanics

Conservation equations for mass, momentum, energy and chemical species, Governing equations, Boundary conditions: turbulence closure and mass transfer models, Dimensionless analysis of simplified equations.

Unit - II: Mathematical models for incompressible flow

Euler equations, Potential flow, Boundary Layer Approximations, Mathematic classification of flows: Hyperbolic, Parabolic, Elliptical and Mixed Flow. Numerical Methods: Finite difference method, Solution of Linear Equation Systems.

Unit - III: Linearization of governing equations and numerical solution

Linear wave equation, Burgers equation, Convection diffusion equation, First and second order numerical methods: Lax-Frederichs, Lax_Wendroff, MacCormack. Implicit and explicit schemes, Finite difference method for the momentum equations, boundary conditions for the velocity.

Unit - IV: Numerical Solution of Navier Stokes and Euler Equation

Mixed variational form: Galerkin and Finite Element approximations

References:

1. J. H. Ferzige, M. Peric, "Computational Methods for Fluid Dynamics", Springer-Verlag Berlin and Heidelberg GmbH & Co., 3rd Edition (2002)
2. D. A., Anderson, J.C. Tanneheil, R.H. Fletcher, Computational Fluid Mechanics and Heat Transfer, Hemisphere, New York (1984).
3. R. Peyret, T. D. Taylor, "Computational Methods for Fluid Flow", Springer Verlag (1983)

4. G. D. Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Clarendon Press, Oxford, 3rd Edition (1986)
5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press (1980).
6. R. B. Bird, R. C. Armstrong, O. Hassagar, Dynamics of Polymeric Liquids, John Wiley, New York (1987).

BCT-40 PROJECT PART-I

Course Category	: Project (P)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 0, Tutorial:0, Practical: 10
No of Credits	: 5
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to: o demonstrate a sound technical knowledge of their selected project topic. o undertake problem identification, formulation and solution. o design engineering solutions to complex problems utilising a systems approach. o do thermodynamic feasibility, material and energy balance of process block diagram o design and optimize major equipment's in the selected project o demonstrate the skills, knowledge, and attitudes of a professional engineer.

The student can also choose a state-of-the-art problem of their own interest based on the recent trends in Chemical Engineering / Science in consultation with the guide. They shall work on the designated problem either individually or in groups (no of students in groups decides by faculty).

During the first term the students are required to:

1. Define the project problem.

2. Write a project proposal including concise introduction of latest published papers in the following order– a. Project title b. Introduction c. Origin of the problem d. Literature review of research and development at national & international level e. Significance of the problem f. Objective g. Methodology h. Details of collaboration (if any)

3. Carry out preliminary investigations if any or product design or process design etc.

4. Summarize the results (if any). The student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. The progress report is to be duly signed by the respective project guide by giving the remarks/marks/grades etc. on the periodic progress done by the student should submit the project report at the end of respective terms to the examiners as a supporting document for evaluation.

Every student will be examined orally based on the topic of his/her project and relevant area to evaluate his understanding of the problem and the progress made by the student during the term. Students should submit a neatly typed and spiral bound research proposal at the end of

the first term in the following format. Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc. Referencing style: 1. Guo J. X. and Gray D. G., Chiroptical behaviour of (acetyl)(ethyl)cellulose liquid-crystalline solutions in chloroform, Macromolecules, 22, (1989), 2086. (Reference numbers should be mentioned in the main text as a superscript) The proposal should contain: 24 Page 1: The cover page - should mention: Project title, Name of the student, Name of the guide, Exam seat number and Year. Page 2: Certificate Page 3: Index Page 4 onwards: Research proposal (as above), experimental investigation details and result if any. Last page: References The department should prepare a template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports. Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide.

Note: The project guides are required to educate the students about antiplagiarism policy of MMMUT and apply the same while doing the project.

BCT-45 INDUSTRIAL/PRACTICAL TRAINING

Course Category	: Audit Course (AC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 0, Tutorial:0, Practical: 0
No of Credits	: 0
Course Assessment Methods	: Continuous assessment through presentation and industrial training in sugar and chemical industries
Course Outcome	Students are expected to: o understand actual process plant o correlate theoretical and practical knowledge o analyse the problems in industries o develop life long learning skills

Students are required to undertake Industrial Training in Sugar Industry after 5th Term for 10 days and reputed Process Chemical Industry after 6th term for 45-50 days. Department will allot a Mentor to every student who will monitor the activity of a student during Industrial Training. The Mentor/Teacher shall guide and supervise the activities of the student while the student is undergoing Industrial Training. The Industrial Training report is to be prepared in consultation with the Mentor/Teacher and industry. Students are required to submit neatly typed and spiral bound training report after joining the college within month in 7th Term. The department will arrange a presentation session for all the students to share their experience during the Industrial training at the start of the term. The report should include information about working of the industry and specific information of the work done by the student in the industry. The students are also required to attach an Original Certificate issued by the competent authority from the industry where he/she has undergone training mentioning the successful completion of the training. The report must be duly signed by his/her Mentor. The student is required to present the report of the skills / knowledge acquired by her/him during the training for his industrial training evaluation/TW. Report should be prepared as the guidelines of Department.

BCT-46: CHEMICAL ENGINEERING DESIGN

Course Category	: Departmental Core (DC)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 0
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through tutorials, attendance, home assignments, quizzes and one minor test, one major theory and practical test.
Course Outcome	Students are expected to: o understand concept of dynamic behaviour of simple processes o design of single loop feedback control systems o do stability analysis of feed back systems o understand frequency response and analysis linear processes

Unit 1: Agitators and Reaction vessels

Types of agitators, their selection, applications, baffling, agitator shaft diameter calculations which includes twisting moment, equivalent bending moment, power requirement calculations for agitation systems.

Reaction vessels: classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil, study and design of internal coil reaction vessels, heat transfer coefficients in coils. **[9 Lecture]**

Unit 2: Design of evaporators and reboilers

Evaporators: classification, criteria for selection, design of calendria type evaporator.

Condensers: heat transfer fundamentals, condensation outside horizontal tubes, condensation inside and outside vertical tubes, condensation inside horizontal tubes, condensation of mixtures.

Reboilers: types, selection, boiling heat transfer fundamentals, estimation of boiling heat transfer coefficients, pool boiling, convective boiling **[9 Lecture]**

Unit 3: Design of auxiliary Process Vessel

reflux drum, knockout drum, liquid-liquid and gas-liquid separators, entrainment separators, oil water separator, decanter, gravity separator, design of safety devices **[9 Lecture]**

Unit 4: Optimisation of Process Equipment and Plant Utilities

Optimization of heat exchangers, evaporators, mass transfer equipment and reactors. Pinch technology analysis. Plant utilities: Air, water, steam **[9 Lecture]**

References

1. L.E. Brownell, E. Young "Process equipment design" John Wiley, New York (1963).
2. B.C. Bhattacharya, "Introduction to Chemical Equipment Design", C. B. S. Publications (2011).
3. V. V. Mahajani, S B Umarji, "Joshi's Process Equipment Design", Laxmi Publications Pvt Ltd. (2017)

4. J. M. Coulson, J. F. Richardson, R. K. Sinott, “Chemical Engineering Vol. VI”, Pergamon Press, 5th Edition (2012).
5. Treyball R. E., “Mass Transfer Operations”, McGraw Hill India, 3rd Edition (2012).
6. S. M. Walas, B. w. Heinamer, “Chemical Process Equipment-Selection and design”, Butterworths (1988).
7. E. E. Ludwig, “Applied Process Design for Chemical and Petrochemical Plants, Vol I&II”, Gulf publishing Co. Publishing Company, Texas, 4th Edition (2007)

BCT-50 PROJECT PART-II

Course Category	: Project (P)
Pre-requisite Subject	: BCT-40
Contact hours/week	: Lecture: 0, Tutorial:0, Practical: 10
No of Credits	: 5
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to: o demonstrate a sound technical knowledge of their selected project topic. o undertake problem identification, formulation and solution. o design engineering solutions to complex problems utilising a systems approach. o do thermodynamic feasibility, material and energy balance of process block diagram o design and optimize major equipment's in the selected project o demonstrate the skills, knowledge, and attitudes of a professional engineer.

During the second term (Project Part-II) the students are required to:

1. Carry out detailed work on previously defined (Project Part-I) project problem.

2. Write a Project Report, which should be broadly divided into the following sections define by the supervisor

Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc.

Referencing style: *2. Guo J. X. and Gray D. G., Chiroptical behavior of (acetyl)(ethyl)cellulose liquid-crystalline solutions in chloroform, Macromolecules, 22, (1989), 2086*. (Reference numbers should be mentioned in the main text as a superscript)

The Project Report should contain in the following order:

1. The cover page –must mention: Project title, Name of the student(s), Name of the guide, Exam seat number and Year.
2. Certificate from guide
3. Certificate from industry (if any)
4. Index
5. Detailed Project Report having sections 'a' to 'g' from above.

The student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. ***The progress report is to be duly signed by the respective project guide by giving the remarks/marks/grades etc***. on the periodic progress done by the student at the mid of the term and should be submitted along with project report at the end of respective terms to the examiners as a supporting document for evaluation.

Each student is required give presentation of his work for 20 minutes using 20-22 slides. The presentation will be followed by question answer session of 5 min. The department/university will provide template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports.
Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide.

Note: Students must check plagiarism policy of MMMUT and apply the same while doing the project.

BCT-71 HETEROGENEOUS CATALYSIS & MULTIPHASE REACTOR DESIGN

Course Category	: Program Elective – III/IV (PE-III/IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand concept of: o heterogeneous processes o diffusion control reactions o gas-solid and gas-liquid reactions o fluidized bed reactors

Unit - I: Heterogeneous Processes

Global rates of reaction. Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. Adsorption isotherms, Determination of surface area of a catalyst. Classification of catalyst, catalyst preparation. Catalyst deactivation. Langmuir Himshelwood and Eley – Rideal model. Rate equation when surface reaction, adsorption and desorption control. External Diffusion effects on heterogeneous catalytic reaction. Modeling diffusion without reaction **[9 Lectures]**

Unit - II: Diffusion control reactions

External resistance to mass transfer. Mass transfer limited reaction in packed beds. Diffusion and reaction in porous catalyst pellets. Effective diffusivity and effective thermal conductivity. Internal effectiveness factor. Thiele modules. Mass transfer and reaction in a packed bed reactor. Gas- solid non-catalytic reactions. **[9 Lectures]**

Unit - III: Gas – Solid/Gas-liquid reactions

Limitation of shrinking core model. Determination of the rate controlling step. Design of gas solid particle reaction. Gas – liquid reaction. Absorption combined with chemical reaction. Mass transfer coefficients and kinetic constants. Application of film penetration and surface renewal theories. Hatta number and enhancement factor for first order reaction. Tower reactor design. **[9 Lectures]**

Unit IV: Fluidized bed reactors

Phenomena of Fluidization, liquid like behaviour of fluidized beds, advantages and disadvantages of fluidized beds, different types of fluidized beds and its applications. Heat and Mass Transfer in Fluidized Beds: Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes. **[9 Lectures]**

References:

8. J. M. Smith, "Chemical Engineering Kinetics", McGraw Hill College, 3rd Edition (1981)
9. H. S. Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India Pvt Ltd, 4th Edition (2008)

10. O. Levenspiel, “Chemical Reaction Engineering”, John Wiley, 3rd Edition (2006)
11. C. G. Hill, “An Introduction to Chemical Engineering Kinetics & Reactor Design”, John Wiley, 2nd Edition (1994)
12. B. Viswanathan, S. Sivasanker, A. V. Ramaswamy, “Catalysis: Principles and Applications”, Alpha Science International, Ltd (2002)
13. R. A. Van Santen, Piet W. N. M. Van Leeuwen, Jacob A. Moulijn, Bruce A. Averill, “Catalysis: An Integrated Approach”, Elsevier Science, 2nd Edition (1994)
14. D. Kunii, O. Levenspiel, “Fluidization Engineering”, Butterworth-Heinemann, 2nd Edition (1991)

BCT-72 PETROLEUM ENGINEERING

Course Category	: Program Elective – III & IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand of: o crude oil evaluation testing and cracking o treatment processes for crude oil purification o cracking of naphtha and gas o isomerization, alkylation and polymerization processes

Unit - I: Crude and Cracking

Composition of crude and classification of crude oil, evaluation of crude oil and testing of petroleum products, refining of petroleum, atmospheric and vacuum distillation, thermal cracking, vis-breaking, coking – catalytic cracking (FCC), hydrocracking, air blowing of bitumen. **[9 Lectures]**

Unit - II: Treatment of Crude oil

Treatment techniques for removal of sulphur compounds to improve performance, production and treatment of LPG, LNG technology, sweetening operations for gases including merox, ethanolamine, copper chloride, etc., storage and stability, product treatment processes – various solvent treatment processes, dewaxing, clay treatment and hydrofining. **[9 Lectures]**

Unit - III: Cracking of naphtha and gas

Cracking of naphtha and gas, catalytic reforming of petroleum feed stocks, extraction of aromatics, next generation processes, thermal cracking process, catalytic cracking processes: fluid catalytic cracking process, shell FCC process, S&W fluid catalytic cracking process, hydrogen addition processes, asphaltenic bottoms cracking process, hydrovisbreaking (hycar) process, solvent processes, deasphalting process, deep solvent deasphalting process, demax process. **[9 Lectures]**

Unit - IV: Isomerization, alkylation and polymerization

Petrochemicals production: dimethyl terephathalate (DMT), ethylene glycol, synthetic glycerine, linear alkyl benzene (LAB), acrylonitrile, methyl methacrylate (MMA), vinyl acetate monomer, phthallic anhydride, maleic anhydride, phenol, acetone, methanol, formaldehyde, acetaldehyde and pentaerythritol, production of carbon black. **[9 Lectures]**

References

1. B. K. Bhaskara Rao, "Modern Petroleum Refining Processes", Oxford and IBH Publishing Company, New Delhi, 2nd Edition (1990).
2. W. L. Nelson, "Petroleum Refinery Engineering", McGraw Hill, New York, 4th Edition (1995).

3. B. K. Bhaskara Rao, “A Text on Petrochemicals”, Khanna Publishers, New Delhi, 1st Edition (1987).
4. C. S. Hsu, P. R. Robinson, “Practical Advances in Petroleum Processing: Volume I & II”, Springer Publications (2006).
5. G. N. Sarkar, “Advanced Petroleum Refining”, Khanna Publishers (2008).
6. R. E. Maples, “Petroleum Refinery Process Economics”, PennWell Corporation (2000)
7. R. Prasad, “Petroleum Refining Technology”, Khanna Publishers (2010).

BCT-73 POLYMER SCIENCE & TECHNOLOGY

Course Category	: Program Elective – III&IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to: o understand basic of polymer o calculate molecular weight of polymer o understand factor affecting polymer properties o understand rheology of polymer and polymer processing

Unit - I: Basics of polymer

Introduction to polymers, classification of polymer, types of polymerization, kinetics of polymerisation. methods of polymerization.

Unit - II: Molecular weight and properties of polymer

Molecular weight of polymers, experimental methods for molecular weight determination, molecular weight distribution curve, factors affecting polymer properties.

Unit - III: Rheology of polymer

Thermoplastics, Thermosetting plastics, rheology of polymer, viscosity determination

Unit - IV: Polymer processing

Effect of additives such as plasticizers, colourants, heat stabilizers, antioxidants, ultraviolet absorbers, antistatic agents, flame retardants, blowing agents, lubricants and fillers. Moulding techniques for plastics: injection moulding, compression moulding, calendaring, blow moulding, extrusion, thermoforming. Wet, dry and melt spinning methods for fibres, vulcanization of rubber, elastomer processing. Nano composites.

References

1. F. W. Billmeyer, "Text book of Polymer Science", Wiley-Blackwell, 3rd Edition (1984).
2. V. R. Gowariker N.V. Vishwanathan, Jayadev Sreedhar, "Polymer Science", New Age (2006).
3. V. H. Shah, "Handbook of Plastic Testing Technology', Wiley-Blackwell, 2nd Edition (1998).
4. J. R. Fried, "Polymer Science and Technology", Prentice Hall India Learning Private Limited, 2nd Edition (2005).

BCT-74 OPTIMIZATION TECHNIQUES IN CHEMICAL ENGINEERING

Course Category	: Program Elective – III&IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors

Course Outcome

Students are expected to:

- formulate optimization problems
- solve optimization problems using basic concepts
- solve unconstrained single and multivariable problems
- solve optimization problems using linear and non-linear programming

Unit - I: Basics of Optimization

Optimization problems formulation, optimization classification, Optimization application to chemical and biochemical engineering problems, review of linear algebra

Unit - II: Basic Concepts of Optimization

Continuity of functions, Unimodal and multimodal functions, Optimality criteria for unconstrained single variable functions, Optimality criteria for unconstrained multivariable functions, Equality constrained problems, Lagrange multipliers, Kuhn Tucker conditions

Unit - III: Unconstrained single and multivariable optimization

Unconstrained single variable optimization: Newton-Raphson method, Bisection method, Secant method

Unconstrained Multivariable Optimization: Simplex method, Hooke-Jeeves pattern search method, Powell's conjugate direction method, Gradient Based Methods: Cauchy's method, Newton's method, Marquardt method

Unit - IV: Linear and Nonlinear Programming

Formulation of linear programming models, Graphical solution, Simplex Method

Constrained Nonlinear Programming: Penalty function method, Lagrange multiplier method

References

1. T. F. Edgar, D. M. Himmelblau, L. S. Lasdon, "Optimization of Chemical Processes", McGraw Hill, 2nd Edition (2001).
2. A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, "Engineering Optimization: Methods and Applications", Wiley India, 2nd Edition (2006).
3. S. S. Rao, "Engineering Optimization: Theory and Practice", John Wiley & Sons Inc, 4th Edition (2009).

BCT-75 STANDARDIZATION & QUALITY ASSURANCE IN CHEMICAL INDUSTRY

Course Category	: Program Elective – III&IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand: o basic concepts of quality control o international standard guidelines of quality control o raw material specification o documentation in industry

Unit-I: Basic of quality control

Concept, evolution and scopes of quality control and quality assurance, Good laboratory practice: Introduction, scope and overview of ICH guidelines QSEM, with special emphasis on Q-series guidelines, quality assurance unit, protocol for conduct of non-clinical testing, control on animal house, report preparation and documentation. CPCSEA guidelines.

Unit-II: Guidelines for quality control

cGMP guidelines according to schedule M, Organization and personnel responsibilities, training, hygiene and personal records, drug industry location, design, construction and plant lay out, maintenance, sanitation, environmental control, utilities and maintenance of sterile areas, control of contamination and good warehousing practice.

Unit-III: Raw Materials

Analysis of raw materials, finished products, packaging materials, in process quality control (IPQC), developing specification, purchase specifications and maintenance of stores for raw materials. In process quality control and finished products quality control for following dosage forms in pharma industry according to Indian and US Pharmacoepia: Tablets, capsules, ointments, suppositories, creams, parenterals, ophthalmic and surgical products.

Unit-IV: Documentation

Three tier documentation, policy, procedures and work instructions, and records (Formats), basic principles- How to maintain, retention and retrieval etc. Standard operating procedures (How to write), master batch record, batch manufacturing record, quality audit plan and reports. Specification and test procedures, protocols and reports. Distribution records and electronic data handling. Concepts of controlled and uncontrolled documents. Submission documents for regulators DMFs, as common technical document and electronic common technical documentation (CTD, eCTD). Concept of regulated and non regulated markets.

References

1. S. Weinberg, "Good Laboratory Practice Regulations", CRC Press, 4th Edition (2007).

2. P.P. Sharma, “How to Practice GMP’s”, Vandana Publications, Agra.
3. E. P. Tobin, “Principles in Good Manufacturing Practices for Begineers”, Validation Resources (2016)
4. Hirsch O. F., “Good laboratory Practice Regulations”, Vol. 38, Marcel Dekker Series, New York (1989).

BCT-76 INDUSTRIAL SAFETY & HAZARD MANAGEMENT

Course Category	: Program Elective – III&IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand: o basic concepts of chemical process safety o importance of safety parameter o hazard and explosion management o risk, emergency and disaster management

Unit - I: Basic concept of chemical process safety

Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, OSHA incidence rate, FAR, FR, The accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, dermal absorption, dose versus response curves, relative toxicity, threshold limit values.

Unit - II: Safety control parameter

Technology and process selection, scale of disaster, fire triangle, distinction between fires and explosion, definitions of ignition, auto-ignition temperature, fire point, flammability limits, mechanical explosion deflagration and detonation, confined explosion, unconfined explosion, vapour cloud explosions, boiling liquid expanding vapour explosion (BLEVE), dust explosion, shock wave, flammability characteristics of liquids and vapours, minimum oxygen concentration (MOC).

Unit - III: Hazard and explosions

Control of toxic chemicals, Storage and handling of flammable and toxic chemical, Runway reactions, Relief system risk and hazards management, Design to prevent Fires and Explosions: Inserting, static Electricity, Explosion proof equipment and Instrument, Ventilation, sprinkler systems and Miscellaneous Design for preventing Fires and Explosion.

Hazards identification: process hazards checklists, hazard surveys, hazard and operability studies (HAZOP), safety reviews

Unit- IV: Risk, emergency and disaster

Risk assessment: review of probability theory, interaction between process units, revealed and unrevealed failure, probability of coincidence, event trees and fault trees.

Tackling disasters, plan for emergency. Risk management routines, Emergency shutdown systems, Role of computers in safety, Prevention of hazard human element, Technology and process selection

References:

1. Daniel A. Crowl and Joseph F. Louvar, “Chemical Process Safety: Fundamentals with applications”, Prentice Hall Inc (1990).
2. P. P. Leos, “Loss prevention in process Industries, Vol I & II”, Butterworth Publication (1983)
3. R. W. King and J. Magid, “Industrial Hazards and Safety Handbook”, Butterworth Publication (1982)
4. A. Khulman, “Introduction of Safety Science”, Springer-Verlag New York Inc (1986)
5. W. E. Baker, “Explosion, hazards and Evaluation”, Elsevier Amsterdam (1983)
6. O. P. Kharbanda, E. A. Stallworthy, “Management of Disasters and How to Prevent Them”, Grower Publishing Ltd. (1986)

BCT-77 PROJECT ENGINEERING & MANAGEMENT

Course Category	: Program Elective – III&IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand: o basics of project engineering o planning and scheduling of projects o concepts of detailed engineering and execution o piping design layout

Unit - I: Basics of Project Engineering

Scope of project engineering, the role of project engineer, R&D, TEFR, plant location and site selection, preliminary data for construction projects, process engineering, flow diagrams, plot plans, engineering design and drafting.

Unit - II: Planning and scheduling of projects

Bar chart and network techniques, procurement operations, office procedures, contracts and contractors, project financing, statutory sanctions

Unit - III: Detailed Engineering

Details of engineering design and equipment selection- design calculations excluded vessels, heat exchangers, process pumps, compressors and vacuum pumps, motors and turbines, other process equipment.

Unit - IV: Piping Design

Thermal insulation and buildings, safety in plant design, plant constructions, start up and commissioning, design calculations excluded

References

1. H. F. Rase, M. H. Barrow, "Project Engineering of Process Plants", John Wiley, 9th Edition (1974).
2. F. P. Helmus, "Process Plant Design, Wiley-VCH (2008).
3. H. S. Agca, G. Cotone, "Introduction to Process Plant Projects", CRC Press (2018)
4. P. F. Navarrete, W. C. Cole, "Planning, Estimating, and Control of Chemical Construction Projects (Cost Engineering)", CRC Press, 2nd Edition (2001)

BCT-78 BIOPROCESS ENGINEERING PRINCIPALS

Course Category	: Program Elective – III&IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand: o basics of biology and biotechnology o metabolic pathways o design concept of bioreactor o basic of biochemical modelling and bioseparation

Unit - I: Basics of Biology and Biotechnology

Basics of Biology; Overview of Biotechnology, Diversity in Microbial Cells, Cell Constituents, Chemicals for Life Kinetics of Enzyme Catalysis

Unit - II: Metabolic pathways

Immobilized Enzymes: effects of intra and inter-phase mass transfer on enzyme kinetics, Major Metabolic Pathways: Bioenergetics, Glucose Metabolism, Biosynthesis, Microbial Growth: Continuum and Stochastic Models

Unit - III: Design concept of Bioreactors

Design, Analysis and Stability of Bioreactors, Kinetics of Receptor-Ligand Binding, Receptor-mediated Endocytosis

Unit - IV: Biological modelling and bio-separation

Multiple Interacting Microbial Population: Prey-Predator Models, Bio-product Recovery & Bio-separations; Manufacture of Biochemical Products

References:

1. J. E. Bailey, D. F. Ollis, "Biochemical Engineering Fundamentals", McGraw Hill Book Company (1986).
2. H. W. Blanch, D.S. Clark, "Biochemical Engineering", Marcel Dekker Inc. (1997).
3. M. L. Shuler, F.Kargi, "Bioprocess Engineering (Basic Concepts)" Prentice Hall of India, (2003).

BCT-79 NUCLEAR REACTOR TECHNOLOGY

Course Category	: Program Elective – III&IV (PE-III&IV)
Pre-requisite Subject	: NIL
Contact hours/week	: Lecture: 3, Tutorial:1, Practical: 10
No of Credits	: 4
Course Assessment Methods	: Continuous assessment through presentation and interaction with supervisors
Course Outcome	Students are expected to understand: o basics of nuclear engineering o basic concept of nuclear reactor o design of nuclear reactor and thermal power station o practices for disposal of nuclear waste

Unit - I: Nuclear Engineering

Atomic Nuclei, Atomic Number and Mass Number, Isotopes, Atomic Mass Unit, Radioactivity and Radioactive Change Rate of Radioactive Decay, Mass, Energy Equivalence, Binding Energy, Release of Energy by Nuclear Reaction, types of Nuclear Reactions, Initiation of Nuclear Reaction, Nuclear Cross, section, Nuclear Fission, The Fission Chain Reaction, moderation, Fertile Materials and Breeding. Nuclear Fusion Reaction

Unit - II: Nuclear reactor

General Components of Nuclear Reactor, General Problems of Reactor Operation, Different Types of Reactors, Pressurised Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type Reactors, Gas-cooled Reactors, Breeder Reactors

Unit - III: Nuclear reactor design and thermal plant

Reactor Containment Design, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Programme for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plants, Nuclear Materials: Introduction, Fuels, Cladding and Structural Materials, Coolants, Moderating and Reflecting Materials, Control Rod Materials, Shielding Materials.

Unit - IV: Treatment of nuclear waste

Nuclear Waste & Its Disposal: Introduction, Unit of Nuclear Radiation, Types of Nuclear Waste, Effects of Nuclear Radiation, Radioactive Waste Disposal System, Gas Disposal System. Safety Rules: Personal Monitoring, Radiation Protection, Radiation Dose

References:

1. P. K. Nag, "Power Plant Engineering", Tata McGraw Hill, 4th Edition (2017)
2. Arora, Domkundwar, "Power Plant Engineering", Dhanpat Rai & Co (2016)
3. G. N. Pandey, "A Text Book on Energy System and Engineering", S. Chand & Co (1994) 4. G. Vaidyanathan, "Nuclear Reactor Engineering", S. Chand & Co (2013)