

Metric 1.1.2 & 1.2.2

Department: Chemical Engineering

1.1.2 Percentage of programmes where syllabus revision was carried out during the last five years (20)

1.2.2 Percentage of programs in which Choice Based Credit System (CBCS)/elective course system has been implemented (20)

Programme Code	Programme Name	Year of Introduction	Status of implementation of CBCS / elective course system (Yes/No)	Year of implementation of CBCS / elective course system	Year of revision (if any)	If revision has been carried out in the syllabus during last 5 years, Percentage of content added or replaced
BT0103	B.Tech. (Chemical Engineering)	2011	Yes	2018	2018	35-40%
BT0203	B.Tech. (Chemical Engineering - Plastic & Polymer)	2011	Yes	2018	2018	35-40%
MT0103	M.Tech (Chemical Engineering)	2014	Yes	2018	2018	35-40%
MS0103	IMSC (Food Technology)	2014	Yes	2018	2018	25-30%




Signature of the HoD)
14/12/20

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Head of Department

Department of Chemical Engineering
BIT, Mesra
Ranchi-835215
Minutes of the Meeting

Ref: SG/CHE./2017-18/60

Date: 26.04.2018

A meeting of "Board of studies" for Chemical Engineering programme was held on 26.04.2018 at 10.30 a.m. in seminar room of the Central Instrumentation Facility. The following points were discussed:

1. Restructuring of the BE Chemical Engineering and BE Chemical Engineering (Plastics & Polymer) programme according to CBCS format given by BIT, Mesra
2. Restructuring of the ME Chemical Engineering Programme according to CBCS format given by BIT, Mesra
3. Restructuring the I.MSc. Food Technology Programme according to CBCS format given by BIT, Mesra

Details of all courses of all the above programmes were also discussed with the BOS members and approved by them in the current form as attached.

Following BOS members were present:

1	HOD, Chemical Engineering	Chairman
2	Dr. Priyabrata Sarkar Professor Polymer Science & Technology Calcutta University	External member
3	Dr. Siddhartha Datta Professor Chemical Engineering, Jadavpur University	External member
4	Dr. (Mrs.) M. Mukherjee, Professor	Internal member
5	Dr. Gautam Sarkhel, Professor	Internal member
6	Dr. (Mrs.) S. Goswami, Professor	Internal member
7	Dr. G.T. Mohanraj, Assistant Professor	Internal member
8	Dr. Bidhan C. Ruidas, Assistant Professor	Internal member
9	Dr. A.K. Sinha, Professor, Dept. of Civil Engg.	Internal member
10	Dr.D.P. Mishra, Professor Department of Mechanical Engg	Internal member
11	Student representative of UG programme Ms. Komal Gupta BE/10261/14 Ms.Sayani Adhikari ME/CHE10001/16	absent Sayani Adhikari
12	Mr. Abhit Lakra, Senior Technical Officer & In Charge, CIPET Ranchi	Alumni of the department(2002)


S. Goswami
HOD, Chemical Engg.

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEWCOURSE STRUCTURE - To be effective from academic session 2018- 19
Based on CBCS & OBE model

(Chemical Engineering)

Semester/ Session of Study (Recommended)	LEVEL	Category of course	Course Code	Courses	Mode of delivery & credits L-Lecture; T-Tutorial; P-Practicals			Total Credits C- Credits
					L (Periods/ week)	T (Periods/ week)	P (Periods/ week)	C
GRAND TOTAL FOR FIRST YEAR								43.5
THIRD Monsoon	THEORY							
	SECOND	FS	MA203	Numerical Methods	2	0	0	2
	FIRST		CE101	Environmental Sciences	2	0	0	2
	SECOND	PC	CL201	Thermodynamics	3	1	0	4
			CL203	Fluid Mechanics	3	0	0	3
			CL204	Chemical Process Calculations	2	1	0	3
			CL205	Mechanical Operations	3	0	0	3
			CL206	Chemical Principles for Chemical Engineers	2	0	0	2
	LABORATORIES							
	SECOND	GE	IT202	Basic IT Workshop	0	0	2	1
FS		MA204	Numerical Methods Lab	0	0	2	1	
MC		MC201/202/203/204	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1	
TOTAL								22
FOURTH Spring	THEORY							
	SECOND	GE	IT201	Basics of Intelligent Computing	3	0	0	3
	FIRST	FS	BE101	Biological Science for Engineers	2	0	0	2
	SECOND	PC	CL207	Process Technology & Economics - I	3	0	0	3
			CL208	Heat Transfer Operations	3	1	0	4
			CL209	Mass Transfer Operation - I	3	0	0	3
			CL210	Transport Phenomena	3	0	0	3
	SECOND	OE		Open Elective (OE-I)	3	0	0	3
	LABORATORIES							
	FIRST	GE	EE102	Electrical Engineering Lab	0	0	3	1.5
SECOND	MC	MC205/206/207/208	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1	
	PC	CL212	Chemical Engineering Lab -I	0	0	4	2	
TOTAL								25.5
FIFTH Monsoon	THEORY							
	FIRST	HSS	MT123	Business Communications	2	0	2	3
	THIRD	PC	CL301	Mass Transfer Operation - II	3	1	0	4
			CL302	Chemical Reaction Engineering-I	3	1	0	4
			CL303	Computer Aided Process Engineering	3	1	0	4
			PE		Program Elective (PE-I)	3	0	0
		OE		Open Elective (OE-II)	3	0	0	3
	LABORATORIES							
THIRD	PC	CL304	Computer Aided Process Engineering Lab.	0	0	4	2	
		CL305	Chemical Engineering Lab -II	0	0	4	2	

								25
SIXTH Spring	THEORY							
	THIRD	PC	CL306	Chemical Reaction Engineering - II	3	0	0	3
			CL307	Process Technology & Economics - II	3	0	0	3
			CL308	Process Control & Instrumentation	3	0	0	3
			CL309	Material Science & Engineering	3	0	0	3
	PE		Program Elective (PE-II)	3	0	0	3	
MC	MC300	Summer Training - Mandatory	N/A			3		
LABORATORIES								
	THIRD	PC	CL310	Design Lab	0	0	3	1.5
			CL311	Chemical Engineering Lab - III	0	0	4	2
TOTAL								21.5
THEORY								
SEVENTH Monsoon	FOURTH	HSS	CL406	Professional Practice, Law and Ethics	2	0	0	2
		PE		Program Elective (PE-III)	3	0	0	3
				Program Elective (PE-IV)	3	0	0	3
		OE		Open Elective (OE-III)/MOOC-I	3	0	0	3
			Open Elective (OE-IV)/MOOC - II	3	0	0	3	
SECOND	MC	MT204	Constitution of India	2	0	0	NC	
LABORATORIES								
	FOURTH	PC	CL401	Process Control & Instrumentation Lab	0	0	3	1.5
			CL403	Plant Design	0	0	4	2
TOTAL								17.5
EIGHTH Spring	FOURTH	PC	CL 400	Research Project / Industry Internship	Total			12
GRAND TOTAL								167

DEPARTMENT OF CHEMICAL ENGINEERING PROGRAMME ELECTIVES (PE)** OFFERED FOR LEVEL 1-4								
PE / LEVEL		Code no.	Name of the PE courses	Prerequisites courses with code	L	T	P	C
3	PE 1	CL321	Petroleum Refinery Engineering & Petrochemicals	CH101, PH101, CL209	3	0	0	3
3		CL322	Energy Engineering	CL201, CL311	3	0	0	3
3		CL323	Pollution Control Equipment Design	CL209, CL208, CL203	3	0	0	3
3		CL324	Analytical Instrumental Methods	CH101, PH101	3	0	0	3
3		CL325	Fibre Science and Technology	CH101, PH101				
3		CL326	Environment and Plastics	CH101, PH101	3	0	0	3
3		CL327	Introduction to Microelectronics Fabrication	CH101, PH101	3	0	0	3
3	PE 2	CL331	Process Modelling, Simulation & Optimization	CH101, PH101, MA103, CL210	3	0	0	3
3		CL332	Safety & Hazards in Process Industries	CL322 ,CH 101, PH101	3	0	0	3
3		CL333	Fluid-Solid Operation	CH101 PH101, CL205 , CL203	3	0	0	3
3		CL334	Reservoir Engineering	CL203	3	0	0	3
3		CL335	Biomaterials	CH101, PH101	3	0	0	3
3		CL336	Rubber Product Technology	CH101, PH101	3	0	0	3
4	PE 3	CL411	Polymer Technology	CH101, PH101	3	0	0	3
4		CL412	Colloid & Interfacial Science	CH101, PH101, CL209	3	0	0	3
4		CL413	Fundamentals of Molecular Simulation	CH101, PH101, CS101, MA117	3	0	0	3
4		CL414	Fertilizer Technology	CH101, PH101	3	0	0	3
4		CL415	Polymer Blends and Alloys	CH101, PH101	3	0	0	3
4		CL416	Paints and Surface Coating Technology	CH101, PH101	3	0	0	3
4	PE 4	CL421	Fine Chemicals	CH101, PH101	3	0	0	3
4		CL422	Polymer Composite	CH101, PH101	3	0	0	3
4		CL423	Membrane Science & Technology	CH101, PH101, CL209, CL203	3	0	0	3
4		CL424	Microfluidics	CL203	3	0	0	3
4		CL425	Plastic Packaging Technology	CH101, PH101	3	0	0	3

** PROGRAMME ELECTIVES TO BE OPTED ONLY BY THE DEPARTMENT STUDENTS

**DEPARTMENT OF CHEMICAL ENGINEERING
OPEN ELECTIVES (OE)*
OFFERED FOR LEVEL 1-4**

OE / LEVEL	Code no.	Name of the PE courses	Pre-requisites	L	T	P	C
OE/3	CL322	Energy Engineering	NIL	3	0	0	3
OE/3	CL332	Safety & Hazards in Process Industries	NIL	3	0	0	3
OE/3	CL335	Biomaterials	NIL	3	0	0	3
OE/3	CL327	Introduction to Microelectronics Fabrication	NIL	3	0	0	3
OE/4	CL422	Polymer Composite	NIL	3	0	0	3
OE/4	CL421	Fine Chemicals	NIL	3	0	0	3
OE/4	CL411	Polymer Technology	NIL	3	0	0	3

*** OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS**

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
In-depth Specialization in Process Engineering, Modelling and Optimization

Students who have registered for **B. Tech in Chemical Engineering** should complete 20 credits opting courses listed below. The credits shall be over and above minimum requirement for degree award. Courses shall be selected from single specialization area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits			Total Credits C - Credits		
					L- Lecture; T-Tutorial; P-Practical					
					L	T	P			
THEORY										
FIFTH Monsoon	Third	DS	CL361	Multiphase flow	3	0	0	3		
			CL363	Advanced Molecular Simulation	3	0	0	3		
		LABORATORY								
		DS	CL364	Chemical Technology Lab	0	0	3	1.5		
TOTAL										
7.5										
THEORY										
SIXTH Spring	Third	DS	CL507	Advanced Process Modelling, Simulation & Optimization	3	0	0	3		
			CL514	Computational Fluid Dynamics	3	0	0	3		
		LABORATORY								
		DS	CL365	Energy Engineering Lab	0	0	3	1.5		
TOTAL										
7.5										
THEORY										
SEVENTH Monsoon	Fourth	DS	CL614	Process Integration	3	0	0	3		
		LABORATORY								
		DS	CL426	Mini Project	0	0	4	2		
TOTAL										
5										
GRAND TOTAL										
<i>Minimum requirement for in-depth specialization award</i>										
20										

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
In-depth Specialization in Polymer Processing

Students who have registered for **B. Tech in Chemical Engineering** should complete 20 credits opting courses listed below. The credits shall be over and above minimum requirement for degree award. Courses shall be selected from single specialization area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits			Total Credits C - Credits		
					Lecture; T-Tutorial; P-Practical	L	T		P	C
THEORY										
FIFTH Monsoon	Third	DS	CL632	Polymer Physics	3	0	0	3		
			CL633	Polymer Product Manufacturing Technology	3	0	0	3		
		LABORATORY								
		DS	CL374	Polymer Rheology Lab	0	0	3	1.5		
TOTAL										
7.5										
THEORY										
SIXTH Spring	Third	DS	CL373	Adhesive Technology	3	0	0	3		
		LABORATORY								
		DS	CL375	Polymer Synthesis Lab	0	0	3	1.5		
TOTAL										
4.5										
THEORY										
SEVENTH Monsoon	Fourth	DS	CL634	Polymer Rheology	3	0	0	3		
			CL635	Die and Mould Design	3	0	0	3		
		LABORATORY								
		DS	CL427	Mini Project	0	0	4	2		
TOTAL										
8										
GRAND TOTAL										
<i>Minimum requirement for in-depth specialization award</i>										
20										

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
Minor in Chemical Engineering
(Offered ONLY to OTHER department students)

Students who have registered for **B. Tech Minor in Chemical Engineering** should complete 20 credits and shall opt for courses listed below. Courses shall be selected from single specialisation area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits			Total Credits C - Credits
					Lecture; T-Tutorial; P-Practical	L	T	
THEORY								
FIFTH Monsoon	Second	PC	CL216	Unit Operation-I	3	0	0	3
	Third	PE*	CL321	Petroleum Refinery Engineering & Petrochemicals	3	0	0	3
			CL322	Energy Engineering	3	0	0	3
			CL323	Pollution Control Equipment Design	3	0	0	3
TOTAL								9
THEORY								
SIXTH Spring	Second	PC	CL217	Unit Operation-II	3	1	0	4
	Third	PE	CL332	Safety & Hazards in Process Industries	3	0	0	3
TOTAL								7
THEORY								
SEVENTH Monsoon	Second	PC	CL218	Unit Operation-III	3	1	0	4
TOTAL								4
GRAND TOTAL								20
<i>Minimum requirement for minor degree award</i>								

* Two courses out of three are compulsory.

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
Minor in Polymer Engineering
(Offered ONLY to OTHER department students)

Students who have registered for **B. Tech Minor in Polymer Engineering** should complete 20 credits and shall opt for courses listed below. Courses shall be selected from single specialisation area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits			Total Credits C - Credits
					Lecture; T-Tutorial; P-Practical	L	T	
THEORY								
FIFTH Monsoon	Third	PC	CL312	Polymer Processing	4	0	0	4
	Second		CL219	Polymer Synthesis and Reaction Engineering	3	0	0	3
TOTAL								7
THEORY								
SIXTH Spring	Third	PE	CL335	Biomaterials	3	0	0	3
			CL336	Rubber Product Technology	3	0	0	3
TOTAL								6
THEORY								
SEVENTH Monsoon	Fourth	PE	CL411	Polymer Technology	4	0	0	4
			CL415	Polymer Blends and Alloys	3	0	0	3
		PE*	CL422	Polymer Composite	3	0	0	3
			CL425	Plastic Packaging Technology	3	0	0	3
TOTAL								7
GRAND TOTAL								20
<i>Minimum requirement for minor degree award</i>								

* One course out of three are compulsory.

COURSE INFORMATION SHEET: CL 201 Thermodynamics

Course code	CL201
Course title	Thermodynamics
Pre-requisite(s)	
Co-requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	4
Class	B. Tech.
Semester / Level	III / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students:

1.	To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries.
2.	To analyze and interpret data, to identify, formulate, and solve engineering problems.
3.	To use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes

After the completion of this course, students will be able to:

CO201.1	Apply the laws of thermodynamics on closed and open systems.
CO201.2	Evaluate the properties of real gases.
CO201.3	Solve problems involving various thermodynamic cycles.
CO201.4	Evaluate the thermodynamic properties (Such as Partial molar properties, Fugacity coefficients, activity coefficients etc.) of pure fluid and fluid mixtures.
CO201.5	Predict equilibrium composition of mixtures under phase and chemical-reaction equilibria.

Syllabus

Module 1: Introduction and Basic Concepts

First law of thermodynamics, Energy balance for closed systems, Mass and Energy balances for open systems, Volumetric properties of pure fluids, Virial equations of state, Cubic equations of state, Theorem of corresponding states, Acentric factor, generalized correlations for gases and liquids, Statements of the second law, Heat engines, Carnot cycle, Refrigerator and Heat pump, Third law of thermodynamics, Microscopic interpretation of entropy. [8L]

Module 2: Thermodynamic Relations and Thermodynamic Properties of Fluids

Euler relation, Gibbs-Duhem relation, Legendre transformation, Helmholtz free energy, Gibbs free energy, Maxwell relations, Gibbs energy as a generating function, Joule-Kelvin Effect, Bridgman table,

Clausius/Clapeyron equation, Antoine equation, Residual properties, Thermodynamic properties of real gases using tables and diagrams: Edmister chart, Lee-Kesler data. [8L]

Module 3: Vapor-Liquid Equilibrium in Mixtures

Introduction to Vapor-Liquid Equilibrium, Vapor-Liquid Equilibrium in ideal mixtures, Dew point and bubble point temperatures/Pressures, VLE from K-value correlations (Flash calculations), Low-Pressure Vapor-Liquid equilibrium in non-ideal mixtures, EOS, SRK. [8L]

Module 4: Thermodynamics of Multicomponent Mixtures

Fundamental Property Relation, The Chemical Potential and Phase Equilibria, Partial Properties, The Ideal-Gas Mixture Model, Fugacity and Fugacity Coefficient (Pure Species and Species in Solution), The Ideal-Solution Model, Excess Properties, The Excess Gibbs Energy and the Activity Coefficient, Models for the Excess Gibbs Energy (Margules equation, Redlich-Kister equation, van Laar equation, Wilson equation, NRTL model and UNIQUAC equation) SRK, PR. [8L]

Module 5: Chemical Reaction Equilibria

The reaction coordinate, Application of Equilibrium Criteria to Chemical Reactions, The standard Gibbs Energy Change and the Equilibrium Constant, Effect of Temperature on the Equilibrium Constant, Evaluation of Equilibrium Constants, Relation of equilibrium constants to composition, Equilibrium Conversions for single Reactions, Phase Rule and Duhem's Theorem for Reacting Systems, Multi-reaction equilibria. [8L]

Text books:

1. Introduction to Chemical Engineering Thermodynamics: J.M. Smith, H.C. Van ness, and M.M. Abbot. 7th Edition, McGraw-Hill's Chemical Engineering Series.
2. Chemical, Biochemical and Engineering Thermodynamics: Stanley I. Sandler. Fourth Edition, John Wiley & Sons, Inc.
3. Chemical Engineering Thermodynamics: Y V C Rao, University Press.

Reference books:

1. Molecular Thermodynamics of Fluid-Phase Equilibria: J.M. Prausnitz, R.N. Lichtenthaler, E G de Azevedo. 3rd Edition, Prentice Hall International Series in the Physical and Chemical Engineering Sciences.
2. Engineering and Chemical Thermodynamics: Milo D. Koretsky. 2nd Edition, John Wiley & Sons, Inc.
3. Using Aspen Plus in Thermodynamics Instruction: Stanley I. Sandler, John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

Introduction to molecular/statistical thermodynamics.

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3 and PO4

COURSE INFORMATION SHEET: CL 203 Fluid Mechanics

Course code: CL203
Course title: Fluid Mechanics
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T:0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: III / Second
Branch: Chemical

Course Objectives

This course enables the students:

1.	To develop an appreciation for the properties of Newtonian fluids.
2.	To apply concepts of mass and momentum conservation to fluid flows and analytically solve a variety of simplified problems.
3.	To understand the dynamics of fluid flows and the governing non-dimensional parameters.

Course Outcomes

After the completion of this course, students will be able to:

CO203.1	Describe fluid pressure, its measurement and calculate forces on submerged bodies.
CO203.2	Understand the flow visualization, boundary layer and momentum correction factor, state the Newton's law of viscosity and Reynolds number. Analyze fluid flow problems with the application of the continuity and momentum equation.
CO203.3	Examine energy losses in pipe transitions and evaluate pressure drop in pipe flow using Hagen-Poiseuille's equation and Bernoulli's principle for laminar flow.
CO203.4	Understand the concept of drag, lift, streamlining, equivalent diameter, sphericity, determine minimum fluidization velocity in fluidized bed and Compute pressure drop in fixed bed, packed bed and fluidized system.
CO203.5	Analyze the general equation for internal flow meters and Determine and analyze the performance aspects of fluid machinery.

Syllabus:**Module 1:**

Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices—manometer, U-tube, inclined tube, well, diaphragm, hydraulic systems – force on submerged bodies (straight, inclined), pressure centre. [8L]

Module 2:

Fluid flow phenomena: Fluid as a continuum, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow; flow visualization – streamline, path line, streak line, stress field; viscosity; Newtonian fluid; Non-Newtonian fluid; Reynolds number-its significance, laminar, transition and turbulent flows: Prandtl boundary layer, compressible and incompressible. Momentum equation for integral control volume, momentum correction factor. [8L]

Module 3:

Internal incompressible viscous flow: Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseuille equation; flow of Non-Newtonian fluid, introduction to turbulent flow in a pipe; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation—kinetic energy correction factor; head loss; friction factor; major and minor losses, Pipe fittings and valves. [8L]

Module 4:

Flow past of immersed bodies: Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; streamlining; packed bed; concept of equivalent diameter and sphericity; Ergun equation, Fluidization: Introduction; different types of fluidization; fluidized bed assembly; governing equation; industrial use. Agitation and mixing of liquids: agitated vessel, blending & mixing, suspension of solid particles. Dispersion operation. Turbine Design/scale up, Flow number, Power Requirement. [8L]

Module 5:

Flow measurement: Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; concept of area meters: rotameter; Local velocity measurement: Pitot tube. Fluid moving machines: Introduction; Basic classification of pumps, Mechanical pump: Centrifugal and Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor. [8L]

Text books:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, Volume I", Pergamon Press.
3. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall Inc.

Reference books:**Gaps in the syllabus (to meet Industry/Profession requirements)****POs met through Gaps in the Syllabus****Topics beyond syllabus/Advanced topics/Design****POs met through Topics beyond syllabus/Advanced topics/Design****Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8
Mid Sem Examination Marks	Y	Y	Y	Y				
End Sem Examination Marks	Y	Y	Y	Y	Y	Y	Y	Y
Quiz	Y	Y	Y	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

COURSE INFORMATION SHEET: CL204 Chemical Process Calculations

Course code:	CL204
Course title:	Chemical Process Calculations
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L: 2 T: 1 P: 0
Class schedule per week:	3 hrs
Class:	B. Tech
Semester / Level:	III / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To use basic, applied chemistry/ thermodynamics for material balance calculations for different unit operations and unit processes.
2.	To use basic, applied chemistry/ thermodynamics for energy balance calculations for different unit operations and unit processes.
3.	To develop the systematic problem solving skills.

Course Outcomes

After the completion of this course, students will be able to:

CO204.1	Apply the concept of dimension and unit conversion to check dimensional consistency of balanced equation and understand the specific terms used in process calculation.
CO204.2	Solve problems related to ideal and real gas and solution.
CO204.3	Solve material balance problems without chemical reactions.
CO204.4	Solve material balance problems with chemical reactions.
CO204.5	Solve energy balance problems of various unit processes.

Syllabus**Module I: Introduction to Stoichiometry:**

Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis, Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another, Stoichiometric and composition relations, Excess & Limiting reactants, Degree of completion, Conversion, Selectivity and Yield. [8L]

Module II: Gas Calculations, Humidity & Saturation:

Gas laws-Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures. Vapour pressure, partial pressure, Vapour pressures of miscible, immiscible liquids and solutions. Real-gas relationships, Rault's Law, Henry's law, Antoine's Equation, Clausius Clapeyron Equation. PVT calculations using ideal and real gas relationships, Relative Humidity and percent saturation; Dew point, Dry and Wet bulb temperatures; Use of humidity charts for engineering calculations. [8L]

Module III: Material Balance without Chemical Reaction:

Unit Operations & Process Variables, Degree of Freedom Analysis, Application of material balances to single and multiple unit operations without chemical reactions involving distillation column, absorption column, evaporators, driers, crystallizer, liquid-liquid and liquid-solid extraction units, Unsteady state material balances. [8L]

Module IV: Material Balance with Chemical Reaction:

Material balances with Single Reaction & Multiple Reactions applicable to single and multiple unit operations, Recycle, purge, bypass in batch, stage wise and continuous operations in systems with or without chemical reaction. Material balances in combustion, gas-synthesis, acid-alkali production reactions. [8L]

Module V: Energy Balance:

Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible and latent heats, Evaluation of enthalpy, Standard heat of reaction, heat of formation, combustion, solution mixing etc., Calculation of standard heat of reaction, Hess Law, Energy balance for systems with and without chemical reaction, Unsteady state energy balances. [8L]

Text books:

1. Haugen, P.A. Watson, K.M., Ragatz R.A Chemical Process Principles Part - I
2. Himmelblau, D.M Basic Principles and Calculation in chemical engineering, Prentice Hall
3. Bhatt B.L.Vora, S.M Stoichiometry, Tata McGraw Hill Publishing Co. Ltd., New Delhi

Reference books:

1. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000
2. Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, "Process Calculations", Second Edition, Prentice Hall of India.
3. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India

101	L28		4	Material balances applied to unit operations with Recycle, purge, bypass in batch, stage wise and continuous operations in systems with or without chemical reaction.	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk-Board	
	L29		4	Material balances in combustion, Excess air calculations,	T1, T2, T3, R1, R2, R3	4, 5		Chalk-Board	
	L30		4	Material balances in combustion, Excess air calculations,	T1, T2, T3, R1, R2, R3	4, 5		Chalk-Board	
11	L31		4	Material balances in gas-synthesis, acid-alkali production reactions.	T1, T2, T3, R1, R2, R3	4, 5		Chalk-Board	
	L32		4	Tutorial				Assignment	
	L33		5	Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations,	T2, R1	5		PPT	
12	L34		5	problems involving sensible and latent heats,	T2, R1	5		Chalk-Board	
	L35		5	Evaluation of enthalpy, Standard heat of reaction,	T2, R1	5		PPT, Chalk-Board	
	L36		5	heat of formation, combustion, solution mixing etc.,	T2, R1	5		PPT, Chalk-Board	
13	L37		5	Calculation of standard heat of reaction, Hess Law,	T1, T2, R1	5		Chalk-Board	
	L38		5	Energy balance for systems with and without chemical reaction,	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk-Board	
	L39		5	Unsteady state energy balances	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk-Board	
14	L40		5	Tutorial				Assignment	

COURSE INFORMATION SHEET: CL 205 Mechanical Operations

Course code: CL 205
Course title: Mechanical Operations
Pre-requisite(s):-
Co- requisite(s):-
Credits: L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: III / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand particulate solid characterization and storage and transportation of solids
2.	To understand principles of size reduction and equipment for size reduction
3.	To understand solid-liquid, liquid-liquid, gas-solid and solid-solid Mechanical separation

Course Outcomes

After the completion of this course, students will have:

CO205.1	Knowledge of particle size analysis, solid storage and transportation properties like frictional properties.
CO205.2	Knowledge of size reduction machineries for various industries and calculate power requirement.
CO205.3	Knowledge to design Gravity and Centrifugal settling processes for various applications, including pollution control in industry.
CO205.4	Knowledge of filtration equipment for different chemical industries, and designing of filtration process
CO205.5	Knowledge of solid-solid and gas-solid separation techniques for various applications including coal, mineral beneficiation environmental pollution control

Syllabus:

Module 1:

Characterization of solid particles: Particle Shape. Particle size analysis Differential and cumulative analysis. **Properties of particulate masses:** Bulk density, coefficient of Internal Friction, Storage of solids, Pressure distribution in hopper. Janssen Equation. **Transportation of Solids:** Studies on performance and operation of different conveyors eg. Belt, Screw, Apron, Flight etc. and elevators. [8L]

Module 2:

Size Reduction: Rittinger's law, Kick's law, Bond's law, Work index, Types of comminuting equipment – Jaw Crushers, Gyratory Crusher, Roll crushers; Grinders-hammer Mill, Ball Mill, Rod Mill etc. Dry and wet grinding, open and closed circuit. Simulation of Milling operation grinding rate function, breakage function. [8L]

Module 3:

Solid Liquid separation : Gravity Settling process – Clarifiers and Thickeners, Flocculation Design of Gravity Thickener,. **Centrifugal Settling:** principle, Centrifuges for solid liquid and liquid liquid separation. [8L]

Module 4:

Filtration: Theory of solid-liquid filtration, principle of filtration, constant pressure and constant rate filtration, compressible and incompressible cakes, Filter aids, Equipment of liquid solid filtration, Batch and continuous pressure filters. Theory of centrifugal filtration, Equipment for centrifugal filtration. [8L]

Module 5:

Solid Solid Separation : Industrial Screening equipment :Screen effectiveness and Capacity.**Wet Classification:** Differential settling, Liquid cyclones,Drag, Rake and Spiral, Bowl, Hydroseparator, Hydraulic classifiers, Tabling, Jigging, Froth floatation, Dense media separation etc.Magnetic separation, Electrostatic Separation. **Gas-solid separation:** Settling chambers, centrifugal settling, Cyclones, ESP, Scrubbers, Filters. [8L]

Suggested Books:

1. McCabe, W.L., Smith J.C., and Harriot, P., “Unit Operations Chemical Engineering”, McGraw-Hill, Inc.
2. Coulson, J.M. and Richardson, J.F., “Chemical Engineering, Volume I”, Pergamon Press.
3. Geankoplis, C.J., “Transport Processes and Unit Operations”, Prentice-Hall Inc.

Gaps in the syllabus (to meet Industry/Profession requirements) : Visit to industries like Coal Washeries, Mineral processing like HINDALCO

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design :

POs met through Topics beyond syllabus/Advanced topics/Design

COURSE INFORMATION SHEET: CL 206

Course code: CL206
Course title: Chemical Principles for Chemical Engineers

Pre-requisite(s):

Co- requisite(s):

Credits: L:02 T:00 P:00

Class schedule per week: 02

Class: B. Tech.

Semester / Level: III / Second

Branch: Chemical Engineering

Name of Teacher:

Course Objectives

This course enables the students:

1.	Explain: Describe the reaction mechanism of common organic transformations
2.	Illustrate: Illustrate Schrodinger wave equation and partition functions
3.	Analysis: Find the relation between entropy and probability

Course Outcomes

After the completion of this course, students will be:

CO206.1	Define: Describe the reaction mechanism of common organic transformations
CO206.2	Illustrate: Demonstrate collision state theory and transition state theory
CO206.3	Application: Apply transition state theory for common organic reactions
CO206.4	Synthesize: Develop suitable model for microbial growth kinetics
CO206.5	Evaluate: Compare the properties of polymer synthesized by different techniques

Syllabus**MODULE- I**

Introduction to organic reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of commonly used industrial chemicals. [9L]

MODULE- II

Fundamentals of Statistical Thermodynamics, Wave Mechanics, Schrodinger wave equation, Models in Statistical Thermodynamics, F-D Statistics, Partition function and application to monoatomic gas, Principles of equipartition of energy and statistics of a photon gas, Application of partition function and relation between entropy and probability. [8L]

MODULE- III

Integrated rate laws. Experimental methods in chemical kinetics. Elementary reactions and reaction mechanism. Temperature dependence of reaction rates. Complex reactions. Theories of reaction rates- Collision theory. Transition state theory. Potential energy surfaces (PES). Free energy and EMF. [9L]

MODULE- IV

Introduction to biotechnology. Prokaryotic and Eukaryotic cells. Metabolism I Kinetics. Mechanism II Kerb cycle. Anaerobic oxidation and fermentation. Growth kinetics for different biological systems. Microbial growth kinetics. Product recovery from over expressed cells. [7L]

MODULE- V

Principles of condensation polymerization, kinetics, chain length regulation and control of molecular weight, Principles of addition polymerization. Principles of ionic polymerization. Principles co-ordination polymerization. Polymer supported catalyst. [7L]

Text Books:

1. M. B. Smith, Organic Synthesis. F. A. Carey and R. J Sundberg, Advanced Organic Chemistry,
2. Introduction to Polymer Science and Chemistry. M. Chandra. Copyright © 2006 by Taylor & Francis Group, LLC. CRC Press, New York
3. A Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and Sons, 2006.
4. Basic Biotechnology edited by Colin Ratledge, Bjorn Kristiansen, 3rd edition, Cambridge University Press,2006

Reference books:

1. Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.
2. The Element of Polymer Science & Engineering: Rudin.
3. I.K. Puri and K. Annamalai, Advanced Engineering Thermodynamics, CRC Press, 2001.
4. Biological science fundamentals and systematics - Volume II edited by Alessandro Minelli , Eloss Publishers, UK, 2009.

Gaps in the syllabus (to meet Industry/Profession requirements):**POs met through Gaps in the Syllabus:****Topics beyond syllabus/Advanced topics/Design:****POs met through Topics beyond syllabus/Advanced topics/Design:**

COURSE INFORMATION SHEET : CL 207 Process Technology and Economics - I

Course code	CL207
Course title	Process Technology and Economics - I
Pre-requisite(s)	Thermodynamics CL201, Chemical Process Calculations CL204
Co- requisite(s)	Mass Transfer Operation CL 209, Heat Transfer Operation CL208.
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. E.
Semester / Level	IV / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students:

1.	To understand the various processes involved in chemical industries for the production of inorganic and organic chemicals.
2.	To understand economic principles as applied in Chemical Engineering.
3.	To identify and solve engineering problems during production.

Course Outcomes

After the completion of this course, students will be able to:

CO207.1	Explain important process industries with manufacturing processes.
CO207.2	Illustrate the different unit operations and unit processes in a given process flow diagram.
CO207.3	Explain the effect of various process parameters on manufacturing processes.
CO207.4	Estimate and understand various financial terms.
CO207.5	Evaluate and analyze the concept of depreciation and profitability measure.

Syllabus**Module 1:**

Sulfuric acid: Properties of sulfuric acid, Hydrates of sulfuric acid, Usage, Contact process, Catalysts, Contact process equipment's, Materials of construction, DCDA process. Phosphorous Industries: Phosphate rock, Superphosphates, Manufacturing of Phosphoric acid (Wet-Process and Electric-Furnace), Phosphates (Sodium phosphates, Pyrophosphates, Calcium Phosphates), manufacturing of diammonium phosphate. **8L**

Module 2:

Chlor-alkali industries: Manufacture of Soda Ash, Caustic Soda and Chlorine. Bleaching Powder, Calcium Hypochlorite, Sodium Hypochlorite. Manufacture of chlorine caustic soda, Mercury cathode and membrane process, hydrochloric acid.

Pulp and Paper Industries: Manufacture of pulp (Kraft pulping and Sulfite pulping), Manufacture of paper. **8L**

Module 3:

Nitrogen industries: Manufacturing of Ammonia; ammonium nitrate, ammonium sulphate; Manufacturing of Urea and Nitric acid.

Fertilizer Industries: Manufacturing of Single Superphosphate (SSP), Triple Superphosphate (TSP) and ammonium phosphate.

Mixed fertilizers: NPK – Manufacturing process and details of major equipments. **8L**

Module 4:

Process design development, preliminary design concepts, flowsheet development. Cost estimation of investment and production. Break-even analysis. Interest and Investment costs: Simple interest, Compound interest, Nominal and Effective interest rates, Continuous interest, Annuities. **8L**

Module 5:

Profitability measures: Rate of return on investment, Present worth and discounted cash flow, Payback period, Capitalized Costs. Depreciation: Types of depreciation, Salvage Value, Present Value, Book Value, Market Value, Replacement Value. Methods for determining depreciation: Straight line method, Declining-balance or Fixed percentage method, Sum-of-the-years-digits method, Sinking-fund Method, Accelerated cost recovery system, Modified accelerated cost recovery system. **8L**

Text books:

1. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.
2. Shreve's Chemical Process Industries, George T. Austin, 5th Edition, Tata McGraw Hill Edition.
3. Plant Design and Economics for Chemical Engineers, Max S. Peters, K. D. Timmerhaus, 4th Edition, McGraw-Hill Inc.
4. Process Engineering Economics, James Riley Couper, Marcel Dekker Inc.

Reference books:

1. Coulson & Richardson's Chemical Engineering Design, R K Sinnott, Vol. 6., Fourth Edition, Elsevier.
2. Encyclopedia of Chemical Technology, Kirk-Othmer, 5th Edition.

Gaps in the syllabus (to meet Industry/Profession requirements)**POs met through Gaps in the Syllabus****Topics beyond syllabus/Advanced topics/Design****POs met through Topics beyond syllabus/Advanced topics/Design**

COURSE INFORMATION SHEET: CL 208 Heat Transfer Operations

Course code:	CL208
Course title:	Heat Transfer Operations
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L: 3 T: 1 P: 0
Class schedule per week:	4 hrs
Class:	B. Tech
Semester / Level:	IV / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment's in process industries.
2.	Understanding the heat exchangers: working principles and basic geometries.
3.	To design heat exchangers and evaporators and analyze their performance.

Course Outcomes

After the completion of this course, students will be able to:

CO208.1	Understand and Solve heat transfer by conduction in solids for steady state and transient conditions.
CO208.2	Explain and solve heat transfer by forced and natural convection.
CO208.3	Discuss and solve heat transfer by radiation.
CO208.4	Determine heat transfer in boiling, condensation and evaporators.
CO208.5	Analyze the performance of heat exchange equipments.

Syllabus

Module I

Basic Concepts: Modes of heat transfer, conduction, convection and radiation, analogy between heat flow and electrical flow. **Conduction:** One dimensional steady state heat conduction, the Fourier heat conduction equation, conduction through plane wall, conduction through cylindrical wall, spherical wall, conduction through composite slab, cylinder and sphere, critical radius of insulation, **Extended surfaces:** heat transfer from a fin, fin effectiveness and efficiency, Introduction to unsteady state heat conduction. [8L]

Module II

Convection: Natural and forced convection, the convective heat transfer coefficient. **Forced Convection:** Correlation equations for heat transfer in laminar and turbulent flows in a Circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer, heat transfer to liquid metals and heat transfer to tubes in cross flow. **Natural Convection:** Natural convection from vertical and horizontal surfaces, Grashof and Rayleigh numbers. [8L]

Module III

Heat transfer by radiation: Basic Concepts of radiation from surface: black body radiation, Planks law, Wien's displacement law, Stefan Boltzmann's law, Kirchhoff's law, grey body, Radiation intensity of black body, View factor, emissivity, radiation between black surfaces and grey surfaces. Solar radiations, combined heat transfer coefficients by convection and radiation. [8L]

Module IV

Boiling and Condensation: Pool boiling, pool boiling curve for water, maximum and minimum heat fluxes, correlations for nucleate and film pool boiling, drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal tube, effect of non-condensable gases on rate of condensation. **Evaporation:** Types of evaporators, boiling point elevation and Duhring's rule, material and energy balances for single effect evaporator, multiple effect evaporators: forward, mixed and backward feeds, capacity and economy of evaporators. [8L]

Module V

Heat Exchangers: Introduction, Industrial use, Types of heat exchangers, Co-current, Counter-current & Cross-current, Principal Components of a Concentric tube & Shell-and Tube Heat Exchanger, Baffles, Tubes and Tube Distribution, Tubes to Tube sheets Joint, Heat Exchangers with Multiple Shell & tube Passes, Fixed-Tube sheet and Removable-Bundle Heat Exchangers, log-mean temperature difference, overall heat transfer coefficient, fouling factors, Design of double pipe and shell and tube heat exchangers. [8L]

Text books:

1. Holman, J. P., 'Heat Transfer', 9th Edn., McGraw Hill, 2004.
2. Kern, D.Q., "Process Heat Transfer", McGraw-Hill, 1999.
3. Cengel, Y.A., Heat Transfer - A Practical Approach, McGraw-Hill, 1998.

Reference books:

1. Incropera, F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 5th ed., John Wiley, 2002.

COURSE INFORMATION SHEET: CL 209 Mass Transfer Operations -I

Course code:	CL209
Course title:	Mass transfer operations-I
Pre-requisite(s):	Thermodynamics (CL 201), Chemical Process Calculations (CL 204)
Co- requisite(s):	Transport Phenomena
Credits:	L: 3 T: 0 P: 0
Class schedule per week:	03
Class: B. E.	
Semester / Level:	IV / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To learn basic knowledge of mass transfer operation and its application.
2.	To learn basic knowledge of mass transfer equipments.
3.	To design mass transfer equipments.

Course Outcomes

After the completion of this course, students will be to:

CO209.1	Explain the basic mechanism of mass transfer including diffusion and convective mass transfer.
CO209.2	Find the mass transfer coefficient and solve problems related to interphase mass transfer.
CO209.3	Explain the gas-liquid contacting process and solve related problems.
CO209.4	Solve problems on VLE and problems related to design calculation of distillation column.
CO209.5	Explain enhanced distillation.

Syllabus**Module 1**

Introduction to mass transfer and applications, Principles of molecular diffusion, Fick's Law, Diffusivity, Equation of continuity and unsteady state diffusion, Diffusion in solids. Convective mass transfer and Mass transfer coefficient, Correlation of mass transfer coefficients. (8L)

Module 2

Interphase mass transfer, Theories of Mass Transfer, individual gas and liquid phase mass transfer coefficient, overall mass transfer coefficient, Analogy between momentum, heat and mass transfer, Concept of stage wise contact processes. (8L)

Module-3

The mechanism of absorption, Equipment for Gas Liquid contact, Kremser equation, plate and packed tower

internals, Packed tower design, H. E. T. P., H. T. U., and N. T. U. concepts, height of column based on conditions in the gas film, height of column based on conditions in the liquid film, height of column based on overall coefficients, plate type towers, number of plates, plate efficiency, absorption factor. (8L)

Module-4

Relative Volatility, calculation of number of plates by McCabe-Thiele method, Total and minimum reflux ratio, distillation with side streams, Enthalpy concentration diagram, calculation of number of plates by Ponchon and Savarit method, Steam distillation, Azeotropic & Extractive Distillations, batch distillation with reflux, Introduction to multicomponent distillation. (8L)

Module-5

Shortcut method on multi component distillation, MESH equations (HK, LK component), Fenske-Underwood- Gilliland method. (8L)

Text books:

1. Mass Transfer Operations: R.E. Treybal Mc Graw Hill, 1981
2. Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
3. Principles of Mass Transfer and Separation Processes, Binay K. Dutta, 2nd edition, Prentice Hall of India,2007.
4. Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Reference books:

Separation Process Principles-Chemical and Biochemical Operations, J. D. Seader, Ernest J. Henley, D. Keith Roper, 3rd Ed., John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50

COURSE INFORMATION SHEET: CL 210 Transport Phenomena

Course code: **CL210**
 Course title: **Transport Phenomena**
 Pre-requisite(s):
 Co- requisite(s):
 Credits: **L:3 T:0 P:0**
 Class schedule per week: **3**
 Class: **B. Tech.**
 Semester / Level: **IV / Second**
 Branch: **Chemical Engineering**
 Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand the mathematical foundation required for analysis of fluid flow.
2.	To understand the mathematical foundation required for analysis of heat and mass transfer.
3.	To learn systematic analysis of fluid flow and heat transfer with emphasis on analogies and specific technique using treating such boundary value problems.

Course Outcomes

After the completion of this course, students will be able to:

CO210.1	Identify and describe mechanisms of transport phenomena, present in given isothermal and non-isothermal, laminar and turbulent flow systems.
CO210.2	Distinguish interrelations between the molecular, microscopic and macroscopic descriptions of transport phenomena
CO210.3	Explain similarities and differences between the descriptions of the combined fluxes and the equations of change for mass, momentum and heat transport.
CO210.4	Apply the method of dimensional analysis to reformulate and then find the form of solutions of the equations of change, to determine the dependence of the interfacial fluxes on system parameters.
CO210.5	Elaborate conceptual and mathematical models, from conservation principles, to complicated systems involving simultaneous mass, momentum, and/or heat transfer processes as well as reactions or other sources/sinks of transport for multi-component mixtures.

Syllabus

Module 1:

Law of conservation, Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity. [8L]

Module 2:

Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces, Reynold's transport theorem, Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal). [8L]

Module 3:

Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change (non-isothermal), equation of continuity, equation of motion for forced and free convection, equation of energy (non-isothermal). [8L]

Module 4:

Shell mass balances, concentration profiles, average concentration, mass flux at surfaces, Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component). [8L]

Module 5:

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, Higbie's penetration theory, Derivation of flux equation, surface renewal theory. [8L]

Text books:

1. Bird R.B., Stewart W.E. and Lightfoot E.N., "Transport Phenomena", 2nd Ed., John Wiley and Sons.
2. Geankoplis C.J., "Transport Processes and Separation Process Principles", 4th Ed., Prentice-Hall of India.

Reference books:

1. Brodkey, R.S., Hershey H.C., "Basic concepts in transport phenomena, a unified approach". Vol 1, Brodkey Publishing.
2. Fox and McDonald's, 'Introduction to fluid Mechanics'
3. Robert E. Treybal, Mass-Transfer Operation

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEWCOURSE STRUCTURE - To be effective from academic session 2018- 19
Based on CBCS & OBE model

(Chemical Engineering -Plastics and Polymer)

Semester/ Session of Study (Recommended)	LEVEL	Category of course	Course Code	Courses	Mode of delivery & credits <i>L-Lecture; T-Tutorial; P-Practicals</i>			Total Credits <i>C- Credits</i>
					L <i>(Periods/week)</i>	T <i>(Periods/week)</i>	P <i>(Periods/week)</i>	C
GRAND TOTAL FOR FIRST YEAR								43.5
THIRD Monsoon	THEORY							
	SECOND	FS	MA203	Numerical Methods	2	0	0	2
	FIRST		CE101	Environmental Sciences	2	0	0	2
	SECOND	PC	CL201	Thermodynamics	3	1	0	4
			CL203	Fluid Mechanics	3	0	0	3
			CL204	Chemical Process Calculations	2	1	0	3
			CL205	Mechanical Operations	3	0	0	3
			CL213	Macromolecular Science	3	0	0	3
	LABORATORIES							
	SECOND	GE	IT202	Basic IT Workshop	0	0	2	1
		FS	MA204	Numerical Methods Lab	0	0	2	1
MC		MC201/202/203/204	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1	
TOTAL								23
FOURTH Spring	THEORY							
	SECOND	GE	IT201	Basics of Intelligent Computing	3	0	0	3
	FIRST	FS	BE101	Biological Science for Engineers	2	0	0	2
	SECOND	PC	CL207	Process Technology & Economics - I	3	0	0	3
			CL208	Heat Transfer Operations	3	1	0	4
			CL209	Mass Transfer Operation - I	3	0	0	3
			CL214	Polymer Technology - I	3	0	0	3
	SECOND	OE		Open Elective (OE-I)	3	0	0	3
	LABORATORIES							
	FIRST	GE	EE102	Electrical Engineering Lab	0	0	3	1.5
SECOND	MC	MC205/206/207/208	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1	
	PC	CL212	Chemical Engineering Lab -I	0	0	4	2	
TOTAL								25.5
FIFTH Monsoon	THEORY							
	FIRST	HSS	MT123	Business Communications	2	0	2	3
	THIRD	PC	CL301	Mass Transfer Operation - II	3	1	0	4
			CL302	Chemical Reaction Engineering-I	3	1	0	4
			CL312	Polymer Processing	3	0	0	3
		PE		Program Elective (PE-I)	3	0	0	3
	OE		Open Elective (OE-II)	3	0	0	3	
	LABORATORIES							
THIRD	PC	CL304	Computer Aided Process Engineering Lab.	0	0	4	2	
		CL305	Chemical Engineering Lab -II	0	0	4	2	
TOTAL								24

THEORY								
SIXTH Spring	THIRD	PC	CL306	Chemical Reaction Engineering - II	3	0	0	3
			CL313	Polymer Technology - II	3	0	0	3
			CL308	Process Control & Instrumentation	3	0	0	3
			CL314	Elastomer Technology	3	0	0	3
	PE		Program Elective (PE-II)	3	0	0	3	
MC	MC300	Summer Training			N/A		3	
LABORATORIES								
	THIRD	PC	CL315	Polymer Technology Lab - I	0	0	3	1.5
			CL311	Chemical Engineering Lab - III	0	0	4	2
TOTAL								21.5
THEORY								
SEVENTH Monsoon	FOURTH	HSS	CL406	Professional Practice, Law and Ethics	2	0	0	2
		PE		Program Elective (PE-III)	3	0	0	3
				Program Elective (PE-IV)	3	0	0	3
		OE		Open Elective (OE-III)/MOOC-I	3	0	0	3
			Open Elective (OE-IV)/MOOC - II	3	0	0	3	
SECOND	MC	MT204	Constitution of India	2	0	0	NC	
LABORATORIES								
	FOURTH	PC	CL401	Polymer Technology Lab - II	0	0	3	1.5
			CL403	Plant Design	0	0	4	2
TOTAL								17.5
EIGHTH Spring	FOURTH	PC	CL 400	Research Project / Industry Internship	Total			12
GRAND TOTAL <i>Minimum requirement for Degree award</i>								167

DEPARTMENT OF CHEMICAL ENGINEERING - PLASTICS & POLYMER
PROGRAMME ELECTIVES (PE)**
OFFERED FOR LEVEL 1-4

PE / LEVEL		Code no.	Name of the PE courses	Prerequisites courses with code	L	T	P	C
3	PE 1	CL321	Petroleum Refinery Engineering & Petrochemicals	CH101, PH101, CL209	3	0	0	3
3		CL322	Energy Engineering	CL201, CL311	3	0	0	3
3		CL323	Pollution Control Equipment Design	CL209, CL208, CL203	3	0	0	3
3		CL324	Analytical Instrumental Methods	CH101, PH101	3	0	0	3
3		CL325	Fibre Science and Technology	CH101, PH101				
3		CL326	Environment and Plastics	CH101, PH101	3	0	0	3
3		CL327	Introduction to Microelectronics Fabrication	CH101, PH101	3	0	0	3
3	PE 2	CL331	Process Modelling, Simulation & Optimization	CH101, PH101, MA103, CL210	3	0	0	3
3		CL332	Safety & Hazards in Process Industries	CL322, CH 101, PH101	3	0	0	3
3		CL333	Fluid-Solid Operation	CH101 PH101, CL205, CL203	3	0	0	3
3		CL334	Reservoir Engineering	CL203	3	0	0	3
3		CL335	Biomaterials	CH101, PH101	3	0	0	3
3		CL336	Rubber Product Technology	CH101, PH101	3	0	0	3
4	PE 3	CL411	Polymer Technology	CH101, PH101	3	0	0	3
4		CL412	Colloid & Interfacial Science	CH101, PH101, CL209	3	0	0	3
4		CL413	Fundamentals of Molecular Simulation	CH101, PH101, CS101, MA117	3	0	0	3
4		CL414	Fertilizer Technology	CH101, PH101	3	0	0	3
4		CL415	Polymer Blends and Alloys	CH101, PH101	3	0	0	3
4		CL416	Paints and Surface Coating Technology	CH101, PH101	3	0	0	3
4		PE 4	CL421	Fine Chemicals	CH101, PH101	3	0	0
4	CL422		Polymer Composite	CH101, PH101	3	0	0	3
4	CL423		Membrane Science & Technology	CH101, PH101, CL209, CL203	3	0	0	3
4	CL424		Microfluidics	CL203	3	0	0	3
4	CL425		Plastic Packaging Technology	CH101, PH101	3	0	0	3

**** PROGRAMME ELECTIVES TO BE OPTED ONLY BY THE DEPARTMENT STUDENTS**

DEPARTMENT OF CHEMICAL ENGINEERING - PLASTICS & POLYMER
OPEN ELECTIVES (OE)*
OFFERED FOR LEVEL 1-4

OE / LEVEL	Code no.	Name of the PE courses		L	T	P	C
OE/4	CL422	Polymer Composite		3	0	0	3
OE/3	CL322	Energy Engineering		3	0	0	3
OE/4	CL421	Fine Chemicals		3	0	0	3
OE/4	CL411	Polymer Technology		3	0	0	3
OE/3	CL332	Safety & Hazards in Process Industries		3	0	0	3
OE/3	CL335	Biomaterials		3	0	0	3
OE/3	CL327	Introduction to Microelectronics Fabrication		3	0	0	3

*** OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS**

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
In-depth Specialization in Process Engineering, Modelling and Optimization

Students who have registered for **B. Tech in Chemical Engineering** should complete 20 credits opting courses listed below. The credits shall be over and above minimum requirement for degree award. Courses shall be selected from single specialization area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits			Total Credits C - Credits	
					Lecture	T-Tutorial	P-Practical		
THEORY									
FIFTH Monsoon	Third	DS	CL361	Multiphase flow	3	0	0	3	
			CL363	Advanced Molecular Simulation	3	0	0	3	
		LABORATORY							
		DS	CL364	Chemical Technology Lab	0	0	3	1.5	
TOTAL								7.5	
THEORY									
SIXTH Spring	Third	DS	CL507	Advanced Process Modelling, Simulation & Optimization	3	0	0	3	
			CL514	Computational Fluid Dynamics	3	0	0	3	
		LABORATORY							
		DS	CL365	Energy Engineering Lab	0	0	3	1.5	
TOTAL								7.5	
THEORY									
SEVENTH Monsoon	Fourth	DS	CL614	Process Integration	3	0	0	3	
		LABORATORY							
		DS	CL426	Mini Project	0	0	4	2	
TOTAL								5	
GRAND TOTAL								20	
<i>Minimum requirement for in-depth specialization award</i>									

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
In-depth Specialization in Polymer Processing

Students who have registered for **B. Tech in Chemical Engineering** should complete 20 credits opting courses listed below. The credits shall be over and above minimum requirement for degree award. Courses shall be selected from single specialization area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits			L- C - Credits		
					Lecture	T-Tutorial	P-Practical			
					L	T	P	C		
THEORY										
FIFTH Monsoon	Third	DS	CL632	Polymer Physics	3	0	0	3		
			CL633	Polymer Product Manufacturing Technology	3	0	0	3		
		LABORATORY								
		DS	CL374	Polymer Rheology Lab	0	0	3	1.5		
TOTAL								7.5		
THEORY										
SIXTH Spring	Third	DS	CL373	Adhesive Technology	3	0	0	3		
		LABORATORY								
		DS	CL375	Polymer Synthesis Lab	0	0	3	1.5		
TOTAL								4.5		
THEORY										
SEVENTH Monsoon	Fourth	DS	CL634	Polymer Rheology	3	0	0	3		
			CL635	Die and Mould Design	3	0	0	3		
		LABORATORY								
		DS	CL427	Mini Project	0	0	4	2		
TOTAL								8		
GRAND TOTAL								20		
<i>Minimum requirement for in-depth specialization award</i>										

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
Minor in Chemical Engineering
(Offered ONLY to OTHER department students)

Students who have registered for **B. Tech Minor in Chemical Engineering** should complete 20 credits and shall opt for courses listed below. Courses shall be selected from single specialisation area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits Lecture; T-Tutorial; P-Practical			Total Credits C - Credits
					L	T	P	
THEORY								
FIFTH Monsoon	Second	PC	CL216	Unit Operation-I	3	0	0	3
	Third	PE*	CL321	Petroleum Refinery Engineering & Petrochemicals	3	0	0	3
			CL322	Energy Engineering	3	0	0	3
			CL323	Pollution Control Equipment Design	3	0	0	3
TOTAL								9
THEORY								
SIXTH Spring	Second	PC	CL217	Unit Operation-II	3	1	0	4
	Third	PE	CL332	Safety & Hazards in Process Industries	3	0	0	3
TOTAL								7
THEORY								
SEVENTH Monsoon	Second	PC	CL218	Unit Operation-III	3	1	0	4
TOTAL								4
GRAND TOTAL								20
<i>Minimum requirement for minor degree award</i>								

* Two courses out of three are compulsory.

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018-2019
Based on CBCS & OBE model
Recommended scheme of study for
Minor in Polymer Engineering
(Offered ONLY to OTHER department students)

Students who have registered for **B. Tech Minor in Polymer Engineering** should complete 20 credits and shall opt for courses listed below. Courses shall be selected from single specialisation area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits			Total Credits C - Credits
					Lecture	T-Tutorial	P-Practical	
THEORY								
FIFTH Monsoon	Third	PC	CL312	Polymer Processing	4	0	0	4
	Second		CL219	Polymer Synthesis and Reaction Engineering	3	0	0	3
TOTAL								7
THEORY								
SIXTH Spring	Third	PE	CL335	Biomaterials	3	0	0	3
			CL336	Rubber Product Technology	3	0	0	3
TOTAL								6
THEORY								
SEVENTH Monsoon	Fourth	PE	CL411	Polymer Technology	4	0	0	4
			CL415	Polymer Blends and Alloys	3	0	0	3
		PE*	CL422	Polymer Composite	3	0	0	3
			CL425	Plastic Packaging Technology	3	0	0	3
TOTAL								7
GRAND TOTAL								20
<i>Minimum requirement for minor degree award</i>								

* One course out of three are compulsory.

COURSE INFORMATION SHEET: CL 201 Thermodynamics

Course code	CL201
Course title	Thermodynamics
Pre-requisite(s)	
Co-requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	4
Class	B. Tech.
Semester / Level	III / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students:

1.	To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries.
2.	To analyze and interpret data, to identify, formulate, and solve engineering problems.
3.	To use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes

After the completion of this course, students will be able to:

CO201.1	Apply the laws of thermodynamics on closed and open systems.
CO201.2	Evaluate the properties of real gases.
CO201.3	Solve problems involving various thermodynamic cycles.
CO201.4	Evaluate the thermodynamic properties (Such as Partial molar properties, Fugacity coefficients, activity coefficients etc.) of pure fluid and fluid mixtures.
CO201.5	Predict equilibrium composition of mixtures under phase and chemical-reaction equilibria.

Syllabus

Module 1: Introduction and Basic Concepts

First law of thermodynamics, Energy balance for closed systems, Mass and Energy balances for open systems, Volumetric properties of pure fluids, Virial equations of state, Cubic equations of state, Theorem of corresponding states, Acentric factor, generalized correlations for gases and liquids, Statements of the second law, Heat engines, Carnot cycle, Refrigerator and Heat pump, Third law of thermodynamics, Microscopic interpretation of entropy. [8L]

Module 2: Thermodynamic Relations and Thermodynamic Properties of Fluids

Euler relation, Gibbs-Duhem relation, Legendre transformation, Helmholtz free energy, Gibbs free energy, Maxwell relations, Gibbs energy as a generating function, Joule-Kelvin Effect, Bridgman table,

Clausius/Clapeyron equation, Antoine equation, Residual properties, Thermodynamic properties of real gases using tables and diagrams: Edmister chart, Lee-Kesler data. [8L]

Module 3: Vapor-Liquid Equilibrium in Mixtures

Introduction to Vapor-Liquid Equilibrium, Vapor-Liquid Equilibrium in ideal mixtures, Dew point and bubble point temperatures/Pressures, VLE from K-value correlations (Flash calculations), Low-Pressure Vapor-Liquid equilibrium in non-ideal mixtures, EOS, SRK. [8L]

Module 4: Thermodynamics of Multicomponent Mixtures

Fundamental Property Relation, The Chemical Potential and Phase Equilibria, Partial Properties, The Ideal-Gas Mixture Model, Fugacity and Fugacity Coefficient (Pure Species and Species in Solution), The Ideal-Solution Model, Excess Properties, The Excess Gibbs Energy and the Activity Coefficient, Models for the Excess Gibbs Energy (Margules equation, Redlich-Kister equation, van Laar equation, Wilson equation, NRTL model and UNIQUAC equation) SRK, PR. [8L]

Module 5: Chemical Reaction Equilibria

The reaction coordinate, Application of Equilibrium Criteria to Chemical Reactions, The standard Gibbs Energy Change and the Equilibrium Constant, Effect of Temperature on the Equilibrium Constant, Evaluation of Equilibrium Constants, Relation of equilibrium constants to composition, Equilibrium Conversions for single Reactions, Phase Rule and Duhem's Theorem for Reacting Systems, Multi-reaction equilibria. [8L]

Text books:

1. Introduction to Chemical Engineering Thermodynamics: J.M. Smith, H.C. Van ness, and M.M. Abbot. 7th Edition, McGraw-Hill's Chemical Engineering Series.
2. Chemical, Biochemical and Engineering Thermodynamics: Stanley I. Sandler. Fourth Edition, John Wiley & Sons, Inc.
3. Chemical Engineering Thermodynamics: Y V C Rao, University Press.

Reference books:

1. Molecular Thermodynamics of Fluid-Phase Equilibria: J.M. Prausnitz, R.N. Lichtenthaler, E G de Azevedo. 3rd Edition, Prentice Hall International Series in the Physical and Chemical Engineering Sciences.
2. Engineering and Chemical Thermodynamics: Milo D. Koretsky. 2nd Edition, John Wiley & Sons, Inc.
3. Using Aspen Plus in Thermodynamics Instruction: Stanley I. Sandler, John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

Introduction to molecular/statistical thermodynamics.

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3 and PO4

COURSE INFORMATION SHEET: CL 203 Fluid Mechanics

Course code: CL203
Course title: Fluid Mechanics
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T:0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: III / Second
Branch: Chemical

Course Objectives

This course enables the students:

1.	To develop an appreciation for the properties of Newtonian fluids.
2.	To apply concepts of mass and momentum conservation to fluid flows and analytically solve a variety of simplified problems.
3.	To understand the dynamics of fluid flows and the governing non-dimensional parameters.

Course Outcomes

After the completion of this course, students will be able to:

CO203.1	Describe fluid pressure, its measurement and calculate forces on submerged bodies.
CO203.2	Understand the flow visualization, boundary layer and momentum correction factor, state the Newton's law of viscosity and Reynolds number. Analyze fluid flow problems with the application of the continuity and momentum equation.
CO203.3	Examine energy losses in pipe transitions and evaluate pressure drop in pipe flow using Hagen-Poiseuille's equation and Bernoulli's principle for laminar flow.
CO203.4	Understand the concept of drag, lift, streamlining, equivalent diameter, sphericity, determine minimum fluidization velocity in fluidized bed and Compute pressure drop in fixed bed, packed bed and fluidized system.
CO203.5	Analyze the general equation for internal flow meters and Determine and analyze the performance aspects of fluid machinery.

Syllabus:**Module 1:**

Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices—manometer, U-tube, inclined tube, well, diaphragm, hydraulic systems – force on submerged bodies (straight, inclined), pressure centre. [8L]

Module 2:

Fluid flow phenomena: Fluid as a continuum, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow; flow visualization – streamline, path line, streak line, stress field; viscosity; Newtonian fluid; Non-Newtonian fluid; Reynolds number-its significance, laminar, transition and turbulent flows: Prandtl boundary layer, compressible and incompressible. Momentum equation for integral control volume, momentum correction factor. [8L]

Module 3:

Internal incompressible viscous flow: Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseuille equation; flow of Non-Newtonian fluid, introduction to turbulent flow in a pipe; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation—kinetic energy correction factor; head loss; friction factor; major and minor losses, Pipe fittings and valves. [8L]

Module 4:

Flow past of immersed bodies: Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; streamlining; packed bed; concept of equivalent diameter and sphericity; Ergun equation, Fluidization: Introduction; different types of fluidization; fluidized bed assembly; governing equation; industrial use. Agitation and mixing of liquids: agitated vessel, blending & mixing, suspension of solid particles. Dispersion operation. Turbine Design/scale up, Flow number, Power Requirement. [8L]

Module 5:

Flow measurement: Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; concept of area meters: rotameter; Local velocity measurement: Pitot tube. Fluid moving machines: Introduction; Basic classification of pumps, Mechanical pump: Centrifugal and Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor. [8L]

COURSE INFORMATION SHEET: CL204 Chemical Process Calculations

Course code:	CL204
Course title:	Chemical Process Calculations
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L: 2 T: 1 P: 0
Class schedule per week:	3 hrs
Class:	B. Tech
Semester / Level:	III / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To use basic, applied chemistry/ thermodynamics for material balance calculations for different unit operations and unit processes.
2.	To use basic, applied chemistry/ thermodynamics for energy balance calculations for different unit operations and unit processes.
3.	To develop the systematic problem solving skills.

Course Outcomes

After the completion of this course, students will be able to:

CO204.1	Apply the concept of dimension and unit conversion to check dimensional consistency of balanced equation and understand the specific terms used in process calculation.
CO204.2	Solve problems related to ideal and real gas and solution.
CO204.3	Solve material balance problems without chemical reactions.
CO204.4	Solve material balance problems with chemical reactions.
CO204.5	Solve energy balance problems of various unit processes.

Syllabus**Module I: Introduction to Stoichiometry:**

Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis, Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another, Stoichiometric and composition relations, Excess & Limiting reactants, Degree of completion, Conversion, Selectivity and Yield. [8L]

Module II: Gas Calculations, Humidity & Saturation:

Gas laws-Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures. Vapour pressure, partial pressure, Vapour pressures of miscible, immiscible liquids and solutions. Real-gas relationships, Rault's Law, Henry's law, Antoine's Equation, Clausius Clapeyron Equation. PVT calculations using ideal and real gas relationships, Relative Humidity and percent saturation; Dew point, Dry and Wet bulb temperatures; Use of humidity charts for engineering calculations. [8L]

Module III: Material Balance without Chemical Reaction:

Unit Operations & Process Variables, Degree of Freedom Analysis, Application of material balances to single and multiple unit operations without chemical reactions involving distillation column, absorption column, evaporators, driers, crystallizer, liquid-liquid and liquid-solid extraction units, Unsteady state material balances. [8L]

Module IV: Material Balance with Chemical Reaction:

Material balances with Single Reaction & Multiple Reactions applicable to single and multiple unit operations, Recycle, purge, bypass in batch, stage wise and continuous operations in systems with or without chemical reaction. Material balances in combustion, gas-synthesis, acid-alkali production reactions. [8L]

Module V: Energy Balance:

Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible and latent heats, Evaluation of enthalpy, Standard heat of reaction, heat of formation, combustion, solution mixing etc., Calculation of standard heat of reaction, Hess Law, Energy balance for systems with and without chemical reaction, Unsteady state energy balances. [8L]

Text books:

1. Haugen, P.A. Watson, K.M., Ragatz R.A Chemical Process Principles Part - I
2. Himmelblau, D.M Basic Principles and Calculation in chemical engineering, Prentice Hall
3. Bhatt B.L.Vora, S.M Stoichiometry, Tata McGraw Hill Publishing Co. Ltd., New Delhi

Reference books:

1. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000
2. Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, "Process Calculations", Second Edition, Prentice Hall of India.
3. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India

Gaps in the syllabus (to meet Industry/Profession requirements)

COURSE INFORMATION SHEET: CL 205 Mechanical Operations

Course code: CL 205
Course title: Mechanical Operations
Pre-requisite(s):-
Co- requisite(s):-
Credits: L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: III / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand particulate solid characterization and storage and transportation of solids
2.	To understand principles of size reduction and equipment for size reduction
3.	To understand solid-liquid, liquid-liquid, gas-solid and solid-solid Mechanical separation

Course Outcomes

After the completion of this course, students will have:

CO205.1	Knowledge of particle size analysis, solid storage and transportation properties like frictional properties.
CO205.2	Knowledge of size reduction machineries for various industries and calculate power requirement.
CO205.3	Knowledge to design Gravity and Centrifugal settling processes for various applications, including pollution control in industry.
CO205.4	Knowledge of filtration equipment for different chemical industries, and designing of filtration process
CO205.5	Knowledge of solid-solid and gas-solid separation techniques for various applications including coal, mineral beneficiation environmental pollution control

Syllabus:

Module 1:

Characterization of solid particles: Particle Shape. Particle size analysis Differential and cumulative analysis. **Properties of particulate masses:** Bulk density, coefficient of Internal Friction, Storage of solids, Pressure distribution in hopper. Janssen Equation. **Transportation of Solids:** Studies on performance and operation of different conveyors eg. Belt, Screw, Apron, Flight etc. and elevators. [8L]

Module 2:

Size Reduction: Rittinger's law, Kick's law, Bond's law, Work index, Types of comminuting equipment – Jaw Crushers, Gyratory Crusher, Roll crushers; Grinders-hammer Mill, Ball Mill, Rod Mill etc. Dry and wet grinding, open and closed circuit. Simulation of Milling operation grinding rate function, breakage function. [8L]

Module 3:

Solid Liquid separation : Gravity Settling process – Clarifiers and Thickeners, Flocculation Design of Gravity Thickener,. **Centrifugal Settling:** principle, Centrifuges for solid liquid and liquid liquid separation. [8L]

Module 4:

Filtration: Theory of solid-liquid filtration, principle of filtration, constant pressure and constant rate filtration, compressible and incompressible cakes, Filter aids, Equipment of liquid solid filtration, Batch and continuous pressure filters. Theory of centrifugal filtration, Equipment for centrifugal filtration. [8L]

Module 5:

Solid Solid Separation : Industrial Screening equipment :Screen effectiveness and Capacity.**Wet Classification:** Differential settling, Liquid cyclones,Drag, Rake and Spiral, Bowl, Hydroseparator, Hydraulic classifiers, Tabling, Jigging, Froth floatation, Dense media separation etc.Magnetic separation, Electrostatic Separation. **Gas-solid separation:** Settling chambers, centrifugal settling, Cyclones, ESP, Scrubbers, Filters. [8L]

Suggested Books:

1. McCabe, W.L., Smith J.C., and Harriot, P., “Unit Operations Chemical Engineering”, McGraw-Hill, Inc.
2. Coulson, J.M. and Richardson, J.F., “Chemical Engineering, Volume I”, Pergamon Press.
3. Geankoplis, C.J., “Transport Processes and Unit Operations”, Prentice-Hall Inc.

Gaps in the syllabus (to meet Industry/Profession requirements) : Visit to industries like Coal Washeries, Mineral processing like HINDALCO

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design :

POs met through Topics beyond syllabus/Advanced topics/Design

COURSE INFORMATION SHEET

Course code:	CL213
Course title:	Macromolecular Science
Pre-requisite(s):	PH113,CH101,CH102
Co- requisite(s):	
Credits:	L:03 T:00 P:00
Class schedule per week:	03
Class:	B. Tech.
Semester / Level:	04/2
Branch:	Chemical Engineering (Plastics & Polymer)
Name of Teacher:	Dr Akhil Kumar Sen, Prof. S.Goswami, Prof. G. Sarkhel, Dr. P.Datta, Dr. A.Choudhury

Course Educational Objectives (CEO)

This course enables the students:

A.	Knowledge: to define chemical structure of polymer, classification and isomerism
B.	Explain: to describe the different molecular weight measurement techniques
C.	Illustrate: Given a type of polymer illustrate the method and kinetics of polymerization

Course Outcomes

After the completion of this course, students will be:

1.	Analyse: Given a type of polymer examine the crystallinity and determine its properties
2.	Synthesize: Given a set o specification synthesize polymer on available resources
3.	Evaluate: Given a set of specification assess the polymer properties
4.	Understanding the reaction kinetics of polymerisation process
5.	Student can understand the polymer solution and it behaviour

Syllabus**MODULE- I**

Classification of polymer. Polymer structure property relationship, Molecular forces and chemical bonding in polymer. Glassy to rubber transition in polymer. Molecular weight and Molecular weight distribution. Molecular weight determination by colligative properties, Ultracentrifuge, Light scattering, Solution viscometry, Gel permeation chromatography. [10]

MODULE- II

Principles of Step-reaction (condensation) polymerization. Mechanism of stepwise polymerization. Kinetics and statistics of linear stepwise polymerization. Polyfunctional step-reaction polymerization, Real Industrial processes. [5]

MODULE- III

Principles of radical chain (addition) polymerization. Initiators and initiator systems. Kinetics of vinyl radical polymerization. Kinetics of copolymerization. Composition of copolymers. Mechanism of Copolymerization Mechanism and kinetics of ionic chain growth polymerization. Mechanism and kinetics

of co-ordination polymerization. Mechanism and kinetics of ring opening polymerization. ATRP, Electrochemical Polymerization. [10]

MODULE– IV

Polymer Solutions: Criteria for polymer solubility. Conformations of dissolved polymer chains. Thermodynamics of Polymer solutions. Phase equilibrium in polymer solutions. Fractionation of polymers by solubility. Polymerization techniques: Bulk, Suspension, Emulsion, Solution polymerization. [7]

MODULE– V

Crystal structure of polymer. Morphology of crystalline polymer. Crystallization and melting. Strain induced morphology. Mechanical properties of crystalline polymer. Viscous flow. Kinetic theory of rubber elasticity. Viscoelasticity. [8]

Text Books: 1. Text book of polymer Science: Billmeyer F.W., 3rd Edn., Wiley Interscience, 1984
2. Principles of polymerization: G. Odian, 2nd Edn. Wiley Interscience New York, 1981
3. Polymer Chemistry, Sixth edition, Charles E. Carraher Jr. Marcel Dekker Inc, 2003.
4. Principles of Polymer Systems, Rodriguez, F, Taylor & Francis, 4th Edn., 1996.

Reference books:

1. Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.
2. The Element of Polymer Science & Engineering: Rudin.
3. Structural Investigation of Polymer: Bodor G., 1st Ed., Ellis Harwood Ltd., 1991.
4. Introduction to Polymer Science 3rd edition, L.H.Sperling, John Wiley and Sons 2001.

Gaps in the syllabus (to meet Industry/Profession requirements):**POs met through Gaps in the Syllabus:**

PO11, PO9, PO2

Topics beyond syllabus/Advanced topics/Design:

1.

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training

COURSE INFORMATION SHEET : CL 207 Process Technology and Economics - I

Course code	CL207
Course title	Process Technology and Economics - I
Pre-requisite(s)	Thermodynamics CL201, Chemical Process Calculations CL204
Co- requisite(s)	Mass Transfer Operation CL 209, Heat Transfer Operation CL208.
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. E.
Semester / Level	IV / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students:

1.	To understand the various processes involved in chemical industries for the production of inorganic and organic chemicals.
2.	To understand economic principles as applied in Chemical Engineering.
3.	To identify and solve engineering problems during production.

Course Outcomes

After the completion of this course, students will be able to:

CO207.1	Explain important process industries with manufacturing processes.
CO207.2	Illustrate the different unit operations and unit processes in a given process flow diagram.
CO207.3	Explain the effect of various process parameters on manufacturing processes.
CO207.4	Estimate and understand various financial terms.
CO207.5	Evaluate and analyze the concept of depreciation and profitability measure.

Syllabus**Module 1:**

Sulfuric acid: Properties of sulfuric acid, Hydrates of sulfuric acid, Usage, Contact process, Catalysts, Contact process equipment's, Materials of construction, DCDA process.

Phosphorous Industries: Phosphate rock, Superphosphates, Manufacturing of Phosphoric acid (Wet-Process and Electric-Furnace), Phosphates (Sodium phosphates, Pyrophosphates, Calcium Phosphates), manufacturing of diammonium phosphate. **8L**

Module 2:

Chlor-alkali industries: Manufacture of Soda Ash, Caustic Soda and Chlorine. Bleaching Powder, Calcium Hypochlorite, Sodium Hypochlorite. Manufacture of chlorine caustic soda, Mercury cathode and membrane process, hydrochloric acid.

Pulp and Paper Industries: Manufacture of pulp (Kraft pulping and Sulfite pulping), Manufacture of paper. **8L**

Module 3:

Nitrogen industries: Manufacturing of Ammonia; ammonium nitrate, ammonium sulphate; Manufacturing of Urea and Nitric acid.

Fertilizer Industries: Manufacturing of Single Superphosphate (SSP), Triple Superphosphate (TSP) and ammonium phosphate.

Mixed fertilizers: NPK – Manufacturing process and details of major equipments. **8L**

Module 4:

Process design development, preliminary design concepts, flowsheet development. Cost estimation of investment and production. Break-even analysis. Interest and Investment costs: Simple interest, Compound interest, Nominal and Effective interest rates, Continuous interest, Annuities. **8L**

Module 5:

Profitability measures: Rate of return on investment, Present worth and discounted cash flow, Payback period, Capitalized Costs. Depreciation: Types of depreciation, Salvage Value, Present Value, Book Value, Market Value, Replacement Value. Methods for determining depreciation: Straight line method, Declining-balance or Fixed percentage method, Sum-of-the-years-digits method, Sinking-fund Method, Accelerated cost recovery system, Modified accelerated cost recovery system. **8L**

Text books:

1. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.
2. Shreve's Chemical Process Industries, George T. Austin, 5th Edition, Tata McGraw Hill Edition.
3. Plant Design and Economics for Chemical Engineers, Max S. Peters, K. D. Timmerhaus, 4th Edition, McGraw-Hill Inc.
4. Process Engineering Economics, James Riley Couper, Marcel Dekker Inc.

Reference books:

1. Coulson & Richardson's Chemical Engineering Design, R K Sinnott, Vol. 6., Fourth Edition, Elsevier.
2. Encyclopedia of Chemical Technology, Kirk-Othmer, 5th Edition.

Gaps in the syllabus (to meet Industry/Profession requirements)**POs met through Gaps in the Syllabus****Topics beyond syllabus/Advanced topics/Design****POs met through Topics beyond syllabus/Advanced topics/Design**

COURSE INFORMATION SHEET: CL 208 Heat Transfer Operations

Course code:	CL208
Course title:	Heat Transfer Operations
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L: 3 T: 1 P: 0
Class schedule per week:	4 hrs
Class:	B. Tech
Semester / Level:	IV / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment's in process industries.
2.	Understanding the heat exchangers: working principles and basic geometries.
3.	To design heat exchangers and evaporators and analyze their performance.

Course Outcomes

After the completion of this course, students will be able to:

CO208.1	Understand and Solve heat transfer by conduction in solids for steady state and transient conditions.
CO208.2	Explain and solve heat transfer by forced and natural convection.
CO208.3	Discuss and solve heat transfer by radiation.
CO208.4	Determine heat transfer in boiling, condensation and evaporators.
CO208.5	Analyze the performance of heat exchange equipments.

Syllabus

Module I

Basic Concepts: Modes of heat transfer, conduction, convection and radiation, analogy between heat flow and electrical flow. **Conduction:** One dimensional steady state heat conduction, the Fourier heat conduction equation, conduction through plane wall, conduction through cylindrical wall, spherical wall, conduction through composite slab, cylinder and sphere, critical radius of insulation, **Extended surfaces:** heat transfer from a fin, fin effectiveness and efficiency, Introduction to unsteady state heat conduction. [8L]

Module II

Convection: Natural and forced convection, the convective heat transfer coefficient. **Forced Convection:** Correlation equations for heat transfer in laminar and turbulent flows in a Circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer, heat transfer to liquid metals and heat transfer to tubes in cross flow. **Natural Convection:** Natural convection from vertical and horizontal surfaces, Grashof and Rayleigh numbers. [8L]

Module III

Heat transfer by radiation: Basic Concepts of radiation from surface: black body radiation, Planks law, Wien's displacement law, Stefan Boltzmann's law, Kirchhoff's law, grey body, Radiation intensity of black body, View factor, emissivity, radiation between black surfaces and grey surfaces. Solar radiations, combined heat transfer coefficients by convection and radiation. [8L]

Module IV

Boiling and Condensation: Pool boiling, pool boiling curve for water, maximum and minimum heat fluxes, correlations for nucleate and film pool boiling, drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal tube, effect of non-condensable gases on rate of condensation. **Evaporation:** Types of evaporators, boiling point elevation and Duhring's rule, material and energy balances for single effect evaporator, multiple effect evaporators: forward, mixed and backward feeds, capacity and economy of evaporators. [8L]

Module V

Heat Exchangers: Introduction, Industrial use, Types of heat exchangers, Co-current, Counter-current & Cross-current, Principal Components of a Concentric tube & Shell-and Tube Heat Exchanger, Baffles, Tubes and Tube Distribution, Tubes to Tube sheets Joint, Heat Exchangers with Multiple Shell & tube Passes, Fixed-Tube sheet and Removable-Bundle Heat Exchangers, log-mean temperature difference, overall heat transfer coefficient, fouling factors, Design of double pipe and shell and tube heat exchangers. [8L]

Text books:

1. Holman, J. P., 'Heat Transfer', 9th Edn., McGraw Hill, 2004.
2. Kern, D.Q., "Process Heat Transfer", McGraw-Hill, 1999.
3. Cengel, Y.A., Heat Transfer - A Practical Approach, McGraw-Hill, 1998.

Reference books:

1. Incropera, F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 5th ed., John

COURSE INFORMATION SHEET: CL 209 Mass Transfer Operations -I

Course code:	CL209
Course title:	Mass transfer operations-I
Pre-requisite(s):	Thermodynamics (CL 201), Chemical Process Calculations (CL 204)
Co- requisite(s):	Transport Phenomena
Credits:	L: 3 T: 0 P: 0
Class schedule per week:	03
Class: B. E.	
Semester / Level:	IV / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To learn basic knowledge of mass transfer operation and its application.
2.	To learn basic knowledge of mass transfer equipments.
3.	To design mass transfer equipments.

Course Outcomes

After the completion of this course, students will be to:

CO209.1	Explain the basic mechanism of mass transfer including diffusion and convective mass transfer.
CO209.2	Find the mass transfer coefficient and solve problems related to interphase mass transfer.
CO209.3	Explain the gas-liquid contacting process and solve related problems.
CO209.4	Solve problems on VLE and problems related to design calculation of distillation column.
CO209.5	Explain enhanced distillation.

Syllabus**Module 1**

Introduction to mass transfer and applications, Principles of molecular diffusion, Fick's Law, Diffusivity, Equation of continuity and unsteady state diffusion, Diffusion in solids. Convective mass transfer and Mass transfer coefficient, Correlation of mass transfer coefficients. (8L)

Module 2

Interphase mass transfer, Theories of Mass Transfer, individual gas and liquid phase mass transfer coefficient, overall mass transfer coefficient, Analogy between momentum, heat and mass transfer, Concept of stage wise contact processes. (8L)

Module-3

The mechanism of absorption, Equipment for Gas Liquid contact, Kremser equation, plate and packed tower internals, Packed tower design, H. E. T. P., H. T. U., and N. T. U. concepts, height of column based on conditions in the gas film, height of column based on conditions in the liquid film, height of column based on overall coefficients, plate type towers, number of plates, plate efficiency, absorption factor. (8L)

Module-4

Relative Volatility, calculation of number of plates by McCabe-Thiele method, Total and minimum reflux ratio, distillation with side streams, Enthalpy concentration diagram, calculation of number of plates by Ponchon and Savarit method, Steam distillation, Azeotropic & Extractive Distillations, batch distillation with reflux, Introduction to multicomponent distillation. (8L)

Module-5

Shortcut method on multi component distillation, MESH equations (HK, LK component), Fenske-Underwood- Gilliland method. (8L)

Text books:

1. Mass Transfer Operations: R.E. Treybal Mc Graw Hill, 1981
2. Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
3. Principles of Mass Transfer and Separation Processes, Binay K. Dutta, 2nd edition, Prentice Hall of India,2007.
4. Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Reference books:

Separation Process Principles-Chemical and Biochemical Operations, J. D. Seader, Ernest J. Henley, D. Keith Roper, 3rd Ed., John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)**POs met through Gaps in the Syllabus****Topics beyond syllabus/Advanced topics/Design****POs met through Topics beyond syllabus/Advanced topics/Design**

COURSE INFORMATION SHEET

Course code:	CL214
Course title:	Polymer Technology-I
Pre-requisite(s):	CL213
Co- requisite(s):	Nil
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	03
Class:	B. Tech
Semester / Level:	04/2
Branch:	Chemical Engineering- Plastics and Polymer
Name of Teacher:	Dr. P. Datta, Dr. G. Sarkhel, Dr.(Mrs.) S. Goswami

Course Objectives: This course enables the students:

- A. *Understand* the structure property relationship of various plastics.
- B. *Explain* the importance of compounding ingredients in plastics and get detailed knowledge about the ingredients.
- C. *Describe* the preparation, properties and application of thermosets and engineering plastics and various copolymers

Course Outcomes: After completion of the course, learner will be able to

CO214.1 *select* additives for different plastics and *formulate* recipe for specific product manufacturing.

CO 214.2 *design* the preparation, properties and application of various commodity plastics

CO 214.3 *demonstrate* preparation, properties and application of engineering plastics

CO 214.4 *analyse* the methods of the preparation, properties and application of specific copolymers.

CO 214.5 *Apply* the importance of structure property relationship to choose the materials for various applications.

Syllabus

MODULE- I

Additives for Plastics: Definition, classification, mechanism of action, method of incorporation of: fillers, coupling agents, plasticizer, cross linking agents, stabilizer, blowing agents. [8]

MODULE- II

Definition, classification, mechanism of action of flame retardants, colorants: pigments and dyes, antistatic agents, antiblock agents, nucleating agents, toughening agent, lubricants

[8]

MODULE- III

Manufacturing process with emphasis on flow sheet, processing application, major engineering problems of PE (LDPE, HDPE, LLDPE, XLPE, UHMHDEP), PTFE, PP. [8]

MODULE- IV

Manufacturing, Properties, processing, applications, major engineering problems, economics and Indian scenario of Polyamides: nylon 6, nylon 66, polyimides, Cellulosics [8]

MODULE- V

Manufacturing, properties, processing, applications of PS, PVC, PVOH, Acrylics, ABS, SAN, ionomers. [8]

Text Books:

1. Plastics materials: Brydson J.A., 3rd Edn., Butter worth, Woburn 1975
2. Plastics Engineering Hand Book: Frados J. Society of plastic & Industry. Inc. 4th Edn., Van Nostrand, N.Y. 1976
3. The Roll of Additives in Plastics, Mascia, L., Edward Arnold, 1974
5. Hand Book of Plastic Testing Technology, Vishu Shah, Wiley Inter Science.

Reference Books:

1. Functional Monomers and Polymers Kiichi Jakenioto, Raphael M, Ottenbrites, Mikhiaru kamachi - Marcel Dekker.
2. Shreve's chemical process Industries, George T. Sustin, Mc Grow Hill.
3. Unit process in Organic synthesis, Groggins, P.H. Mc Grow Hill.

Gaps in the syllabus (to meet Industry/Profession requirements)

Practical problems faced in industries during manufacturing of additive materials needs to addressed by industry personal

POs met through Gaps in the Syllabus

PO11, PO9, PO4

Topics beyond syllabus/Advanced topics/Design

- Processing of plastics with emphasis on their flow properties in specific processing equipment under specific condition
- Analysis of flow characteristics of polymers during processing with respect to their chemical structure and properties

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018- 19
Based on CBCS & OBE model
Recommended scheme of study for M.Tech in Chemical Engineering

SEMESTER / Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits <i>L-Lecture; T-Tutorial; P-Practical</i>			Total Credits <i>C- Credits</i>
					L <i>(Periods/week)</i>	T <i>(Periods/week)</i>	P <i>(Periods/week)</i>	C
FIRST / Monsoon	FIFTH	THEORY						
		PC	CL 501	Advanced Transport Phenomena-I	3	0	0	3
			CL502	Advanced Mathematical Techniques in Chemical Engg	3	0	0	3
			CL503	Advanced Reaction Engg.	3	0	0	3
		PE		Program Elective (PE-I)	3	0	0	3
	OE		Open Elective (OE-I)	3	0	0	3	
		LABORATORY						
	FIFTH	PC	CL504	Design & Simulation Lab	0	0	4	2
			CL505	Computational Laboratory	0	0	4	2
		TOTAL						
SECOND/ Spring	FIFTH	THEORY						
		PC	CL506	Advanced Transport Phenomena- II	3	0	0	3
			CL507	Advanced Process Modelling, Simulation and Optimization	3	0	0	3
			CL508	Advanced Thermodynamics	3	0	0	3
		PE		Program Elective (PE-II)	3	0	0	3
	OE		Open Elective (OE-II)	3	0	0	3	
		LABORATORY						
	FIFTH	PC	CL509	Computer Aided Process Engg.	0	0	4	2
			CL510	Chemical Engg. Research Lab-I	0	0	4	2
		TOTAL						
TOTAL FOR FIFTH LEVEL							38	
THIRD / Monsoon	SIXTH	THEORY						
		PC	CL 600	Thesis Part 1				8
			CL 602	Advanced Separation Process	3	0	0	3
	PE		Program Elective (PE-III)	3	0	0	3	
		LABORATORY						
	SIXTH	PC	CL603	Chemical Engg. Research Lab-II	0	0	4	2
	TOTAL							16
FOURTH/ Spring	SIXTH	PC	CL650	Thesis Part 2				16
	TOTAL							16
TOTAL FOR SIXTH LEVEL							32	
GRAND TOTAL FOR M.TECH PROGRAMME (38 + 32)							70	

DEPARTMENT OF CHEMICAL ENGINEERING
PROGRAMME ELECTIVES (PE) **
OFFERED FOR LEVEL 5-6 of M.Tech. In Chemical Engineering

PE / LEVEL	Code no.	Name of the PE courses	Prerequisites courses with code	L	T	P	C
Programme Elective -I							
PE/5 (MO)	CL511	Complex Fluid Technology	CL210,CL203	3	0	0	3
PE/5 (MO)	CL512	Biochemical Engineering	CL209,CL302, CL308	3	0	0	3
PE/5 (MO)	CL513	Process safety and Management	CL205,CL308	3	0	0	3
Programme Elective - II							
PE/5 (SP)	CL514	Computational Fluid Dynamics	CL210,CL203,MA203,CS101	3	0	0	3
PE/5 (SP)	CL515	Process Intensification	CL308,CL210	3	0	0	3
PE/5 (SP)	CL516	Heterogeneous Catalysis and Catalytic Processes	CL302,CH101, PH113, CL301	3	0	0	3
Programme Elective -III							
PE/6 (MO)	CL631	Composite Manufacturing Technology	CH101, PH111,MA103	3	0	0	3
PE/6 (MO)	CL632	Polymer Physics	CH101, PH111,MA103	3	0	0	3
PE/6 (MO)	CL633	Polymer Product manufacturing Technology	CH101, PH111,MA103	3	0	0	3
PE/6 (MO)	CL634	Polymer Rheology	CH101, PH111,MA103	3	0	0	3
PE/6 (MO)	CL635	Die and Mould	PE201, ME101	3	0	0	3
PE/6 (MO)	CL614	Process Integration	CL308,CL210	3	0	0	3

**** PROGRAMME ELECTIVES TO BE OPTED ONLY BY THE DEPARTMENT STUDENTS**

**DEPARTMENT OF CHEMICAL ENGINEERING
OPEN ELECTIVES (OE)*
OFFERED FOR LEVEL 5-6 of M.Tech in Chemical Engineering**

OE / LEVEL	Code no.	Name of the PE courses	Prerequisites courses with code	L	T	P	C
OE/5 (MO)	CL516	Heterogeneous Catalysis and Catalytic Processes	NIL	3	0	0	3
OE/5 (MO)	CL515	Process Intensification	NIL	3	0	0	3
OE/5 (SP)	CL614	Process Integration	NIL	3	0	0	3
OE/5 (SP)	CL631	Composite Manufacturing Technology	NIL	3	0	0	3

*** OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS**

COURSE INFORMATION SHEET

Course code: CL501

Course title: Advanced Transport Phenomena – I

Pre-requisite(s): B.E./B.Tech. in Chemical Engineering.

Co-requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M. Tech.

Semester/Level: I/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To acquire knowledge on momentum, heat and mass transfer in Chemical engineering systems and their analogous behaviour.
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Course Outcomes:

After the completion of the course students will be able to:

CO1	Identify and describe mechanisms of transport phenomena, present in given isothermal and non-isothermal, laminar and turbulent flow systems.
CO2	Distinguish interrelations between the molecular, microscopic and macroscopic descriptions of transport phenomena.
CO3	Explain similarities and differences between the descriptions of the combined fluxes and the equations of change for mass, momentum and heat transport.
CO4	Apply the method of dimensional analysis to reformulate and then find the form of solutions of the equations of change, to determine the dependence of the interfacial fluxes on system parameters.
CO5	Elaborate conceptual and mathematical models, from conservation principles, to complicated systems involving simultaneous mass, momentum, and/or heat transfer processes as well as reactions or other sources/sinks of transport for multi-component mixtures.

SYLLABUS

Module I:

Vectors & Tensors: Geometric representation of vectors; Einstein summation convention; Basic review of vector algebra; Representation using Kronecker delta and alternating unit tensor; Review of vector calculus. Tensors: dyadic products with another tensor, vector etc; tensor operations required for stress analysis. (8L)

Module II:

Transport by molecular motion: Newton's law and viscosity, Fourier's law of Heat conduction., Fick's law of Diffusion. (8L)

Module III:

Kinematics: Motion, streamlines, pathlines and streaklines, Governing equations of fluid mechanics. Introduction: Equation of continuity, equation of motion, Euler equation, Bernoulli equation, Momentum boundary layer theory (Laminar boundary theory & turbulent boundary layer theory), dimensionless number and its significance. (8L)

Module IV:

Navier-stokes equation, creeping flow around a solid sphere, expression for total drag, Turbulent flow: Transition to turbulence, Prandtl' mixing length, Turbulence models. Boundary layer on immersed bodies, two dimensional boundary layer equation, laminar boundary layer on flat plate (Blasius exact solution), Von-Karmann's integral momentum equation, boundary layer separation flow and pressure drag, Flow of compressible fluids, thermodynamic considerations, continuity and momentum equation for one dimensional compressible flow, one dimensional normal shock, flow through fluidized beds. Navier-Stokes equation and various approaches of simulation (stream velocity, primitive variable). (8L)

Module V:

Modes of heat transfer; concepts of (a) thermal conductivity – constant and temperature dependent, (b) thermal diffusivity and (c) heat transfer coefficient. Fourier's law of heat conduction. Shell energy balance and boundary conditions – Heat conduction with electrical, nuclear, viscous and chemical heat source, Heat conduction through composite walls, Heat conduction in fins. Free convection-flow between two vertical walls. (8L)

Books recommended:

TEXT BOOK

1. R.B. Bird, W.E. Stewart, and E.N. Lightfoot, Transport Phenomena, Second edition, John Wiley and Sons, 2002. (T1)
2. R.W. Fox, A.T. Mc Donald, P.J. Pritchard, Introduction to Fluid Mechanics, Willey, 6th edition. (T2)
3. Chemical Engineering by Coulson and Richardson, Volume I. (T3)

COURSE INFORMATION SHEET

Course code: CL502

Course title: Advanced Mathematical Techniques in Chemical Engineering

Pre-requisite(s): BE (Chemical Engineering) or equivalent

Co-requisite(s): NIL

Credits: 3 L:3 T:0 P:0

Class schedule per week: 3

Class: M. Tech.

Semester / Level: I/05

Branch: Chemical Engineering

Course Objectives:

This course enables the students:

1.	To develop appropriate methods to solve a linear system of equations.
2.	To develop appropriate numerical methods to solve a ordinary differential equation (IVP)/ special ordinary differential equation/ partial differential equation.

Course Outcomes:

After the completion of this course, students will be:

CO1	Explain vector space; Metric, Norm, Inner Product space.
CO2	Solve linear system of equations.
CO3	Evaluate a derivative at a value using an appropriate numerical method calculate a definite integral using an appropriate numerical method.
CO4	Solve a differential equation using an appropriate numerical method.
CO5	Solve a partial differential equation using an appropriate numerical method.

SYLLABUS

Module I:

Introduction of vector space, Metric, Norm, Inner Product space, completeness of space. Vectors: Linear combination of vectors, dependent/independent vectors; Orthogonal and orthonormal vectors; Gram-Schmidt orthogonalization; Examples. Contraction Mapping: Definition; Applications in Chemical Engineering with examples. Matrix, determinants and properties. (8L)

Module II:

Eigenvalue Problem: Various theorems, Solution of a set of algebraic equations, Solution of a set of ordinary differential equations, Solution of a set of non-homogeneous first order ordinary differential equations (IVPs). Applications of eigenvalue problems: Stability analysis, Bifurcation theory. (8L)

Module III:

Partial Differential equations: Classification of equations, Boundary conditions, Principle of Linear superposition. Special ODEs and Adjoint operators: Properties of adjoint operator, Theorem for eigenvalues and eigenfunctions. (8L)

Module IV:

Solution of linear, homogeneous PDEs by separation of variables: Cartesian coordinate system & different classes of PDEs, Cylindrical coordinate system, Spherical Coordinate system. (8L)

Module V:

Solution of non-homogeneous PDEs by Green's theorem, Solution of PDEs by Similarity solution method, Solution of PDEs by Integral method, Solution of PDEs by Laplace transformation, Solution of PDEs by Fourier transformation. (8L)

Books recommended:

TEXT BOOK

1. Mathematical Methods in Chemical Engineering by S. Pushpavanam, Prentice Hall of India. (T1)
2. Applied Mathematics and Modeling for Chemical Engineers by R. G. Rice & D. D. Do, Wiley. (T2)

REFERENCE BOOK

1. Mathematical Method in Chemical Engineering by A. Varma & M. Morbidelli, Oxford University Press. (R1)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Numerical solution of industrial problems.

POs met through Gaps in the Syllabus: **PO4**

Topics beyond syllabus/Advanced topics/Design:

Global optimization algorithms such as Genetic algorithm.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO3 & PO4**

COURSE INFORMATION SHEET

Course code: CL503

Course title: Advanced Reaction Engineering

Pre-requisite(s): BE in Chemical Engineering or equivalent.

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester/Level: I/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To learn the energy balance, temperature and concentration profiles in various reactors.
2.	To design chemical Reactors.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Determine kinetics from experimental data.
CO2	Perform the energy balance and obtain concentration profiles in multiphase reactors.
CO3	Determine the chemical reaction equilibria for various reactions.
CO4	Evaluate heterogeneous reactor performance considering mass transfer limitations.
CO5	Determine kinetics of a bio-reactor.

SYLLABUS

Module I:

Basics - mass and energy balance equations for reactors, Kinetics - rate law, theories of rate constants, determination of kinetics from experimental data, multiple reaction kinetics. Kinetics of different reaction: biochemical reactions (Michaelis–Menten kinetics, Monod model kinetics), polymerization reactions kinetics. (8L)

Module II:

Design of biochemical reactor, polymerization reactor. Other reactor types - Semi-batch, Packed Bed, Fluidized Bed, Membrane, Slurry, Trickle Bed. Gas-Liquid reactions/reactors – Fundamentals. (8L)

Module III:

Non-ideal reactor models- Flow, Reaction and Dispersion, Numerical solutions to flows with dispersion and reaction, Modelling real reactors with combinations of ideal reactors. (8L)

Module IV:

Gas-Solid reactions/reactors - Catalytic and Non-Catalytic Reaction fundamentals Concepts of catalysis- Kinetics, Deactivation, Effectiveness factor, Diffusion effects, External resistance to mass transfer, Shrinking core model. (8L)

Module V:

Chemical Reaction Equilibria: Criterion of chemical reaction equilibrium, Application of Equilibrium Criteria to Chemical Reactions, the standard Gibbs Energy Change and the Equilibrium Constant, Effect of Temperature on the Equilibrium Constant, Evaluation and Relation of Equilibrium Constants, Equilibrium Conversions for single Reactions, Phase Rule and Duhem's Theorem for Reacting Systems. (8L)

Books recommended:

TEXT BOOK

1. Elements of chemical reaction engineering, H.S. Fogler. (T1)
2. Chemical Reactor Analysis and Design, G. F. Froment and K. B. Bischoff (T2)
3. Chemical Engineering Kinetics, J. M. Smith. (T3)

REFERENCE BOOK

1. Heterogeneous Catalysis in Industrial Practice, Satterfield, C. N., (R1).

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Programme Elective-I

COURSE INFORMATION SHEET

Course code: CL511

Course title: Complex Fluid Technology

Pre-requisite(s): CL210, CL203

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester/Level: I/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To have concepts required to analyse the behaviour of such fluids which are Non-Newtonian and are encountered in various engineering applications.
2.	To describes the most commonly used classes of material systems and their rheological behaviour.

Course Outcomes:

After the completion of the course students will be able to

CO1	Analyse fluid flow problems with the application of the momentum and energy equations.
CO2	Analyse mixing processes of polymer melts.
CO3	Explain principles of Brownian Motion.
CO4	Explain Theories of Polymer Statics and Dynamics.
CO5	Examine the behaviour of complex fluids by using of probes like Rheology, Microscopy, Light Scattering.

SYLLABUS

Module I:

Overview of complex fluids Definition of complex fluids Examples from the kitchen, industry, and research. Basic principles of Micro-hydrodynamics: Creeping flow equations, Langevin equation Resistance/Mobility relations, Lorentz Reciprocal Theorem, Foxen's Law, Greens Identity, Oseen Tensor. [8L]

Module II:

Simple systems Calculation of effective viscosities Pair interactions and hydrodynamic interactions Sedimentation. [8L]

Module III:

Basic principles of Brownian Motion: Langevin equation, Connection with diffusion equation, Fluctuation dissipation theorem, Stokes Einstein relation, Simulations of Brownian dynamics. [8L]

Module IV:

Polymers: Theories of Polymer Statics, Rouse Dynamics, Zimm Dynamics. Other Colloidal Forces: Van Der Waals Interactions, Electrostatic Interactions, Poisson-Boltzmann Equation. [8L]

Module V:

Probes of complex fluids: Rheology, Microscopy, Light Scattering. [8L]

Books recommended:

TEXT BOOK

1. Larson, R.G. The Structure and Rheology of Complex Fluids Oxford University Press, 1999. **(T1)**
2. Russel, Saville, and Schowalter Colloidal Dispersions Cambridge University Press, 1989. **(T2)**
3. Leal, G.L. Laminar Flow and Convective Transport Processes Butterworth-Heinemann, 1992. **(T3)**

REFERENCE BOOK

1. Deen, W.M. Analysis of Transport Phenomena Oxford University Press, 1998. **(R1)**
2. Doi & Edwards The Theory of Polymer Dynamics Oxford University Press, 1986. **(R2)**
3. Kim & Karrila Micro-hydrodynamics: Principles and Selected Applications Butterworth-Heinemann, 1991. **(R3)**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Experimental techniques for investigating complex fluids.

Phase transitions in liquid crystals.

POs met through Gaps in the Syllabus: **PO4 & PO5**

COURSE INFORMATION SHEET

Course code: CL512
Course title: Biochemical Engineering
Pre-requisite(s): CL209, CL302, CL308
Co- requisite(s):
Credits: L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: I/05
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:

This course enables the students:

1.	To understand the basics of biology and Principles of biochemical processes.
2.	To gain knowledge on enzyme kinetics, metabolic pathways and microbial growth.
3.	Introduction to the basics of bioreactor design.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Analyse and evaluate kinetics of biochemical processes.
CO2	Understand and develop models for biochemical processes.
CO3	Design bioreactors for specific applications.
CO4	Evaluate mechanisms of biochemical processes.
CO5	Evaluate microbial population models.

SYLLABUS

Module I:

Basics of Biology; Overview of Biotechnology; Diversity in Microbial Cells, Cell Constituents, Chemicals for Life. (8L)

Module II:

Kinetics of Enzyme Catalysis. Immobilized Enzymes: effects of intra and inter-phase mass transfer on enzyme kinetics (8L)

Module III:

Major Metabolic Pathways: Bioenergetics, Glucose Metabolism, Biosynthesis. (8L)

Module IV:

Microbial Growth: Continuum and Stochastic Models. Design, Analysis and Stability of Bioreactors. (8L)

Module V:

Kinetics of Receptor-Ligand Binding Receptor-mediated Endocytosis Multiple Interacting Microbial Population: Prey-Predator Models. Bio-product Recovery & Bio-separations; Manufacture of Biochemical Products. (8L)

Books recommended:

TEXT BOOK

1. Biochemical Engineering Fundamentals by J. E. Bailey & D. F. Ollis, McGraw Hill Book Company, 1986. (T1)
2. Biochemical Engineering by H. W. Blanch & D. S. Clark, Marcel Dekker, Inc., 1997. (T2)

REFERENCE BOOK

1. Bioprocess Engineering (Basic Concepts) by M. L. Shuler & F. Kargi, Prentice Hall of India, 2003. (R1)
2. Transport Phenomena in Biological Systems by G. A. Truskey, F. Yuan, D. F. Katz, Pearson Prentice Hall, 2004. (R2)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design of bioreactors for specialized applications such as pharmaceutical products
POs met through Topics beyond syllabus/Advanced topics/Design: **PO2, PO3, PO4**

COURSE INFORMATION SHEET

Course Code: CL513

Course title: Process Safety and Management

Pre-requisite(s): BE Chemical Engineering or equivalent.

Co- requisite(s):

Credits: 03 L: 03 T: 00 P: 00

Class schedule per week: 03

Class: M. Tech

Semester/Level: I/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course enables the students:

1.	To acquire comprehensive knowledge of safety and hazards aspects in industries and the management of hazards.
2.	To develop a safe protocol by safety audit and risk assessment and minimize potential damages to process equipment's, people and the environment.

Course Outcomes:

After the completion of this course, students will be able:

CO1.	To understand the importance of plant safety and safety regulations, personal protective equipment's, principles and procedures of safety audit.
CO2.	To implement various safety aspect of fire and explosion in a chemical plant
CO3.	To identify and mitigate different types of toxic chemical hazards
CO4.	To assess and mitigate different hazards due to storage and transportation of chemicals plant operations.
CO5	To design safety protocols for chemical industry using various hazard evaluation tools.

SYLLABUS

Module I:

Introduction: Industrial processes and hazards potential, mechanical electrical, thermal and process hazards. Safety and hazards regulations, Industrial hygiene. Factories Act, 1948 and Environment (Protection) Act, 1986 and rules thereof. (8L)

Module II:

Fire & Explosion and their prevention: Shock wave propagation, vapor cloud and boiling liquid expanding vapors explosion (VCE and BLEVE), mechanical and chemical explosion, multiphase reactions, transport effects and global rates. Preventive and protective management from fires and explosion-inerting, static electricity passivation, ventilation, and sprinkling, proofing, relief systems – relief valves, flares, scrubbers. (8L)

Module III:

Leaks and Leakages: Spill and leakage of liquids, vapours, gases and their mixture from storage tanks and equipment; Estimation of leakage/spill rate through hole, pipes and vessel burst; Isothermal and adiabatic flows of gases, spillage and leakage of flashing liquids, pool evaporation and boiling; Release of toxics and dispersion. Naturally buoyant and dense gas dispersion models; Effects of momentum and buoyancy; Mitigation measures for leaks and releases. (8L)

Module IV:

Hazard Identification and Evaluation:

Hazards identification-toxicity, fire, static electricity, noise and dust concentration; Material safety data sheet, hazards indices- Dow and Mond indices, hazard operability (HAZOP) and hazard analysis (HAZAN). (8L)

Module V:

Safety Management:

Safety policy, Safety standards, Techniques to measure safety performance, Safety targets and objectives, Audits of safety standards and practices. (8L)

Books recommended:

TEXT BOOK

1. Chemical Process Safety: Fundamentals with Applications: Daniel A. Crowl and J.F.Louvar. (T1)
2. F.P. Lees, Loss Prevention in Process Industries, Vol. 1 and 2, Butterworth, 1983. (T2)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Case studies.

POs met through Gaps in the Syllabus: **PO5**

Topics beyond syllabus/Advanced topics/Design:

Management of change, Emergency Planning and Response.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5**

Open Elective-I

COURSE INFORMATION SHEET

Course code: CL516

Course title: Heterogeneous Catalysis and Catalytic Processes

Pre-requisite(s): BE Chemical Engg. Or equivalent

Co- requisite(s):

Credits: L: 3 T:0 P:0

Class schedule per week: 03

Class: M. Tech

Semester/Level: I/5

Branch: Chemical Engineering

Name of Teacher:

Course Objectives

This course enables the students:

1	This course examines the detailed structures, preparation methods and reactivities of solid catalysts.
2	Several important catalyst properties and their determination techniques such as surface area and pore size measurements, temperature Programmed desorption (TPD), and various spectroscopic techniques.
3	The relationship between the structures and reactivities of important catalysts used in various applications.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Explain various catalyst preparation methods for an end application.
CO2	Evaluate various properties of catalysts.
CO3	Correlate the structure of catalyst with its reactivity.
CO4	Evaluate catalyst deactivation kinetics.
CO5	Model the various catalytic reactors.

SYLLABUS

Module I:

Basic concepts in heterogeneous catalysis, catalyst preparation and characterization, poisoning and regeneration. (8L)

Module II:

Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes. (8L)

Module III:

Commercial reactors: adiabatic and multi-tubular packed beds, fluidized bed, trickle-bed, slurry reactors. (8L)

Module IV:

Heat and mass transfer and its role in heterogeneous catalysis. Calculations of effective diffusivity and thermal conductivity of porous catalysts. (8L)

Module V:

Reactor modelling; Chemistry and engineering aspects of catalytic processes along with problems arising in industry. Catalyst deactivation kinetics and modeling. (8L)

Books recommended:

TEXT BOOKS:

1. Catalytic Chemistry: Bruce Gates (T1)
2. Optimal distribution of catalyst in a pellet: Morbidelli and Verma (T2)
3. Catalysis of Organic reactions: editor M.E.Ford, Marcel Dekker Inc. (T3)

REFERENCE BOOK

1. Heterogeneous Reactions Vol 1 and Vol II : M. M. Sharma and Doraiswamy (R1)
2. Principles and practice of heterogeneous Catalysis: Thomas, J.M., Thomas W.J. (R2)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Industrial reactor data analysis and its application towards better reactor design.
POs met through Gaps in the Syllabus: **PO4 & PO5**

Topics beyond syllabus/Advanced topics/Design:

Design and analysis of Non-isothermal industrial reactor.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO4 & PO5**

COURSE INFORMATION SHEET

Course code: CL515

Course title: Process Intensification

Pre-requisite(s): BE (Chemical Engg.) or equivalent

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester/Level: I/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1	To provide an understanding of the concept of Process Intensification.
2	To provide knowledge and understanding of application of intensification techniques to a range of processes e.g. heat and mass transfer, separation processes.
3	To provide an understanding of basic operating principles of a variety of intensified process equipment such as spinning disc reactor, rotary packed beds, oscillatory flow reactors, compact heat exchangers and micro-reactors etc.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Explain the concept of Process Intensification and the methodologies for PI.
CO2	Explain the benefits of PI in the process industries.
CO3	Explain the operating principles of a number of intensified technologies.
CO4	Analyse the range of potential applications of intensified equipment.
CO5	Design compact heat exchanger.

SYLLABUS

Module I:

Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application. [8L]

Module II:

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Micro reaction Technology, From basic Properties to Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes. [8L]

Module III:

Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Hige reactors. [8L]

Module IV:

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NO_x Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example. [8L]

Module V:

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sono-crystallization, Reactive separations, Supercritical fluids. [8L]

Books recommended:

Text books:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003. (T1)
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008. (T2)
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013. (T3)

COURSE INFORMATION SHEET

Course code: CL504

Course title: Design and Simulation Lab

Pre-requisite(s): BE (Chemical Engineering) or equivalent

Co- requisite(s):

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M. Tech.

Semester/Level: I/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To simulate steady state chemical engineering processes using ASPEN PLUS.
2.	To simulate steady state chemical engineering processes using SIMULINK.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Analyse heat and mass transfer operation using Aspen plus simulator.
CO2	Simulate chemical process plant and effect of process variables on the plant operation using ASPEN PLUS.
CO3	Develop governing equations of unsteady state chemical engineering processes, based on mass and energy balance.
CO4	Control the process variables using SIMULINK.
CO5	Analyse phase equilibria data using various regression methods.

SYLLABUS

Problem 1:

Study of Vapour Liquid Equilibrium using ASPEN PLUS

Property analysis and Simulation Method. Regression of binary VLE data. NIST thermo data engine analysis. Flash Calculation.

Problem 2:

Study of Liquid-Liquid Equilibrium using ASPEN PLUS

Analysis of liquid-liquid equilibrium data, Regression of liquid-liquid equilibrium. Study of Liquid-Liquid Extraction systems.

Problem 3:

Reactor Analysis using ASPEN PLUS.

Reactor study using RStoic, RYield, REquil, RGibbs, RCSTR, RPlug and RBatch reactor module and effect of Process variable using 'Sensitivity Analysis' tool. Study of Chemical Equilibrium using ASPEN PLUS.

Problem 4:

Study of Distillation Column using ASPEN PLUS

Shortcut Distillation Calculations using DSTWU module and Sensitivity analysis. Rigorous Distillation Calculation using RadFrac module and Sensitivity analysis.

Problem 5:

Chemical Plant Simulation using ASPEN PLUS

Simulation of a distillation train. Simulation of a vinyl chloride monomer production unit. Simulation of CO₂ capture plant using Physical/chemical solvent.

Problem 6:

Study of composition dynamics in a continuous stirred tank reactor CSTR

Objectives: i) To formulate time domain mass balance equation of a CSTR with 1st order irreversible and isothermal reaction and construct MATLAB SIMULINK block diagram of the system of one equation ii) Transient analysis of the CSTR using SIMULINK.

Problem 7:

Control of composition in a continuous stirred tank reactor CSTR

Objectives: i) To construct MATLAB SIMULINK block diagram of a CSTR from mass balance equation ii) To control composition of CSTR manipulating inlet flow rate.

Problem 8:

Study of level and temperature dynamics in a stirred tank heater

Objectives: i) To formulate time domain mass balance and energy balance equation of a stirred tank heating system and construct MATLAB SIMULINK block diagram of the system of two equation ii)

To obtain dynamics of level and temperature using SIMULINK, iii) Transient analysis of stirred tank heater.

Problem 9:

Study of temperature dynamics in a non-isothermal continuous stirred tank reactor (CSTR)

Objectives: i) To construct MATLAB SIMULINK block diagram of a non-isothermal CSTR from energy balance equation ii) To control temperature of CSTR manipulating inlet flow rate.

Problem 10:

Temperature control in a stirred tank heater

Objectives: i) To construct MATLAB SIMULINK block diagram of a stirred tank heater from mass and energy balance equation ii) To control temperature of stirred tank heater manipulating inlet flow rate.

Books recommended:

TEXT BOOK

1. Using Aspen Plus® in Thermodynamics Instruction A Step-by-Step Guide by Stanley I. Sandler. Wiley & Sons, Inc., Hoboken, New Jersey. (T1)
2. Process Simulation and Control Using Aspen Plus by Amiya K. Jana. PHI Learning Private Limited, New Delhi(T2)

REFERENCE BOOK

1. Distillation Design And Control Using ASPEN™ Simulation by William L. Luyben. Wiley & Sons, Inc., Hoboken, New Jersey. (R1)
2. Process Modeling, Simulation and Control for Chemical Engineers, William L. Luyben, McGraw Hill. (R2)
3. Introduction To MATLAB For Engineering Students by David Houcque. (R3)
4. A Beginner's Guide to MATLAB by Christos Xenophontos. (R4)

Course Evaluation:

Theory (Quiz), final examinations (Lab performance and Viva-voce)

Gaps in the syllabus (to meet Industry/Profession requirements):

Economic analysis of industrial processes.

POs met through Gaps in the Syllabus: **PO3 & PO5**

Topics beyond syllabus/Advanced topics/Design:

Dynamic simulation of industrial plants using Aspen Plus.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5**

COURSE INFORMATION SHEET

Course code: CL505

Course title: Computational Laboratory

Pre-requisite(s): BE (Chemical Engineering) or equivalent

Co- requisite(s):

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M. Tech.

Semester/Level: I/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To simulate free convection momentum and heat transport from bluff body using CFD software.
2.	To determine liquid physical properties using molecular simulation.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Formulate the free convection problem for Newtonian fluids.
CO2	Create proper domain and grid for flow geometries using Computational Fluid Dynamics Software.
CO3	Solve momentum and heat transport governing equations for bluff bodies in Newtonian fluids using Computational Fluid Dynamics Software.
CO4	Determine optimized structure of molecules using Quantum chemistry.
CO5	Determine physical properties of liquid using molecular simulation.

SYLLABUS

1. Laminar steady natural convection momentum transport from a cylinder in Newtonian fluid using Computational Fluid Dynamics Software.
2. Laminar steady natural convection heat transport from a cylinder in Newtonian fluid using Computational Fluid Dynamics Software.
3. Laminar steady natural convection momentum transport inside a cavity in Newtonian fluid using Computational Fluid Dynamics Software.
4. Laminar steady natural convection heat transport inside a cavity in Newtonian fluid using Computational Fluid Dynamics Software.
5. Laminar steady natural convection momentum transport from a confined cylinder in Newtonian fluid using Computational Fluid Dynamics Software.
6. Laminar steady natural convection heat transport from a confined cylinder in Newtonian fluid using Computational Fluid Dynamics Software.
7. Geometry optimization of simple molecules using Quantum Chemistry.
8. Determination of single component liquid density using Monte Carlo Simulation.
9. Determination of vapor-liquid coexistence curve for *n*-Pentane using Monte Carlo Simulation.
10. Computation of physical properties of simple molecules using Molecular Dynamics Simulation.

Books recommended:

TEXT BOOK

1. Computer Simulation of Liquids, M. P. Allen, D. J. Tildesley, Clarendon Press, 1987. **(T1)**
2. Molecular Modelling: Principles and Applications, Andrew R. Leach, Leach AR, Prentice Hall, 2001. **(T2)**
3. Understanding Molecular Simulation: From Algorithms to Applications, Daan Frenkel, Berend Smit, Academic Press, 1996. **(T3)**
4. Quantum Chemistry, Donald A McQuarrie, Viva Student Edition, University Science Books, 2011. **(T4)**

REFERENCE BOOK

1. Essentials of Computational Chemistry: Theories and Models, Christopher J. Cramer, Wiley, 2005. **(R1)**
2. Molecular Simulation of Fluids, Richard J. Sadus, Elsevier, 2002. **(R2)**
3. The Art of Molecular Dynamics Simulation, D.C. Rapaport, Cambridge University Press. **(R3)**

COURSE INFORMATION SHEET

Course code: CL506

Course title: Advanced Transport Phenomena – II

Pre-requisite(s): Advanced Transport Phenomena – I

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester/Level: II/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To acquire knowledge on systematic analysis of mass and heat transfer with emphasis on analogies and specific techniques.
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Course Outcomes:

After the completion of the course students will be able to:

CO1	Perform energy and mass balances for a given system at macroscopic/microscopic scale.
CO2	Develop modelling thinking by relating a problem involving heat and mass transfer to the fundamental transport equations and specify initial and boundary conditions.
CO3	Solve the governing equations to obtain temperature and concentration profiles.
CO4	Analyze transport related problem and predict the physical behaviour of the process.
CO5	Identify and solve problems of simple cases of two-phase flow.

SYLLABUS

Module I:

Equation of energy (general convection-diffusion equation) – rectangular coordinate system. Use of the Energy equation - Unsteady state conduction in finite and semi-infinite slabs. Concept of thermal boundary layer vis-a-vis hydrodynamic boundary layer – effect of Prandtl number on thermal boundary layer thickness. Dimensional analysis of equation of Energy. Radiation-Direct radiation between black bodies and non-blackbodies at different Temperature. (8L)

Module II:

Concentrations, Velocities and Mass and Molar fluxes. Concept of Mass diffusivity and Mass transfer coefficient. Fick's law of diffusion. Shell mass balance and boundary conditions – Diffusion through stagnant gas film, Diffusion in a falling film, Diffusion with heterogeneous chemical reaction, Simultaneous mass and heat transfer problem. (8L)

Module III:

Equations of Continuity for binary mixture, simplification of general equation for special cases. Dimensional analysis of the equations of Continuity – role of Schmidt number. (8L)

Module IV:

Generalized Transport Equation: General Advection-Diffusion equation - conservation equations (Motion, Energy and Species concentration) in terms of general variable (Φ) and diffusivity. Concept of coupled equations. (8L)

Module V:

Flow of multiphase mixtures: Two phase gas vapor liquid flow, horizontal and vertical flows of gas liquids, liquid, gas – solid mixtures, slip and hold up effects, phase separation and settling behavior, pressure, momentum and energy relations, practical methods for evaluating pressure drop. (8L)

Books recommended:

TEXT BOOK

1. Advanced Heat and Mass Transfer, A. Faghri, Y. Zhang, J. Howell. (T1)
2. Process Heat Transfer: Kern D.Q., McGraw Hill. (T2)
3. Unit Operations of Chemical Engineering: McCabe, W.L., Smith, J.C., Harriot, P., McGraw Hill, 1993. (T3)
4. R.B. Bird, W.E. Stewart, and E.N. Lightfoot, Transport Phenomena, Second edition, John Wiley and Sons, 2002. (T4)

REFERENCE BOOK

1. Mass Transfer Operations: Treybal R.E., Mc Graw Hill, 1981. (R1)
2. Chemical Engineering, vol. 1, Coulson & Richardson, Butterworth Heinemann. (R2)
3. Kothandaraman, C.P. and S. Subramanyan, Heat and Mass Transfer Data Book. New Age International. (R3)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

COURSE INFORMATION SHEET

Course code:	CL507
Course title:	Advanced Process Modelling, Simulation & Optimization
Pre-requisite(s):	BE (Chemical Engineering)
Co- requisite(s):	
Credits : 3	L: 3 T: 0 P: 0
Class schedule per week:	3
Class:	M. Tech
Semester/Level:	II/05
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To learn optimization techniques for the solution of linear and nonlinear systems and apply them in real chemical engineering problems.
2.	To learn global optimization techniques.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Develop information flow diagram from real process, from information flow diagram to numerical form.
CO2	Design, manage and operate procedures for the simulation, control and instrumentation of chemical processes.
CO3	Apply Conservation of Mass, Momentum and Energy to Chemical Engineering Systems.
CO4	Develop Mathematical Model Equations and Solve the Equations using Numerical Techniques for Chemical Engineering Systems.
CO5	Solve Chemical Engineering Optimization Problems.

SYLLABUS

Module I:

Mathematical Model: Introduction and Necessity Definition of modelling and simulation - validation with experiments, benchmarking; Need of models – predictive capability, trend analysis; Micro, meso and macroscale models - concept of multiple scales using crystallizer as an example, deterministic and stochastic descriptions Experimentation, empiricism, data correlation and mathematical modeling using examples. (8L)

Module II:

Examples from Crystallization of solid, Coagulation, Coalescence and breakage of drops, Grinding, Microbial population dynamics, Reaction in a porous particle etc. Monte Carlo methods – Basics of random no. and probability distributions Poisson process, Birth-death process, Solution of Laplace's diffusion eqn. Time and event driven simulation methods, Interval of quiescence Lattice simulation – examples from particle deposition, catalyst sintering etc. (8L)

Module III:

Optimization basics and convexity, Multidimensional constrained optimization Gradient Secant and Newton methods. Karsh-Kuhn-Tucker optimality conditions. Linear programming Simplex method, Nonlinear programming Sequential quadratic programming (SQP). (8L)

Module IV:

Generalized reduced gradient method (GRG) and penalty function methods, mixed integer linear programming (MLP) mixed integer nonlinear programming (MNLP) evolutionary optimization techniques. (8L)

Module V:

Genetic Algorithm, Simulated Annealing, Particle swarm optimization, differential evolution, self-organizing migrating algorithm, and scatter search. (8L)

Books recommended:

TEXT BOOK

1. T.F. Edgar and D. M. Himmelblau, Optimization of Chemical Processes 2nd Edition, McGraw Hill International Editions, Chemical Engineering Series, 2001. (T1)
2. Floudas, C.A., Nonlinear and Mixed Integer Optimization: Fundamentals and Applications, Oxford University Press, New York 1995. (T2)
3. G.V, Reklatis, A. Ravindran and K.M.Ragsdell, Engineering Optimization – Methods and Applications. (T3)

REFERENCE BOOK

1. S. S. Rao, Engineering Optimization, Theory and Practice 4th Ed, John Wiley and sons 2009. (R1)
2. L.T.Biegler, I,E, Grossmann, and A. W. Westergerg, systematic Methods of Chemical Process Design, Prentice Hall International Series, 1997. (R2)

COURSE INFORMATION SHEET

Course code: CL508

Course title: Advanced Thermodynamics

Pre-requisite(s):BE (Chemical Engineering)

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester/Level: II/5

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students to:

1.	Learn basics of statistical thermodynamics.
2.	Learn advanced concepts in thermodynamics with emphasis on thermodynamic relations, equilibrium and stability of multiphase multi-component systems.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Understand the terminology associated with chemical engineering thermodynamics.
CO2	Estimate thermodynamic properties of substances in gas or liquid state of ideal and real mixture.
CO3	Explain the basics of statistical thermodynamics.
CO4	Explain the basics of quantum mechanics and molecular simulation.
CO5	Solve problems involving equilibria of different phases as well as reaction equilibria.

SYLLABUS

Module I:

Review of Basic Postulates, Maxwell's relations, Legendre Transformation, Pure Component properties. Theory of corresponding states, real fluids Equilibrium, Phase Rule, Single component phase diagrams. (8L)

Module II:

Introduction to Multicomponent Multiphase equilibrium, introduction to Classical Mechanics, quantum Mechanics, Canonical Ensemble, Microcanonical Ensemble, Grand Canonical Ensemble, Boltzmann, Fermi-Dirac and Bose Einstein Statistics, Fluctuations, Monoatomic and Diatomic Gases. (8L)

Module III:

Introduction to Classical Statistical Mechanics, phase space, liouville equation, Crystals, Inter molecular forces and potential energy functions, imperfect Monoatomic Gases, Molecular theory of corresponding states. (8L)

Module IV:

Introduction to Molecular Simulations, Mixtures, partial molar properties, Gibbs-Duhem's equations, fugacity and activity coefficients, Ideal and Non-ideal solutions. (8L)

Module V:

Molecular theories of activity coefficients, lattice models, multiphase Multicomponent phase Equilibrium. VLE/SLE/LLE/VLLE. Chemical Equilibrium and Combined phase and reaction equilibria. (8L)

Books recommended:

TEXT BOOK

1. McQuarrie D.A, Statistical Mechanics, Viva Books Private Limited, 2003. (T1)
2. Hill Terrel, An Introduction to Statistical Thermodynamics, Dover, 1960. (T2)
3. Allen MP, Tildesley DJ, Computer simulation of liquids, Oxford, 1989. (T3)
4. Callen, HB. Thermodynamics and an Introduction to Thermodstatics, 2nd Edition, John Wiley and Sons, 1985. (T4)

REFERENCE BOOK

1. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular thermodynamics of fluid phase Equilibria (3rd edition), Prentice Hall Inc., New Jersey, 1996. (R1)
2. J.M. Smith. H.C. Van Ness and M.M. Abott. "Introduction to Chemical Engineering Thermodynamics: McGraw Hill International edition (5th ed.). 1996. (R2)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Programme Elective-II

COURSE INFORMATION SHEET

Course code: CL514

Course title: Computational Fluid Dynamics

Pre-requisite(s): BE Chemical Engineering

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M. Tech.

Semester / Level: II/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1	To be able to apply the CFD methods to solve Navier-Stokes equations for simple fluid flow problems.
2	To solve momentum and heat transport Problems using computational fluid dynamics.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Solve the transport equations using suitable boundary conditions.
CO2	Formulate and Solve fluid flow problems using finite difference methods.
CO3	Solve Navier-Stokes equation for incompressible flows using SIMPLE algorithm.
CO4	Formulate and Solve fluid flow problems using finite volume methods.
CO5	Simplify chemical engineering problems.

SYLLABUS

Module I:

Philosophy of computational fluid dynamics (CFD), review of equations governing fluid flow and heat transfer, simplified flow models such as incompressible, inviscid, potential and creeping flow. Classification of partial differential equations, initial and boundary conditions, review of applied numerical methods. (8L)

Module II:

Finite difference method: introduction, discretization method, consistency, error and stability analysis, fundamentals of fluid flow modeling. Finite difference applications in heat conduction and convection: steady and transient heat conduction in rectangular and cylindrical geometries, convective heat transfer. (8L)

Module III:

Solution of viscous incompressible flows by stream function-vorticity formulation; Solution of Navier-Stokes equation for incompressible flows using SIMPLE algorithm. (8L)

Module IV:

Finite Volume Method: Discretization methods, approximations of surface integrals and volume integrals, interpolation and differential practices, implementation of boundary conditions, application to the engineering problems. (8L)

Module V:

Introduction to multiphase and turbulence modeling, Solution of chemical engineering problems.

(8L)

Books recommended:

TEXT BOOK

1. K. Muralidhar and T. Sundararajan, Computational fluid flow and heat transfer, 2nd edition, Narosa Publishing House, 2003. (T1)
2. S.V. Patankar, Numerical Heat Transfer & Fluid Flow, Hemisphere Publishing Co-operation, McGraw-Hill, 1980. (T2)

REFERENCE BOOK

1. P.S. Ghoshdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw Hill, 1998. (R1)
2. J.D. Anderson, Computational Fluid Dynamics, McGraw Hill, 1995. (R2)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Finite Element method.

POs met through Gaps in the Syllabus: **PO5, PO6**

COURSE INFORMATION SHEET

Course code: CL515

Course title: Process Intensification

Pre-requisite(s): CL308, CL210

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester/Level: II/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1	To provide an understanding of the concept of Process Intensification.
2	To provide knowledge and understanding of application of intensification techniques to a range of processes e.g. heat and mass transfer, separation processes.
3	To provide an understanding of basic operating principles of a variety of intensified process equipment such as spinning disc reactor, rotary packed beds, oscillatory flow reactors, compact heat exchangers and micro-reactors etc.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Explain the concept of Process Intensification and the methodologies for PI.
CO2	Explain the benefits of PI in the process industries.
CO3	Explain the operating principles of a number of intensified technologies.
CO4	Analyse the range of potential applications of intensified equipment.
CO5	Design compact heat exchanger.

SYLLABUS

Module I:

Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application. [8L]

Module II:

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Micro reaction Technology, From basic Properties to Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Microfabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes. [8L]

Module III:

Scales of mixing, Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors. [8L]

Module IV:

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NO_x Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Phase-change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example. [8L]

Module V:

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sono-crystallization, Reactive separations, Supercritical fluids. [8L]

Books recommended:

Text books:

4. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003. (T1)
5. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008. (T2)
6. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013. (T3)

COURSE INFORMATION SHEET

Course code: CL516

Course title: Heterogeneous Catalysis and Catalytic Processes

Pre-requisite(s): CL302, CH101, PH113, CL301

Co- requisite(s):

Credits: L: 3 T:0 P:0

Class schedule per week: 03

Class: M. Tech

Semester/Level: II/5

Branch: Chemical Engineering

Name of Teacher:

Course Objectives

This course enables the students:

1	This course examines the detailed structures, preparation methods and reactivities of solid catalysts.
2	Several important catalyst properties and their determination techniques such as surface area and pore size measurements, temperature Programmed desorption (TPD), and various spectroscopic techniques.
3	The relationship between the structures and reactivities of important catalysts used in various applications.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Explain various catalyst preparation methods for an end application.
CO2	Evaluate various properties of catalysts.
CO3	Correlate the structure of catalyst with its reactivity.
CO4	Evaluate catalyst deactivation kinetics.
CO5	Model the various catalytic reactors.

SYLLABUS

Module I:

Basic concepts in heterogeneous catalysis, catalyst preparation and characterization, poisoning and regeneration. (8L)

Module II:

Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes. (8L)

Module III:

Commercial reactors: adiabatic and multi-tubular packed beds, fluidized bed, trickle-bed, slurry reactors. (8L)

Module IV:

Heat and mass transfer and its role in heterogeneous catalysis. Calculations of effective diffusivity and thermal conductivity of porous catalysts. (8L)

Module V:

Reactor modelling; Chemistry and engineering aspects of catalytic processes along with problems arising in industry. Catalyst deactivation kinetics and modeling. (8L)

Books recommended:

TEXT BOOKS:

4. Catalytic Chemistry: Bruce Gates (T1)
5. Optimal distribution of catalyst in a pellet: Morbidelli and Verma (T2)
6. Catalysis of Organic reactions: editor M.E.Ford, Marcel Dekker Inc. (T3)

REFERENCE BOOK

3. Heterogeneous Reactions Vol 1 and Vol II : M. M. Sharma and Doraiswamy (R1)
4. Principles and practice of heterogeneous Catalysis: Thomas, J.M., Thomas W.J. (R2)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Industrial reactor data analysis and its application towards better reactor design.
POs met through Gaps in the Syllabus: **PO4 & PO5**

Topics beyond syllabus/Advanced topics/Design:

Design and analysis of Non-isothermal industrial reactor.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO4 & PO5**

Open Elective-II

COURSE INFORMATION SHEET

Course code: CL614

Course title: Process Integration

Pre-requisite(s): CL308, CL210

Co-requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester /Level: II/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1	To learn the concept of Process Intensification.
2	To apply the techniques of intensification to a range of chemical processes and process Equipment's.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Assess the importance and limitations of process intensification.
CO2	Explain the principles of intensified technologies/Equipments such as compact heat exchanger, Hige reactors, Reactive absorption, Reactive distillation.
CO3	Plan for research in new energy systems, materials and process intensification.
CO4	Explain basics of pinch technology and its application.
CO5	Explain and design of heat exchanger networks.

SYLLABUS

Module I:

Introduction to Process Intensification and Process Integration (PI). Areas of Application and Techniques available For PI, Onion Diagram, Process Integration in Chemical Industries, Formulation of a Design Problem, Chemical Process Design and Integration, Hierarchy of Chemical Process Design and Integration, Continuous and Batch Processes, New Design and Retrofit, Approaches to Chemical Process Design and Integration, Process Control. (8L)

Module II:

Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology. Key steps of Pinch Technology: Concept of ΔT_{min} , Data Extraction, Targeting, Designing, Optimization-Super targeting. Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve. (8L)

Module III:

Targeting of Heat Exchanger Network, Designing of Heat Exchanger Networks, Hot Composite Curve, Cold Composite Curve, Problem Table Algorithm, Grand Composite Curve, Area Targeting by Uniform Bath formula and Unit Targeting by Euler's formula, Heuristics for Pinch Design, Maximum Energy Recovery Design, Evolution of Network. (8L)

Module IV:

Choice of Idealized reactor model and reactor performance. Reactor configurations: Temperature Control, Gas-Liquid and Liquid Reactors, Choice of Reactors. Heat Integration characteristics of reactors, Appropriate placements of reactors. Use of GCC for Heat Integration of reactor. (8L)

Module V:

Distillation sequencing, Heat Integration characteristics of Distillation column, appropriate placement of distillation column, various configurations for heat integration of distillation column. (8L)

Books recommended:

TEXT BOOK

1. Chemical Process Design and Integration Robin Smith, John Wiley and Sons. Ltd., New Delhi, 2005. (T1)
2. Product & Process Design Principles Warren D. Seider, J. D. Seader and Daniel R. Lewin, Wiley Publication. (T2)

REFERENCE BOOK

1. Heat Exchanger Network Synthesis U. V. Shenoy, Gulf Publication. (R1)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Case Studies related to industrial problems.

POs met through Gaps in the Syllabus: **PO5**

COURSE INFORMATION SHEET

Course code: CL631
Course title: Composite Manufacturing Technology
Pre-requisite(s): CH101, PH111, MA103
Co- requisite(s): Nil
Credits: L: 03 T: 00 P: 00
Class schedule per week: 03
Class: M. Tech
Semester / Level: III/06
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:

This course enables the students:

1.	To impart the fundamentals of polymer composites and its applications.
2.	To know about manufacture, properties and application of polymer and fibre.
3.	Explain the basic properties, characteristics and constituents of composite materials.
4.	Present and apply the different fabrication processes for composite materials, including bonding, fastening, laminating, and finishing techniques.
5.	Perform design, construction, and fabrication of laminate parts, Define and use appropriate terminology as it relates to composite structure design and manufacturing.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Classify the different type of polymeric composites and its applications.
CO2	Select different types of matrix and reinforcement materials.
CO3	Ability to select the process for fabrication of polymer composites.
CO4	Relate theoretical knowledge with typical products and its stress-strain behavior.
CO5	Aware of different testing and characterization of polymer composites.

SYLLABUS

Module I:

Polymer composite systems: Types of composites, reinforcements, Types of Resin. (8L)

Module II:

Natural fibre: Jute, sisal, cotton, hemp **Ceramic fibre:** silicon carbaide, zinc, Alumina, glass,
Synthetic fibre: polyethylene, polyester, nylon, Kevlar. (8L)

Module III:

Thermoset, elastomer - resins (polyesters, epoxide, vinyl ester, phenol formaldehyde, polyimide, reinforced polyolefin, Semi crystalline and amorphous polymers - PEEK, PP, PEK, PBT, PC, ABC, nylon etc.) additives, reinforcements (particulate, fibrous, gaseous). (8L)

Module IV:

Processing techniques - open mould, hand layup spray up, vacuum bag moulding, pressure bag moulding, autoclave moulding, closed mould, SMC, DMC, RTM., Continuous manufacturing process - pultrusion, filament winding, centrifugal casting. Application (sandwich constructions - aircraft, racing cars, helicopter rotor blades etc.), Nano composites. (8L)

Module V:

Mechanical behaviour of composites. Deformation Behaviour of reinforced plastics, Types-reinforcement, matrix, Forms of fibre reinforcement in composites, Analysis of Continuous fibre composites, Deformation behaviour of a single ply or lamina, Deformation behaviour of Laminates, Analysis of multi-layer isotropic materials, Analysis of Non-symmetric laminates, Analysis of short fibre composites, Creep behaviour of fibre reinforced plastics, Fatigue behaviour of reinforced plastics, Impact behaviour of reinforced plastics. Bending buckling and vibration of laminated plates. Testing and joining of composite materials. (8L)

Books recommended:

TEXT BOOK

1. Dyson, R.W., "Engineering Polymers", Blackie, 1990. (T1)
2. Crawford, R.J., Plastics Engineering, Pergamon Press. (T2)

REFERENCE BOOK

1. Richardson, T., Composites – a design guide industrial press Inc., New York, 1987. (R1)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

- Apply quality systems to composite manufacturing and product testing.
- Need more design problem on fibre orientation

POs met through Gaps in the Syllabus: **PO5, PO6**

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

COURSE INFORMATION SHEET

Course code: CL509

Course title: Computer Aided Process Engineering

Pre-requisite(s): BE (Chemical Engineering) or equivalent

Co- requisite(s):

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M. Tech.

Semester/Level: II/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To be able to learn basic concept of steady and unsteady state process simulation and preliminary flowsheet development.
2.	To learn model formulation and solution for continuous process with multiple unit.
3.	To be able to use commercial softwares for development of flowsheet for chemical processes.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Formulate and Solve steady state operating conditions of a system with multiple unit operations with and without chemical reaction.
CO2	Model, Solve and Analyze transient behaviour of a chemical process.
CO3	Formulate and Compute vapor-liquid equilibrium of ideal and non-ideal liquid mixture.
CO4	Make use of Aspen software to develop and analyze different types of unit operations and unit processes.
CO5	Make use of Aspen software to develop and analyze a chemical process.

SYLLABUS

Problem 1:

Computation of the steady state operating conditions of a system with multiple unit operations without chemical reaction.

Objectives: i) To formulate number of independent material balance equations of the system for degree of freedom analysis. ii) Solution of the set of linear/nonlinear equations using MATLAB user defined functions such as, matrix solver, *fsolve*, etc.

Problem 2:

Computation of the steady state operating conditions of a system with multiple unit operations involving chemical reaction.

Objectives: i) To formulate number of independent material balance equations of the system for degree of freedom analysis. ii) Solution of the set of linear/nonlinear equations using MATLAB user defined functions such as, matrix solver, *fsolve*, etc.

Problem 3:

Study of temperature and level dynamics of a stirred tank heater.

Objectives: i) To formulate energy balance equations for all the unit operations in terms of state variables, ii) Solve the energy balance equations simultaneously using MATLAB user defined functions like *ode45*, *ode15s*, etc., iii) Explain the dynamics of state variables (temperature of each tank) with the help of transient analysis.

Problem 4:

Computation of bubble point temperature of ideal liquid mixture.

Objectives: i) To formulate vapor liquid equilibrium relationship for ideal liquid mixture using computational algorithm and MATLAB/C codes.

Problem 5:

Computation of bubble point temperature of non-ideal liquid mixture.

Objectives: i) To formulate vapor liquid equilibrium relationship for non-ideal liquid mixture using computational algorithm and MATLAB/C codes.

Problem 6:

Transient analysis in a non-adiabatic CSTR using lumped parameter model

Objectives: i) To formulate unsteady material balance and energy balance equations of the non-adiabatic CSTR ii) linearize the model equations to make it a state-space model, iii) solution of the set of ordinary differential equations using MATLAB user defined functions such as, *ode45*, *ode23*, *ode15s* or C/C++ codes with Runge-Kutta method. iv) perform transient analysis.

Problem 7:**Transient analysis in a PFR using distributed parameter model**

Objectives: i) To formulate unsteady material balance equations of the PFR ii) Discretize the equation with finite difference scheme iii) solution of the discretized equation with finite difference numerical method iv) perform transient analysis.

Problem 8:**Flash calculation using ASPEN PLUS**

Objectives: i) Prepare ASPEN PLUS flowsheet of a flash chamber ii) perform flash calculation

Problem 9:**Making ASPEN PLUS steady state simulation of a chemical process plant**

Objectives: i) Prepare ASPEN PLUS flowsheet of a process for making benzene ii) perform steady state simulation

Problem 10:**Making ASPEN PLUS steady state simulation of a chemical process plant**

Objectives: i) Prepare ASPEN PLUS flowsheet of a process for making ethanol ii) perform steady state simulation

Books recommended:**TEXT BOOK**

1. Stephenopolos, S., "Chemical process control", Prentice Hall of India, New Delhi, 1984.
2. Introduction to Chemical Engineering Computing, Bruce A Finlayson, JOHN WILEY & SONS, INC., PUBLICATION.

REFERENCE BOOK

1. DELANCEY, G., PRINCIPLES OF CHEMICAL ENGINEERING PRACTICE, Wiley, 2013.
2. DeCoursey, W.J., Statistics and Probability for Engineering Applications with Microsoft[®] Excel, Newnes, Elsevier, 2003.

Course Evaluation:

Theory (Quiz), final examinations (Lab performance and Viva-voce)

Gaps in the syllabus (to meet Industry/Profession requirements):

Process Optimization.

POs met through Gaps in the Syllabus: **PO4, PO5**

Topics beyond syllabus/Advanced topics/Design:

Molecular Simulation.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO4, PO5, PO6**

COURSE INFORMATION SHEET

Course code: CL510

Course title: Chemical Engineering research Lab - I

Pre-requisite(s): BE (Chemical Engineering) or equivalent

Co- requisite(s):

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M. Tech.

Semester/Level: II/05

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To study the different types of characterization techniques useful for chemical engineering.
2.	To understand the application of different analytical techniques.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Determine the composition of solution.
CO2	Analyze the surface morphology of solid material.
CO3	Determine the surface structure of solid material.
CO4	Determine the composition of gas mixture.
CO5	Analyze the thermal behavior of material.

SYLLABUS

1. Characterization of organic sample by FTIR spectroscopy.
2. Determination of unknown concentration by UV-VIS Spectroscopy.
3. Study of Differential Scanning Calorimetric (DSC).
4. Study of Thermo Gravimetric Analysis (TGA).
5. Analysis by HPLC.
6. Determination of surface morphology by Scanning Electron Microscopy (SEM).
7. To study the diffraction pattern of material by Wide Angle X-Ray Diffraction (WAXRD).
8. Determination of surface area of porous sample by Physisorption technique [BET].
9. Determination of gas composition by GAS Chromatography technique.
10. Measurement of composition by AAS.

Books recommended:

TEXT BOOK

1. Material Characterization Techniques, Sam Zhang, Lin Li, Ashok Kumar, CRC Press, 2008.

REFERENCE BOOK

1. Characterization Techniques for polymer Nanocomposites, Edited by Vikas Mittal, Wiley-VCH, 2012.
2. Optical Techniques for Solid-State Materials Characterization, Rohit P. Prasankumar, Antoinette J. Taylor, CRC Press, 2011.

Course Evaluation:

Theory (Quiz), final examinations (Lab performance and Viva-voce)

Gaps in the syllabus (to meet Industry/Profession requirements):

Composition analysis by Nuclear Magnetic Resonance (NMR).

POs met through Gaps in the Syllabus: **PO6**

Topics beyond syllabus/Advanced topics/Design:

Characterization techniques related to bio-chemical research.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5**

COURSE INFORMATION SHEET

Course code: CL602

Course title: Advanced Separation Process

Pre-requisite(s): BE (Chemical Engineering)

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech..

Semester/Level: III/ 6

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To learn various advanced aspects of separation processes and the selection of separation processes.
2.	To understand the principles and processes of multicomponent distillation and absorption.
3.	To understand chromatography techniques and membrane separation processes.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Calculate compositions of various species in multicomponent distillation.
CO2	Explain membrane distillation, Extractive Distillation, Salt Distillation, Pressure Swing Distillation.
CO3	Estimate multicomponent diffusion and mass transfer coefficients.
CO4	Learn basics of various membranes preparation and characterization techniques and solve separation problems related to membrane.
CO5	Explain and design gas-liquid contacting equipments.

SYLLABUS

Module I:

Multi Component Distillation, Selection of operating pressure, Equilibrium for Multi component System, Methods for Multi Component Distillation, Design of Batch Distillation for Multicomponent with Rectification with constant reflux & constant overhead component. (8L)

Module II:

Continuous distillation of multi component system, Energy Conservation in Distillation column, Advance topics in distillation. Distillation Curve Maps, Extractive Distillation, Salt Distillation, Pressure Swing Distillation, Homogeneous Azeotropic Distillation, Heterogeneous Azeotropic Distillation, Reactive Distillation, Supercritical Fluid Extraction. (8L)

Module III:

Diffusion in nonideal system and development of generalized Maxwell-Stefan formulation, Study of Generalized Fick's law, Estimation of binary and multicomponent Diffusion Coefficients, Study of interphase mass and energy transfer. Modeling and simulation of absorption and leaching process (8L)

Module IV:

Membrane Separation Techniques: Principles, characteristic, and classification of membrane separation processes; Membrane materials, structures, and preparation techniques; Membrane modules; Plant configurations. Membrane characterization: Pore size and pore distribution; Bubble point test; Challenge test; Factors affecting retentivity, concentration polarization, gel polarization, fouling, cleaning and regeneration of membranes. Mechanisms of separation: Porous membranes, dense membranes, and liquid membranes. Membrane separation models: Irreversible thermodynamics; Capillary flow theory; Solution diffusion model; Viscous flow models; Models for separation of gas (vapour) mixtures; Science and technology of microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis and electrodialysis, pervaporation, liquid membrane permeation, gas permeation. Membrane reactors: Polymeric, ceramic, metal and bio-membrane.

(8L)

Module V:

Advances in Absorption - Criteria for selection of packed tower, tray tower, Spray chamber, Venturi Scrubber etc. Design of Falling Film Absorption, Design of Spray Chamber Design of Venturi Scrubber, Advantage of Falling Film Absorber. (8L)

Books recommended:

TEXT BOOK

1. Introduction to Process Engineering and design by S.B.Thakore & B.I. Bhatt. (T1)
2. Chemical Engineering Handbook 7th edition by R.H.Perry & Green D. (T2)

Programme Elective-III

COURSE INFORMATION SHEET

Course code:	CL631
Course title:	Composite Manufacturing Technology
Pre-requisite(s):	CH101, PH111, MA103
Co- requisite(s):	Nil
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	03
Class:	M. Tech
Semester / Level:	III/06
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:

This course enables the students:

1.	To impart the fundamentals of polymer composites and its applications.
2.	To know about manufacture, properties and application of polymer and fibre.
3.	Explain the basic properties, characteristics and constituents of composite materials.
4.	Present and apply the different fabrication processes for composite materials, including bonding, fastening, laminating, and finishing techniques.
5.	Perform design, construction, and fabrication of laminate parts, Define and use appropriate terminology as it relates to composite structure design and manufacturing.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Classify the different type of polymeric composites and its applications.
CO2	Select different types of matrix and reinforcement materials.
CO3	Ability to select the process for fabrication of polymer composites.
CO4	Relate theoretical knowledge with typical products and its stress –strain behavior.
CO5	Aware of different testing and characterization of polymer composites.

SYLLABUS

Module I:

Polymer composite systems: Types of composites, reinforcements, Types of Resin. (8L)

Module II:

Natural fibre: Jute, sisal, cotton, hemp **Ceramic fibre:** silicon carbaide, zinc, Alumina, glass, **Synthetic fibre:** polyethylene, polyester, nylon, Kevlar. (8L)

Module III:

Thermoset, elastomer - resins (polyesters, epoxide, vinyl ester, phenol formaldehyde, polyimide, reinforced polyolefin, semi crystalline and amorphous polymers - PEEK, PP, PEK, PBT, PC, ABC, nylon etc.) additives, reinforcements (particulate, fibrous, gaseous). (8L)

Module IV:

Processing techniques - open mould, hand lay up spray up, vacuum bag moulding, pressure bag moulding, autoclave moulding, closed mould, SMC, DMC, RTM., Continuous manufacturing process - pultrusion, filament winding, centrifugal casting. Application (sandwich constructions - aircraft, racing cars, helicopter rotor blades etc.), Nano composites. (8L)

Module V:

Mechanical behaviour of composites. Deformation Behaviour of reinforced plastics, Types-reinforcement, matrix, Forms of fibre reinforcement in composites, Analysis of Continuous fibre composites, Deformation behaviour of a single ply or lamina, Deformation behaviour of Laminates, Analysis of multi-layer isotropic materials, Analysis of Non-symmetric laminates, Analysis of short fibre composites, Creep behaviour of fibre reinforced plastics, Fatigue behaviour of reinforced plastics, Impact behaviour of reinforced plastics. Bending buckling and vibration of laminated plates. Testing and joining of composite materials. (8L)

Books recommended:

TEXT BOOK

1. Dyson, R.W., "Engineering Polymers", Blackie, 1990. (T1)
2. Crawford, R.J., Plastics Engineering, Pergamon Press. (T2)

REFERENCE BOOK

1. Richardson, T., Composites – a design guide industrial press Inc., New York, 1987. (R1)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

- Apply quality systems to composite manufacturing and product testing.
- Need more design problem on fibre orientation

POs met through Gaps in the Syllabus: **PO5, PO6**

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

COURSE INFORMATION SHEET

Course code: CL 632
Course title: Polymer Physics
Pre-requisite(s): CH101, PH111, MA103
Co- requisite(s):
Credits: L:03 T:00 P:00
Class schedule per week: 03
Class: M. Tech.
Semester/Level: III/06
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Learn the fundamental knowledge on the physics of polymer materials, their volume and surface properties;
2.	knowledge on polymer materials with special properties, obtained by various physical and chemical methods, and of their performances;
3.	ability to use analysis techniques to identify the properties of polymer materials of interest in modern applications;
4.	work in a team for solving experimental and technological issues; identify and use bibliographic resources for continuous formation
5.	To familiarize with recent advances in the field of Polymer Physics

Course Outcomes:

At the end of the course, a student should be able to:

CO1	account for different descriptions of size and shape of a polymer, and being able to predict phase properties and aggregate structure from the chemical properties and structure of the monomers, using the Flory-Huggins theory.
CO2	account for the molecular theory of rubber elasticity and apply this on relevant problems.
CO3	apply phenomenological theory to characterise linear viscoelastic materials. account for the origin of deformation and fracture of polymeric materials from a molecular basis.
CO4	suggest and motivate choice of polymeric materials in different products and practical applications, especially regarding rheology and strength.
CO5	Analyze viscoelastic properties of polymer materials and validate the properties in terms of models available in literature.

SYLLABUS

Module I:

A single ideal chain; mean-square end-to-end distance, radius of gyration. Gaussian chain. freely jointed chain. worm-like chain, stretching and confinement, structure factor, excluded volume, solvent quality, theta-temperature. Polymer solutions: Flory Huggins Theory, osmotic pressure. Polymer solutions: scaling laws for good solvents, concentration fluctuation and correlation length. Polymer solutions: Size of a polymer in semi-dilute solutions, poor solvents and phase separation, fractionation. (8L)

Module II:

Measurements of polymer sizes in solution: osmotic pressure, light scattering, intrinsic viscosity, size-exclusion chromatography. Polymer melts / concentrated solutions, SANS studies of chain dimensions and of correlation hole. Polyelectrolytes. Debye-Huckel theory, Donnan equilibrium. Rubber elasticity; gels. Polymer thermodynamics: phase behavior of polymer blends; stability and metastability. Dynamics of polymeric liquids: phenomenology and constitutive equations, Maxwell model. Rouse theory: equations of motion, normal modes, time-temperature superposition. (8L)

Module III:

Diffusion & viscoelasticity, experimental tests of Rouse theory. Zimm theory: hydrodynamic interactions, free-draining and non-draining limits, pre-averaging approximation, experimental tests. Reptation theory: tube model; primitive chain, reptation dynamics. The glass transition; free volume theory. End-teethered chains: polymer brushes, self-assembly and order-disorder transitions of diblock copolymers. Liquid crystalline polymers, polymer crystallization. (8L)

Module IV:

Linear Viscoelasticity: Boltzmann Superposition Principle, Empirical models for linear viscoelasticity, Relaxation Spectrum, Dynamic Response, Time temperature superposition, Polymeric Yield and Ductility. (8L)

Module V:

Measurement of viscosity: Rotational and sliding surface viscometer, capillary & slit rheometers - sources of error and their corrections. Rheo-optics & molecular orientation, Effects of Molecular structure on Rheological properties. Rheology of multi- phase systems, Reacting systems, liquid crystal polymer. (8L)

Books recommended:

TEXT BOOK

1. Text Book of Physical Chemistry ; S. Glasstone, Mc millan and Co. 1962, New Delhi, 2nd Ed. 1962. (T1)
2. Introduction to Physical Polymer Science, L.H. Sperlings, John Wiley and Sons. New York, 3rd Ed. 2001. (T2)

COURSE INFORMATION SHEET

Course code:	CL633
Course title:	Polymer Product Manufacturing Technology
Pre-requisite flow chart:	CH101, PH111, MA103
Co-requisite:	
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	3
Class:	M.Tech.
Semester / Level:	III/6
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:

This course enables the students:

1	Understanding: Outline the steps of specific process to manufacture a specific product, identify the various parts of the machine and explain the function of it.
2.	Apply: Solve numerical problems on simple flow analysis for polymers during a specific processing, interpretation and analysis of rheological data using models for non-Newtonian fluids.
3.	Predict: the reasons behind specific product defect and propose probable solutions specific to processing technique.

Course Outcomes:

After the completion of this course, students will be able to:

CO1	Understanding: Choose the methods of product manufacture with given plastic material for the specific use.
CO2	Analyze: Identify the defects in plastic products, interpret the product quality in terms of machine parameters and suggest professional engineering solutions as remedies which will be sustainable and economical.
CO3	Apply: Apply most modern technology to modify the process variables on existing machine to manufacture a specific plastic/ rubber/composite product.
CO4	Create: optimize the design for manufacturing specific product, handle projects related to development of new products.
CO5	Design: design and develop polymer product with defined structural properties.

SYLLABUS

MODULE- I

Compression moulding –Process description, various parts of the machine, Types of moulds, analysis of melt flow inside a mould, Advantages and limitations of compression moulding, Materials used- with and without reinforcement, Manufacturing of specific products-shoes, sheets. [8L]

MODULE II:

Extrusion: Extruder various parts of the machine Classification-single screw, twin screw (co and counter rotating type), Flow analysis: pressure flow, leak flow, drag flow, influence of polymer properties, Technology of product manufacturing: dies used for Pipe, films, Tapes. [8L]

MODULE III:

Injection moulding–Effect of mould cooling on product quality, ejection, Part cooling analysis, Reaction Injection Moulding-process description, materials used, product defects and its remedies. [8L]

MODULE IV:

Pultrusion- process description, Materials used-resin, reinforcement, Classification, Machinery, defects, remedies, **Blow moulding-** process description, Materials used-resin, reinforcement, Classification, Machinery, defects, remedies, Analysis of product quality. [8L]

MODULE V:

Calendering- process description, Materials used-resin, reinforcement, Classification, Machinery, defects, remedies classification, flow analysis, **Rotomoulding-** process description, Materials used-resin, reinforcement, Classification, Machinery, defects, remedies classification. [8L]

Books recommended:

TEXT BOOK

1. Plastics Engineering, Crawford, R.J., Pergamon Press. (T1)
2. Polymer Extrusion, Chris Rauwendaal, Hanser, 1994. (T2)
3. Plastics Product Design and Process Engineering, H. Belofsky, Hanser, 1995. (T3)
4. Blow Moulding Handbook, Rosato, D.V. and Rosato D.V., Hanser, 1989. (T4)
5. Plastic Extrusion Technology, Hensen, Hanser, 1997. (T5)
6. Polymer processing, D.H.Morton-Jones, Chapman & Hall, New York, 1989. (T6)

REFERENCE BOOK

1. Principles of Polymer Processing, Tadmor, Z and Gogos, C.G., John Wiley and Sons, 1982. (R1)
2. Plastics: Product Design and Process Engineering, Belofsky, H., Hanser Pub. 1995. (R2)
3. Fundamentals of Polymer Processing, Middleman, Mc Graw Hill, 1979. (R3)
4. Rotational Moulding Technology, R.J Crawford and J.L.Throne, William Andrew publishing, 2002. (R4)
5. Thermoforming, J.L.Throne, Hanser, 1987. (R5)

COURSE INFORMATION SHEET

Course code: CL634
Course title: Polymer Rheology
Pre-requisite(s): Macromolecular Science, Polymer Technology
Co- requisite(s):
Credits: L: 03 T:00 P:00
Class schedule per week: 03
Class: M. Tech.
Semester/Level: III/6
Branch: Chemical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To provide the student with an understanding of deformation and flow of polymeric materials such as polymeric liquids, suspensions, melts, colloids, foams, gels, etc.
2.	To understand mechanical behaviour of polymeric materials under applied load for short term and long-term flow behavior of polymer melts.
3.	An ability to perform experimental techniques for measuring the rheological properties.

Course Outcomes

After the completion of this course, students will be:

CO1	An ability to apply knowledge of mathematics, science and engineering.
CO2	Attain the knowledge in flow behaviour of polymers.
CO3	Acquire knowledge in handling rheological instruments and ability to design and conduct experiments, as well as analyze and interpret data.
CO4	Able to describe the viscoelastic behavior of polymers with respect to their chemical structures.
CO5	To construct a corresponding master curve from the experimental data, which can be used to predict the material response at different temperatures, times, and/or frequencies.

SYLLABUS

Module I:

Introduction and Basic concept of Rheology, classification of fluids, Newtonian and non-Newtonian fluids-Viscosity Models, Yield stress fluids, thixotropic fluids - Structural model, Shear Flow, Dependence of viscosity with temp, pressure, shear stress, shear rate etc. Fluid flow through pipe, parallel plates, slit channel, Annulus Flow. [8L]

Module II:

Viscoelasticity – effect of rate of strain, temperature and time on mechanical behaviour of polymeric materials. Viscoelastic models – stress strain response of spring and dashpot, Maxwell element, Voigt kelvin element – response to creep and stress relaxation, three and four-parameter model. Viscosity of polymer melts– Normal stress, die-swell and melt fracture, Weissenberg effect, Elongational fluid flow. [8L]

Module III:

Measurement of rheological properties: Rotational and capillary rheometers, capillary & slit rheometers - sources of error and their corrections. torque rheometers, Mooney viscometer. [8L]

Module IV:

Dynamic mechanical properties, Complex viscosity, Boltzmann Superposition principle, time temperature superposition, Relaxation spectrum, WLF equation. Applications of rheology to polymer processing (injection moulding, extrusion and blow moulding). [8L]

Module V:

Molecular theories of Prediction of linear behaviour, Rouse Model, Bueche Ferry law. Theories of Entangled Melts, Reptation, Doi Edwards Theory, Curties- Bird Model. Rheo-optics & molecular orientation. Effects of Molecular structure on Rheological properties. Rheology of multiphase systems, Reacting systems, liquid crystal polymers. [8L]

Books recommended:

TEXT BOOK

1. Dynamics of Polymeric Liquids, Bird RB, Armstrong RC and Hassager O, John Wiley & Sons, 1987. (T1)
2. J.A.Brydson, Flow properties of polymer melts, life books, London, 1978. (T2)
3. R.J. Crawford, Plastics Engineering, Butterworth – Heinemann, Oxford, 1998. (T3)
4. P.N.Cogswell, Polymer Melt Rheology, A guide for Industrial Practice, George Godwin. (T4)
5. John M. Dealy and Kurt F. Wissburn, Melt rheology and its role in plastics processing, Chapman, London, 1995. (T5)

REFERENCE BOOK

1. Richard C. Progelhof and James L. Throne, Polymer Engineering Principles, Hanser Publishers, New York, 1993. **(R1)**
2. R.S. Lenk, Polymer Rheology, Applied Science, London, 1978. **(R2)**
3. J.D. Ferry, Viscoelastic Properties of Polymers, John Wiley & Sons, New York, 1986. **(R3)**
4. Chang Dae Han. Rheology in Polymer Processing, Academic Press, New York, 1976. **(R4)**
5. The Structure and Rheology of Complex Fluids, Larson RG, Oxford University Press, 1999. **(R5)**
6. Rheology and Non-Newtonian Fluids, Irgens F, Springer, 2014. **(R6)**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	Y
Semester End Examination	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

COURSE INFORMATION SHEET

Course code: CL635
Course title: DIE AND MOLD DESIGN
Pre-requisite(s):
Co- requisite(s):
Credits: L: 03 T: 00 P: 00
Class schedule per week: 03
Class: M. Tech
Semester / Level: III/06
Branch: Chemical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To learn about the design of injection mould and its various parts.
2.	To learn about the design of compression & transfer mould and its various parts.
3.	To learn about the design of blow mould and its various parts.
4.	To learn about the design of extrusion dies and its various parts.
5.	To understand the concept of different types of mould fabrication & selection of materials for various parts of mould.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to understand about design of various types of moulds such as injection, compression, blow moulding and extrusion dies.
CO2	Able to develop knowledge in selection of mould for different processing techniques such as injection, compression, blow and extrusion process.
CO3	Able to list the various parts of moulds and its design.
CO4	Able to understand about different types of mould fabrication.
CO5	Able to design a mould or die for a new product.

Syllabus

MODULE 1:

Injection mould design: Introduction – different types of injection moulds, basic mould elements. Methodological mould design. Computation of number of cavities, cavity layout. Selection of parting line. Feed system – design of sprue, runner & gate, Cooling systems, Ejection systems, Mould venting, Mould Alignment, Lifting and clamping. Mechanical Design, Strength of cavities, Support pillar, screws in molds. (8L)

MODULE 2:

Compression & Transfer Mould design: Types of compression moulds, loading chamber design, heater types & calculation, pressure pad area calculation. Transfer moulds: Types of transfer molds, design of pot and plunger, Feed system, Ejection method, cull pick up. (8L)

MODULE 3:

Blow Mould design: Types of blow mould, Mould material selection, Parting line, neck, pinch off design, parison design, flash trimming, mould venting, mould cooling, mould alignment. (8L)

MODULE 4:

Extrusion die design: Introduction – different types of die exit cross sections: Circular, slit, annular, profile. (8L)

MODULE 5:

Mould fabrication: Selection of materials for moulds and dies. Steels for moulding tools and their treatment. Selection of materials for various parts of mould like cavity, core, back plates, push back pin, guide pin, guide bushes, ejector elements, etc. Selection of materials for various parts of Dies. Outline of method of fabrication: Lathe, milling, grinding, drilling, EDM, shaping, etc., (8L)

Text books:

- (1) Injection Mold Design, R.G.W. Pye, George Godwin. (T1)
- (2) How to make Injection molds, Menges/Mohren, Hanser, 1993. (T2)
- (3) Production Technology, R.K. Jain, S. Chand & Co., 1991. (T3)
- (4) Blow Molding Handbook, D.V. Rossato, Hanser, 1989. (T4)
- (5) Extrusion Dies for Plastics and Rubber, W. Michaeli, Hanser, 1992. (T5)

Reference books:

- (1) Plastic Mold Engineering Handbook, Dubois & Rribble, Chapman & Hal, 1987. (R1)
- (2) P.S. CRACKNELL and R.W DYSON, “Hand Book of Thermoplastics – Injection Mould Design”, Chapman & Hall, 1993. (R2)
- (3) Mold Engineering, Herbert Rees, Hanser, 1995. (R3)
- (4) Laszlo Sors and Imre Balazs, “Design of Plastics Moulds and Dies”, Elsevier, Amsterdam Oxford – Tokyo – NY, 1989. (R4)

COURSE INFORMATION SHEET

Course code: CL614

Course title: Process Integration

Pre-requisite(s): CL308, CL210

Co- requisite(s):

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: M.Tech.

Semester /Level: III/06

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1	To learn the concept of Process Intensification.
2	To apply the techniques of intensification to a range of chemical processes and process Equipment's.

Course Outcomes:

After the completion of the course students will be able to:

CO1	Assess the importance and limitations of process intensification.
CO2	Explain the principles of intensified technologies/Equipments such as compact heat exchanger, Hige reactors, Reactive absorption, Reactive distillation.
CO3	Plan for research in new energy systems, materials and process intensification.
CO4	Explain basics of pinch technology and its application.
CO5	Explain and design of heat exchanger networks.

SYLLABUS

Module I:

Introduction to Process Intensification and Process Integration (PI). Areas of Application and Techniques available For PI, Onion Diagram, Process Integration in Chemical Industries, Formulation of a Design Problem, Chemical Process Design and Integration, Hierarchy of Chemical Process Design and Integration, Continuous and Batch Processes, New Design and Retrofit, Approaches to Chemical Process Design and Integration, Process Control. (8L)

Module II:

Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology. Key steps of Pinch Technology: Concept of ΔT_{min} , Data Extraction, Targeting, Designing, Optimization-Super targeting. Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve. (8L)

Module III:

Targeting of Heat Exchanger Network, Designing of Heat Exchanger Networks, Hot Composite Curve, Cold Composite Curve, Problem Table Algorithm, Grand Composite Curve, Area Targeting by Uniform Bath formula and Unit Targeting by Euler's formula, Heuristics for Pinch Design, Maximum Energy Recovery Design, Evolution of Network. (8L)

Module IV:

Choice of Idealized reactor model and reactor performance. Reactor configurations: Temperature Control, Gas-Liquid and Liquid Reactors, Choice of Reactors. Heat Integration characteristics of reactors, Appropriate placements of reactors. Use of GCC for Heat Integration of reactor. (8L)

Module V:

Distillation sequencing, Heat Integration characteristics of Distillation column, appropriate placement of distillation column, various configurations for heat integration of distillation column. (8L)

Books recommended:

TEXT BOOK

1. Chemical Process Design and Integration Robin Smith, John Wiley and Sons. Ltd., New Delhi, 2005. (T1)
2. Product & Process Design Principles Warren D. Seider, J. D. Seader and Daniel R. Lewin, Wiley Publication. (T2)

REFERENCE BOOK

1. Heat Exchanger Network Synthesis U. V. Shenoy, Gulf Publication. (R1)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

COURSE INFORMATION SHEET

Course code: CL603

Course title: Chemical Engineering research Lab - II

Pre-requisite(s): BE (Chemical Engineering) or equivalent

Co- requisite(s):

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M. Tech.

Semester/Level: III/06

Branch: Chemical Engineering

Name of Teacher:

Course Objectives:

This course will enable the students:

1.	To gather the basic knowledge of different research fields which included in the domain of chemical engineering.
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Course Outcomes:

After the completion of the course students will be able to:

CO1	Prepare the supported metal oxide catalyst.
CO2	Prepare the membrane and study its property.
CO3	Analyze the basic principle of electrolysis.
CO4	Build the basic knowledge of biochemical engineering.
CO5	Analyze the kinetic of hydrocarbon reactions.

SYLLABUS

1. Preparation of supported Metal Oxide Catalyst.
2. Preparation of UF membrane by phase inversion method and its characterization.
3. Metal recovery from Dilute solution by Electrochemical Method.
4. Bioethanol preparation.
5. Biodiesel Preparation.
6. Studies on energy storage using phase change material.
7. Transient analysis of Plate Heat Exchanger.
8. Waste water treatment by Phenton's Reagent.
9. Glycerol dehydration by reactive distillation.
10. Determination of calorific value by Bomb Calorimeter.

Books recommended:

TEXT BOOK

1. Material Characterization Techniques, Sam Zhang, Lin Li, Ashok Kumar, CRC Press, 2008.

REFERENCE BOOK

1. Characterization Techniques for polymer Nanocomposites, Edited by Vikas Mittal, Wiley-VCH, 2012.
2. Optical Techniques for Solid-State Materials Characterization, Rohit P. Prasankumar, Antoinette J. Taylor, CRC Press, 2011.

Course Evaluation:

Theory (Quiz), final examinations (Lab performance and Viva-voce)

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2018- 19
Based on CBCS & OBE model
Recommended scheme of study For B.Sc and Integrated M.Sc in Food Technology

Semester/ Session of Study (Recommended)	LEVEL	Category of course	Course Code	Courses	Mode of delivery & credits <i>L-Lecture; T-Tutorial;P-Practicals</i>			Total Credits <i>C- Credits</i>		
					L <i>(Periods/week)</i>	T <i>(Periods/week)</i>	P <i>(Periods/week)</i>	C		
THEORY										
FIRST Monsoon	FIRST	BS	PH 113	Physics	3	1	0	4		
			MA 103	Mathematics I	3	1	0	4		
		GE	CS 101	Programming for problem solving	3	1	0	4		
		PC	BE 203	Microbiology	3	0	0	3		
		LABORATORY								
		BS	PH114	Physics Lab	0	0	3	1.5		
			CS 102	Programming for problem solving Lab	0	0	3	1.5		
		GE	PE 101	Workshop Practises	0	0	3	1.5		
		MC	MC 101/102/103/10 4	NCC/ NSS/PT & Games/ Creative Arts				1		
										20.5
THEORY										
SECOND Spring	FIRST	BS	CE101	Environmental Science	2	0	0	2		
			CH 101	Chemistry	3	1	0	4		
			MA 107	Mathematics II	3	1	0	4		
	SECOND	HSS	MT 123	Business communication	2	0	2	3		
	FIRST	GE	EC 101	Basics of Electronics & Communication Engineering	3	1	0	4		
	LABORATORY									
	SECOND	PC	BE 201	Microbiology Lab	0	0	3	1.5		
	FIRST	BS	CH 102	Chemistry Lab	0	0	3	1.5		
			GE	EC 102	Electronics and Communication Lab	0	0	3	1.5	
			MC	MC 105/106/107/10 8	NCC/ NSS/PT & Games/ Creative Arts				1	

									22.5	
			THEORY							
THIRD Monsoon	SECOND	PC	FT201	Food Chemistry	4	0	0	4		
			FT 202	Introduction to Food Engineering	3	0	0	3		
			FT 203	Food Microbiology	4	0	0	4		
			FT204	Basics of Food Processing & Preservation	4	0	0	4		
			FT 205	Introduction to Agricultural Practices	4	0	0	4		
				LABORATORY						
		PC	FT 206	Food Chemistry Lab	0	0	4	2		
			FT 207	Food Preservation Lab	0	0	4	2		
			FT208	Food Microbiology Lab	0	0	4	2		
		MC	201/202/203/204	NCC/ NSS/PT & Games/Creative Art				1		
							26			
			THEORY							
FOURTH Spring	SECOND	PC	FT 209	Food Analysis	4	0	0	4		
			FT210	Food Biochemistry and Human nutrition	4	0	0	4		
			FT211	Fruits and Vegetable Processing Technology	4	0	0	4		
			FT212	Fluid Mechanics and Mechanical Operations	3	1	0	4		
		OE		Open Elective - I	3	0	0	3		
			LABORATORY							
	SECOND	PC	FT213	Fruits and Vegetable Processing Lab	0	0	4	2		
			FT214	Food Analysis Lab-I	0	0	4	2		
		GE	ME102	Engineering Graphics	0	0	4	2		
		MC	205/206/207/208	PT & Games/NCC/NSS/CA				1		
							26			
			THEORY							
FIFTH Monsoon	THIRD	PC	FT301	Cereal Pulses & Oilseeds Technology	4	0	0	4		
			FT302	Heat Transfer in Food Processing	3	0	0	3		
			FT303	Meat, Fish and Poultry Product Technology	4	0	0	4		
		PE		Programme Elective-I	3	0	0	3		
		OE		Open Elective- II	3	0	0	3		
				LABORATORY						
		FT304	Cereal Technology Lab	0	0	4	2			

	THIRD	PC	FT305	Food Product Development Lab	0	0	4	2		
FT306			Food Analysis Lab-II	0	0	4	2			
SPT		FT307	Industrial Training 4 weeks				2			
								25		
THEORY										
SIXTH Spring	THIRD	PC	FT 308	Dairy Technology	4	0	0	4		
			FT309	Mass Tranfer in Food Processing	3	0	0	3		
			FT310	Thermodynamics and Refrigeration	3	0	0	3		
		PE		Programme Elective II	3	0	0	3		
		HSS	FT311	Food Business Management	3	0	0	3		
		LABORATORY								
		PC	FT312	Dairy Technology Lab.	0	0	4	2		
		PE	FT313	Food Engineering Lab	0	0	4	2		
RP	FT300	Dissertation	0	0	10	5				
							25			
TOTAL CREDIT FOR B.Sc. Honours (Food Technology)								145		
I.M.Sc. Food Technology (Semester VII to X semester) /M.Sc. Food Technology (Semester I to IV Semester)										
THEORY										
M.Sc. (FIRST) / I.M.Sc. (SEVENTH) Monsoon	FOURTH	PC	FT 401	Bakery and Confectionary Technology	3	1	0	4		
			FT 402	Food Laws Safety and Quality	3	1	0	4		
			FT 403	Advanced Food Chemistry and Microbiology	3	1	0	4		
			FT 404	Fats and Oils Technology	3	1	0	4		
	SECOND	BS For Lateral Entry	FT 201	Food Chemistry	3	0	0	-		
			FT 203	Food Microbiology	3	0	0	-		
		OE		Open Elective I	3	0	0	3		
	HSS	MT 204	Constitution of India	2	0	0	Non Credit			
	LABORATORY									
	FOURTH	PC	FT407	Advanced Food Chemistry and Microbiology Lab	0	0	6	3		
FT409			Advanced Food Processing Lab 1	0	0	4	2			
							24			
THEORY										
	FOURTH	PC	FT410	Novel Techniques in Food Processing and Packaging	3	1	0	4		
			FT411	Food Product Development and Consumer Science	3	1	0	4		
		PE		Programme Elective III	3	0	0	3		

M.Sc. (SECOND) / I.M.Sc. (EIGHTH) Spring				Programme Elective IV	3	0	0	3
				Open Elective II	3	0	0	3
	FOURTH	FC for Lateral Entry	FT209	Food analysis	3	0	0	Non Credit
		LABORATORY						
		PC	FT414	Advanced Food Analysis Lab I	0	0	6	3
	FT415		Advanced Food Processing Lab II	0	0	4	2	
							22	
THEORY								
M.Sc. (THIRD) / I.M.Sc. (NINTH) Monsoon	FIFTH	PC	FT501	Flavour Chemistry and Technology	3	1	0	4
			FT502	Food Processing Plant Engineering & Layout	3	1	0	4
			FT503	Applied Statistics for Food Technology	3	1	0	4
		PE		Programme Elective V	3	0	0	3
				Programme Elective VI	3	0	0	3
	LABORATORY							
	FIFTH	PC	FT504	Advanced Food Analysis Lab II	0	0	4	2
			FT505	Advanced Food Product Development Lab	0	0	4	2
							22	
M.Sc. (FOURTH) / I.M.Sc. (TENTH) Spring	FIFTH	RP	FT500	Dissertation	3	0	0	12
TOTAL CREDIT [I-IV SEMESTER]								80
I.M.Sc. Food Technology (Semester VII to X semester) /M.Sc. Food Technology (Semester I to IV Semester)								
Grand Total for I.M.Sc.(Semester I to Semester X)=(145+80)=225								

**DEPARTMENT OF CHEMICAL ENGINEERING
PROGRAMME ELECTIVES (PE)
OFFERED FOR LEVEL 1-4 LM.SC FOOD TECHNOLOGY**

PE / LEVEL		Code no.	me of the PE cour	Prerequisites courses with code	L	T	P	C
3	PE 1	FT320	Food Additives & Ingredients	FT 201	3	0	0	3
3		FT321	Flavour Chemistry & Technology	FT 201	3	0	0	3
3		FT 322	Food Toxicology	FT 201	3	0	0	3
3	PE 2	FT330	Food Packaging Technology	FT202	3	0	0	3
3		FT331	Food Industry Waste Management	FT 201, FT 202	3	0	0	3
3		FT332	Technology of Plantation Crops and spices	FT 201	3	0	0	3
4	PE 3	FT420	Principles of Food Processing and Preservation	FT 201, FT 203	3	0	0	3
4		FT421	Automation in Food Processing Industry	FT 201, FT 203	3	0	0	3
4		FT422	Enzymes in Food Processing	FT 201, FT 203	3	0	0	3
4	PE 4	FT423	Food Processing Technology	FT 201, FT 203	3	0	0	3
4		FT424	Post Harvesst Engineering	FT 201, FT 203	3	0	0	3
4		FT425	Food Supply Chain Management	FT 201, FT 203	3	0	0	3
5	PE 5	FT 511	Computer Application in Food Industry	FT 201, FT 202	3	0	0	3
5		FT 512	Food Biotechnology	FT 201, FT 202	3	0	0	3

5		FT 513 Grain Storage Technology	FT 201, FT 202	3	0	0	3
6		FT 514 Nutraceuticals & Functional Foods	FT 201, FT 202	3	0	0	3
6	PE 6	FT 515 Food Processing Equipment Design	FT 201, FT 202	3	0	0	3
6		FT 516 Agricultural and Rural Economics	FT 201, FT 202	3	0	0	3
*FT420 and FT 423 are only for Lateral Entry							
** PROGRAMME ELECTIVES TO BE OPTED ONLY BY THE FOOD TECHNOLOGY STUDENTS							

COURSE INFORMATION SHEET

Course code: PH 113
Course title: Physics
Pre-requisite(s): Intermediate Physics & Mathematics
Co- requisite(s):
Credits: L: 03T: 01P: 00
Class schedule per week: 04
Class: B. Tech
Semester / Level: I/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students:

1.	To explain principles of physical optics
2.	To construct Maxwell's equations from basic principles and use it to solve electromagnetic plane wave equations
3.	To distinguish between Newtonian Mechanics and special theory of relativity and develop the relationship of length contraction, time dilation and Einstein energy mass relation and to apply the concepts of special theory of relativity in various field of physics and engineering.
4.	To illustrate the phenomena of old quantum theory and derive Heisenberg uncertainty principle and Schrödinger's equations
5.	To understand basic lasing action, study various types of lasers and to have basic idea of fiber optics.

Course Outcomes

After the completion of this course, students will be:

CO 1	To interpret the intensity variation of light due to Polarization, interference and diffraction.
CO 2	To formulate and solve the engineering problems on electromagnetism.
CO 3	To explain special theory of relativity and apply its concepts in various fields of physics and engineering.
CO 4	To explain fundamentals of quantum mechanics and apply it to problems on bound states.
CO 5	To analyze working principle of lasers and to summarize its applications.

**PH 113: Physics
SYLLABUS**

Module1: (9L)

Physical Optics: Polarization, Malus' Law, Brewster's Law, Double Refraction, Interference in thin films (Parallel films), Interference in wedge-shaped layers, Newton's rings, Fraunhofer diffraction by single slit, Double slit.

Module2: (9L)

Electromagnetic Theory: Curl, Gradient, Divergence, Gauss theorem, Stokes theorem, Gauss's law, Applications, Concept of electric potential, Relationship between E and V, Polarization of dielectrics, dielectric constant, Boundary conditions for E & D, Gauss's law in magnetostatics, Ampere's circuital law, Boundary conditions for B & H, Equation of continuity of charge, Displacement current, Maxwell's equations.

Module3: (9L)

Special Theory of Relativity: Introduction, Inertial frame of reference, Galilean transformations, Postulates, Lorentz transformations and its conclusions, Length contraction, time dilation, velocity addition, Mass change, Einstein's mass energy relation.

Module4: (9L)

Quantum Mechanics: Planck's theory of black-body radiation, Compton effect, Wave particle duality, De Broglie waves, Davisson and Germer's experiment, Uncertainty principle, physical interpretation of wave function, Schrodinger equation in one dimension, free particle, particle in an infinite square well.

Module5: (9L)

Lasers: Spontaneous and stimulated emission, Einstein's A and B coefficients, Population-inversion, Light amplification, Basic laser action, Ruby and He-Ne lasers, Properties and applications of laser radiation, Elementary ideas of fiber optics and application of fiber optic cables.

Text books:

1. Optics, by A. Ghatak, 4th Edition, Tata Mcgraw Hill, 2009 (T1)
2. Elements of Electromagnetics by Mathew N.O. Sadiku,, Oxford University Press, 2001 (T2)
3. Concept of Modern Physics by Arthur Beiser,, 6th edition, Tata McGraw- Hill, 2009 (T3)

Reference books:

1. Fundamentals of Physics, Halliday, Walker and Resnick (R1)

COURSE INFORMATION SHEET

Course code: MA 103
Course title: Mathematics I
Pre-requisite(s): Basic Calculus, Basic Algebra
Co- requisite(s):
Credits: L: 03T: 01P: 00
Class schedule per week:04
Class: B. Tech
Semester / Level: I/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students to understand

1.	Infinite sequences and series.
2.	Theory of matrices including elementary transformations, rank and its application inconsistency of system of linear equations, eigenvalues, eigenvectors etc.
3.	Multivariable functions, their limits, continuity, partial differentiation, properties and applications of partial derivatives.
4.	Integrals of multivariable functions viz. double and triple integrals with their applications.
5.	Properties like gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions.

Course Outcomes

After the completion of this course, students will be able to

CO 1	Decide the behaviour of sequences and series using appropriate tests.
CO 2	Get an understanding of partial derivatives and their applications in finding maxima -minima problems.
CO 3	Apply the principles of integral to solve a variety of practical problems in engineering and sciences.
CO 4	Demonstrate a depth of understanding in advanced mathematical topics.
CO 5	Enhance and develop the ability of using the language of mathematics in engineering.

MA 103: Mathematics I

SYLLABUS

Module1: (9L)

Sequences and Series: Sequences, Convergence of Sequence. Series, Convergence of Series, Tests for Convergence: Comparison tests, Ratio test, Cauchy's root test, Raabe's test, Gauss test, Cauchy's Integral test, Alternating series, Leibnitz test, Absolute and Conditional Convergence.

Module2: (9L)

Matrices: Rank of a Matrix, elementary transformations, Row - reduced Echelon form. Vectors, Linear independence and Dependence of Vectors. Consistency of system of linear equations. Eigenvalues, Eigenvectors, Cayley - Hamilton theorem.

Module3: (9L)

Advance Differential Calculus: Function of several variables, Limit, Continuity, Partial derivatives, Euler's theorem for homogeneous functions, Total derivatives, Chain rules, Jacobians and its properties, Taylor series for function of two variables, Maxima – Minima, Lagrange's method of multipliers.

Module4: (9L)

Advance Integral Calculus: Beta and Gamma functions: definition and properties. Double integrals, double integrals in polar coordinates, Change of order of integration, Triple Integrals, cylindrical and spherical coordinate systems, transformation of coordinates, Applications of double and triple integrals in areas and volumes.

Module5: (9L)

Vector Calculus: Scalar and vector point functions, gradient, directional derivative, divergence, curl, vector equations and identities. Line Integral, Work done, Conservative field, Green's theorem in a plane, Surface and volume integrals, Gauss – divergence theorem, Stoke's theorem.

Text Books:

1. Thomas' Calculus by M. D. Weir, J. Hass and F. R. Giordano 11th Edition, Pearson Education, 2008E. **(T1)**
2. Calculus by H. Anton, I. Brivens and S. Davis, 10th Edition, John Wiley and sons, Singapore Pte. Ltd., 2013. **(T2)**
3. Higher Engineering Mathematics, Ramana B.V. Tata McGraw Hill New Delhi, 11th Reprint, 2010. **(T3)**

Reference Books:

1. Calculus, by M. J. Strauss, G. L. Bradley And K. J. Smith, 3rd Ed, Dorling Kindersley (India) Pvt. Ltd. (P Ed), Delhi, 2007. **(R1)**
2. Linear Algebra and its Applications by David C. Lay, 3rd Edition, Pearson Ed. Asia, Indian Reprint, 2007. **(R2)**
3. Advanced Engineering Mathematics by D. G. Zill and W.S. Wright, 4th Edition, 2011. **(R3)**

COURSE INFORMATION SHEET

Course code: CS 101
Course title: Programming for Problem Solving
Pre-requisite(s):
Co- requisite(s): Programming for Problem Solving Lab
Credits: L: 03T: 01P: 00
Class schedule per week: 04
Class: B. Tech
Semester / Level: I/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students:

1.	To learn computer language.
2.	To learn coding for solving scientific and engineering problems.
3.	To learn the problem-solving process through computer.
4.	To know the limitations of system during program execution.
5.	To know the practical application of various programming techniques.

Course Outcomes

After the completion of this course, students will be able to

CO 1	To formulate simple algorithms for arithmetic and logical problems.
CO 2	To translate the computer algorithms to computer programs.
CO 3	To test and execute the programs and correct syntax and logical errors.
CO 4	To apply programming to solve simple numerical method problems, differentiation of function and simple integration.
CO 5	To decompose a problem into functions and synthesize a complete program using divide and conquer approach.

CS 101: Programming for Problem Solving SYLLABUS

Module1: (9L)

Introduction to Programming: Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.) Problem Solving: Steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudo code with examples. From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code

Module2: (9L)

Arithmetic expressions and precedence, Conditional Branching and Loops, Writing and evaluation of conditionals, Iterations, Loops.

Module3: (9L)

Array, Character array, strings. Case studies to discuss the various Problems related to Basic science (Matrix addition, Matrix-matrix multiplication, Roots of an equation etc.), Sorting, Searching.

Module4: (9L)

Functions (including using built in libraries), Parameter passing in functions, call by value, call by reference. Passing arrays to functions, Recursion (Finding Factorial, Fibonacci series, Ackerman function etc.).

Module5: (9L)

Structures, Defining structures and Array of Structures Pointers: Defining pointers, Use of Pointers in self-referential structures, File Handling

Text Books:

1. Problem solving and Program design in C by Jerry R Hanly, 7th Edition, Pearson Education. Programming in ANSI C, Tata McGraw-Hill.
2. Reema Thareja, Introduction to C Programming by E. Balaguruswamy,, 2nd Edition, Oxford University Press, 2015.
3. The C Programming Language by Brian W. Kernighan and Dennis M. Ritchie, Prentice-Hall. Schaum's Outline of Programming with C Gottfried,, Tata McGraw-Hill.

COURSE INFORMATION SHEET

Course code: BE 203
Course title: Microbiology
Pre-requisite(s): Intermediate level Physics, Chemistry & Mathematics
Co- requisite(s):
Credits: L: 03T: 00P: 00
Class schedule per week: 03
Class: IMSc
Semester / Level: II/01
Branch: Food Technology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To develop fundamental understanding of the microbial world, basic structure and functions of microbes, metabolism, nutrition, their diversity, physiology and relationship to environment and human health.
2.	To explain the basic microbial structure , function and study the comparative characteristics of prokaryotes and eukaryotes
3.	To develop the knowledge of different culture media composition, its applications and preparation and demonstrate various physical and chemical means of sterilization
4.	To apply general bacteriology and microbial techniques for isolation of pure cultures of bacteria, fungi and algae
5.	To relate the microbial growth , pathways and associated control parameters
6.	To solve the problems in microbial infection and their control.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to develop the knowledge in the basic area of Microbiology
CO 2	Able to explain the basic microbial structure , function and study the comparative characteristics of prokaryotes and eukaryotes
CO 3	Able to formulate various culture media and have understanding of their applications
CO 4	Able to explain various physical and chemical means of sterilization
CO 5	Able to build knowledge on general bacteriology and microbial techniques for isolation of pure cultures of bacteria, fungi & algae and able to understand the microbial growth , pathways and associated control parameters

BE203 MICROBIOLOGY

Syllabus

Module-I

Brief history on the development and scope of microbiology, Methods in Microbiology-Microscopy, Methods of sterilization; culture media, Pure culture methods, Staining of Bacteria, Micrometry, Air sampling, Classification of microorganisms

Module-II

Cell structure and major characteristics of cellular (bacteria, fungi, algae, protozoa) and acellular (viruses) organisms, Archaeobacteria, Growth of Microorganisms: Nutritional and physical requirements, Batch culture, Continuous culture, Synchronous growth, Fed-batch culture

Module-III

Environmental & Industrial Microbiology: Water treatment, Bacteriological analysis of water, Bioleaching, Bioremediation, Industrially important micro-organisms and secondary metabolites.

Module-IV

Agricultural Microbiology: Plant-microbial interactions, Biodeterioration of agricultural products, control of microbes and safe storage of agricultural products/food.

Module-V

Medical Microbiology: Microbial flora of healthy human host, host-pathogen interactions in animals, Diseases caused by bacteria, virus, fungi and protozoans; natural resistance and nonspecific defense mechanisms.

Text books:

Prescott, Harley, and Klein, Microbiology, 7th Ed., Tata McGraw-Hill, 2008

Reference books:

Pelczar, Chan and Krieg, Microbiology, 5th Edition, Tata McGraw-Hill, 1986

Frazier and Westhoff, Food Microbiology, 4th Edition, Tata McGraw-Hill, 1995

COURSE INFORMATION SHEET

Course code: PH 114
Course title: Physics Lab
Pre-requisite(s): Intermediate Physics (Theory and Lab)
Co- requisite(s):
Credits: 1.5 L:OT: 00P: 03
Class schedule per week:03
Class: B. Tech
Semester / Level: I/01
Branch:All
Name of Teacher:

List of Experiments

1. Error analysis in Physics Laboratory
2. To determine the frequency of AC mains with the help of sonometer
3. To determine the wavelength of sodium light by Newton's rings Method
4. To determine the resistance per unit length of a Carey Foster's bridge wire and then to find the resistivity of the material of a given wire.
5. Measurement of mechanical equivalent of heat by electrical method
6. Determination of refractive index of the material of a prism using spectrometer and sodium light
7. To determine the frequency of electrically maintained tuning fork by Melde's experiment
8. Measurement of voltage and frequency of a given signal using cathode ray oscilloscope
9. To determine the wavelength of prominent spectral lines of mercury light by a plane transmission grating using normal incidence
10. To determine the electromotive force (emf) of an unknown cell using a stretched wire potentiometer
11. To study the frequency response and quality factor of series LCR circuit.
12. To find the specific rotation of sugar solution by using a polarimeter.
13. To determine the Hall voltage and calculate the Hall coefficient and carrier concentration of a semiconductor sample

COURSE INFORMATION SHEET

Course code: CS 102
Course title: Programming for Problem Solving Lab
Pre-requisite(s): Intermediate Physics (Theory and Lab)
Co- requisite(s): Programming for Problem Solving
Credits: 1.5 L: 00T: 00P: 03
Class schedule per week: 03
Class: B. Tech
Semester / Level: I/01
Branch: All
Name of Teacher:

Sample Program List

Module 1 & Module 2: Introduction and Control Flow

1. Write an interactive program that will read in a +ve integer value and determine the following
 - i) If the integer is a prime number
 - ii) If the integer is a Fibonacci number
2. WAP in C to compute $\sin x = x - x^3/3! + x^5/5! - x^7/7! \dots$ to five place of accuracy. Test the program for $x = 1$, $x = 2$, and $x = 3$. In each case display the number of terms used to obtain the final answer.
3. WAP to generate every 3rd integer beginning with $I = 2$ and continue for all integers that are less than 150. Calculate the sum of those integers that are evenly divisible by 5.
4. WAP to find whether a given year is a leap year or not. Modify it to generate a list of leap years between two year limits given by user.
5. WAP to display the following pattern :

6. Using Ternary Among 3

				11				
				11	10	11		
				11	10	9	10	11
				11	10	9	8	9
				11	10	9	8	9
				11	10	9	8	9
				11	10	9	8	9
				11	10	9	8	9

 / Conditional operator find the greatest numbers.

7. WAP to convert a decimal number into an equivalent number of the input base. Test your program for base 2, 8 & 16.
8. WAP to read a number n, and print it out digit-by-digit, as a series of words. For e.g. 123 would be printed as “one two three”.
9. WAP to check whether any input +ve integer is palindrome or not.
10. WAP to simulate a simple calculator (+ - / * %) that takes two operands and an operator as input and displays the result.
11. WAP to find the GCD of two input +ve integer numbers. Using this find GCD of 9 numbers.
12. WAP to swap the values of two variables without using a third variable.

Module 3: Array

13. Read a line of mixed text, and then write it out with all lower case and uppercase letters reversed, all digits replaced by 0s and all other characters (non-letters and nondigits) replaced by ‘*’.
14. WAP to find the product of two matrices A and B. Display the source matrices and product matrix C in matrix format.
15. WAP to find whether a given matrix is a triangular matrix or not.

16. WAP to find the transpose of a matrix. Display the source and the transposed matrix in matrix format.
17. Implement Prob. No. – 14 to 16 using functions for reading, manipulating and displaying the corresponding matrices in matrix form.
18. WAP to sort a list of strings alphabetically using a 2-dim. Character array.
19. WAP to display the row sum and the column – sum of an input 2- dim. Matrix. Display the source matrix with row and column sum.

Module 4: Functions, Pointer & String

20. Write a recursive function to calculate $S = 2 + 4 + 6 + 8 + \dots + 2N$. Implement the function in a complete C program.
21. Write a function that accepts two arguments an array and its size n. It performs Bubble up sort on the array elements. Using indirection operator '*' implement this in a complete C program. Display the source and the sorted array.
22. Using pointer, write a function that receives a character string and a character as argument. Delete all occurrences of this character in the string. The function should return corrected string with no holes.
23. Write a function for reading character string using pointer. Calculate the length of the string (without using strlen ()). Finally print the string in reverse order, using pointer.
24. Implement prob. No. 14 using pointers representation of 2 – dim. array.
25. Implement prob. No. 15 using pointer representation of 2 dim. array.
26. Implement prob. No. 16 using pointer representation of 2 dim. array.
27. WAP to sort a list of strings into alphabetical order using array of pointers.

Module 5: Structure and File

28. Create records of 60 students, where each record has fields-name, roll, GPA and fees. Write a function update () to reduce the fees of those students who have obtained GPA greater than 8.5 by 25% of the original fees. Write a complete program to exercise this function in the main program and display all the records before and after updation.
29. Define a structure that describes a hotel. It should have members that include the name, address, grade, average room charge and number of rooms. Write a function to perform the following operations:
 - a) To print out hotels of a given grade in order of charges.
 - b) To print out hotels with room charges less than a given value.
30. WAP to concatenate the contents of two files into a third file.
31. WAP to copy the content of one file into another file. Names of both the files are to be input as command line arguments

COURSE INFORMATION SHEET

Course code: CE101
Course title: Environmental Science
Pre-requisite(s): NA
Co- requisite(s): NA
Credits: L:2 T:0P:0
Class schedule per week: 02
Class: B.Tech
Semester / Level: II/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students:

1	To develop basic knowledge of ecological principles and their applications in environment.
2	To identify the structure and composition of the spheres of the earth, the only planet sustaining life.
3	To analyse, how the environment is getting contaminated and probable control mechanisms for them.
4	To generate awareness and become a sensitive citizen towards the changing environment.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to explain the structure and function of ecosystems and their importance in the holistic environment.
CO 2	Able to identify the sources, causes, impacts and control of air pollution.
CO 3	Able to distinguish the various types of water pollution happening in the environment and understand about their effects and potential control mechanisms.
CO 4	Able to judge the importance of soil, causes of contamination and need of solid waste management.
CO 5	Able to predict the sources of radiation hazards and pros and cons of noise pollution.

CE101: Environmental Science Syllabus

Module 1: (6L)

Ecosystem and Environment: Concepts of Ecology and Environmental science, ecosystem: structure, function and services, Biogeochemical cycles, energy and nutrient flow, ecosystem management, fate of environmental pollutants, environmental status and reports on climate change.

Module 2: (6L)

Air Pollution: Structure and composition of unpolluted atmosphere, classification of air pollution sources, types of air pollutants, effects of air pollution, monitoring of air pollution, control methods and equipment for air pollution control, vehicular emissions and control, indoor air pollution, air pollution episodes and case studies.

Module 3: (6L)

Water Pollution: Water Resource; Water Pollution: types and Sources of Pollutants; effects of water pollution; Water quality monitoring, various water quality indices, water and waste water treatment: primary, secondary and tertiary treatment, advanced treatments (nitrate and phosphate removal); Sludge treatment and disposal.

Module 4: (5L)

Soil Pollution and Solid Waste Management: Lithosphere – composition, soil properties, soil pollution, ecological & health effects, Municipal solid waste management – classification of solid wastes, MSW characteristics, collection, storage, transport and disposal methods, sanitary landfills, technologies for processing of MSW: incineration, composting, pyrolysis.

Module 5: (5L)

Noise pollution & Radioactive pollution: Noise pollution: introduction, sources: Point, line and area sources; outdoor and indoor noise propagation, Effects of noise on health, criteria noise standards and limit values, Noise measurement techniques and analysis, prevention of noise pollution; Radioactive pollution: introduction, sources, classification, health and safety aspects, Hazards associated with nuclear reactors and disposal of spent fuel rods-safe guards from exposure to radiations, international regulation, Management of radioactive wastes.

Text books:

1. Environmental Chemistry by A. K. De. (3rd Ed). 2008.. New Age Publications India Ltd.
2. Environmental Studies: From Crisis to Future by R. Rajagopalan. 2016 3rd edition, Oxford University Press.
3. Fundamentals of Ecology by Eugene P. Odum. 1971. 3rd ed.- WB Saunders Company, Philadelphia.
4. Chemistry for Environmental Engineering and Science by C. N. Sawyer, P. L. McCarty and G. F. Parkin. 2002. John Henry Press.
5. Environmental Science by S.C. Santra. 2011. New Central Book Agency.

Reference books:

1. Basic Concepts of Environmental Chemistry by D.W. Conell., CRC Press.
2. Environmental Engineering by Peavy, H.S, Rowe, D.R, Tchobanoglous, G., Mc-Graw - Hill International
3. Introduction to Environmental Engineering and Science by G.M. Masters & Wendell Ela. 1991., PHI Publishers.

COURSE INFORMATION SHEET

Course code: CH 101
Course title: Chemistry
Pre-requisite(s): Intermediate level chemistry
Co- requisite(s):
Credits: L: 03T: 01P: 00
Class schedule per week: 04
Class: All
Semester / Level: II/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students:

1.	To create concept of Chemical bonding & Coordination Chemistry.
2.	To understand the basic 3D structure in organic chemistry including stereochemistry, aromaticity and reaction mechanism.
3.	To understand the reaction dynamics and to know different types of catalysis.
4.	To understand the modern techniques related to spectroscopy and structural characterization.
5.	To develop knowledge on the physical state and electrochemistry of molecules.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to explain the bonding in a molecular structure.
CO 2	Able to explain the 3D structure, aromaticity and stereochemistry of organic molecules.
CO 3	Able to explain the spectroscopic data for structural characterization of the molecules.
CO 4	Able to predict the rate, molecularity and mechanism of a simple as well as catalytic reaction.
CO 5	Able to interpret the phases of solid and the electrochemical behavior of the molecules.

CH 101: Chemistry SYLLABUS

Module1: (9L)

Chemical Bonding Ionic bond: Radius ratio rule, Born-Landé equation, Born-Haber cycle. Metallic Bond: valence bond and band theories, defects in solids, Werner's Theory, Bonding in Transition metal complexes, Ligands, coordination complexes, Ligand Field, Crystal Field Theory, Octahedral, Tetrahedral and square planar complexes, CFSE, Jahn Teller theorem, electronic spectra, magnetism, and isomerization in coordination compounds.

Module2: (9L)

Organic Structure and Stereochemistry Covalent bond: Lewis structure, Valence Bond theory, Molecular orbital theory, Molecular orbital of diatomic and polyatomic system, hybridization, conjugated molecules, Huckel molecular orbital theory of conjugated systems. Isomerism, Geometrical isomerism: cis-trans and syn-anti isomerism; Optical isomerism & Chirality; Wedge, Fischer, Newmann and Sawhorse Projection formulae and interconversions; E/Z, D/L, R/S nomenclature system; Conformational studies of ethane, n-butane, Cyclohexane.

Module3: (9L)

Kinetics and Catalysis: Order & molecularity of reactions: chain, parallel, Competing, Side, Consecutive reactions; Kinetics of Fast reactions, Characteristics of catalyst, types of catalysis, catalytic poison; Theories of catalysis; Acid base catalysis: including kinetics, Enzyme catalysis, Mechanism and kinetics of enzyme catalyzed reaction, Michaelis-Menten equation, Important catalysts in industrial processes; Hydrogenation using Wilkinson's catalyst, Hydroformylation by using Cobalt-catalyst, Phase transfer catalyst.

Module4: (9L)

Spectroscopic Techniques Absorption and emission Spectroscopy, Lambert-Beers Law, Principles and applications of UV-Visible, Factors influencing for UV-VIS spectrum; Rotational and Vibrational spectroscopy, Principle of FT-IR, and NMR spectroscopy; Modern techniques in structural elucidation of compounds by UV-VIS, IR, & NMR Spectroscopy.

Module5: (9L)

Phase and Chemical equilibrium Phase Rule: Terms Involved, Phase diagram of one component (Water) & two component (Pb/Ag) system & their applications. Law of chemical equilibrium, equilibrium constants and their significance, Weak and strong electrolytes, Standard electrode potential and its application to different kinds of half cells, EMF and its measurement and application, Batteries and Fuel Cells, Chemical and Electrochemical corrosion, Factors affecting the rate of corrosion.

Text books:

1. Inorganic Chemistry: Principles of Structure and Reactivity by Huheey, J. E., 4th edition, Pearson. (T1)
2. Organic Chemistry by Morrison, R. N. & Boyd, R. N., Seventh Edition, Pearson (T2)
3. Physical Chemistry by Atkins, P. W. & Paula, J., 10th Ed., Oxford University Press, 2014. (T3)

Reference books:

1. Concise Inorganic Chemistry by Lee, J. D. ELBS, 1991. (R1)
2. Physical Chemistry by Mortimer, R. G. 3rd Ed., Elsevier (2009). (R2)
3. Organic Spectroscopy by William Kemp, 3rd Ed., 2008 Macmillan. (R3)

COURSE INFORMATION SHEET

Course code: MA 107
Course title: Mathematics II
Pre-requisite(s): Mathematics - I
Co- requisite(s):
Credits: L: 03T: 01P: 00
Class schedule per week:04
Class: All
Semester / Level: II/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students to understand:

1.	Various methods to solve linear differential equations of second and higher order.
2.	special functions viz. Legendre's and Bessel's and different properties associated with them.
3.	Diverse mathematical techniques for solving partial differential equations of first order and higher order, along with their applications in wave and heat equations using Fourier series.
4.	The theory of functions of a complex variable, complex differentiation and integration.
5.	About random variables and elementary probability distribution.

Course Outcomes

After the completion of this course, students will be:

CO 1	Investigate the occurrence of differential equations in science and engineering and use methods available for their solutions.
CO 2	Gain an understanding on complex variable functions and using their properties in real life problems.
CO 3	Construct appropriate probability models in solving real world problems.
CO 4	Demonstrate a depth of understanding in advanced mathematical topics.
CO 5	Enhance and develop the ability of using the language of mathematics in engineering.

MA 107: Mathematics II SYLLABUS

Module1: (9L)

Ordinary Differential Equations – I Linear differential equations, Wronskian, Linear independence and dependence of solutions, Linear differential equations of second and higher order, Operator method, Legendre's and Euler – Cauchy's form of linear differential equation, Method of variation of parameters.

Module1I: (9L)

Ordinary Differential Equations – II: Ordinary and singular points of differential equation, Power and Frobenius series solutions. Bessel's differential equation, Bessel function of first kind and its properties. Legendre's differential equation, Legendre's polynomial and its properties.

Module1II: (9L)

Fourier series and Partial Differential Equations Fourier series: Euler formulae for Fourier series, Dirichlet conditions, Half range Fourier series. Partial Differential Equations: Linear partial differential equations, Lagrange's method. Method of separation of variables and its application in solving one dimensional wave and heat equations.

Module IV: (9L)

Complex Variable-Differentiation & Integration Function of a complex variable, Limit, Continuity, Differentiability, Analyticity, Analytic functions, Cauchy – Riemann equations. Harmonic functions, Harmonic Conjugate. Cauchy's theorem, Cauchy's Integral formula, Taylor and Laurent series expansions. Singularities and its types, Residues, Residue theorem.

Module 5: Applied Probability(9L)

Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, variance, moment generating function. Introduction to Binomial, Poisson and Normal Distribution.

Text Books:

1. Advanced Engineering Mathematics by E. Kreyszig,, 9th Edition, John Wiley & Sons, 2006. **(T1)**
2. Advanced Engineering Mathematics by D. G. Zill and W.S. Wright,, 4th Edition, 2011.
3. JComplex Variables and Applications, by W. Brown and R. V. Churchill, 7th Edition, McGraw Hill, 2004. **(T2)**
4. Advanced Engineering Mathematics by R.K. Jain and S.R.K. Iyengar, 3rd Edition, Narosa Publishing, 2009. **(T3)**
5. Probability and Statistics for Engineers by R. A . Johnson, I. Miller and J. Freund:, PHI. **(T4)**

Reference Books:

1. Elementary Differential Equations and Boundary Value Problems by W. E. Boyce and R. C. DiPrima, 9th Edition ., Wiley India, 2009. **(R1)**
2. A text book of Engineering Mathematics by N.P. Bali and Manish Goyal, Laxmi Publications, Reprint, 2008. **(R2)**
3. An Introduction to Ordinary Differential Equations by E. A. Coddington, Prentice Hall India, 1995. **(R3)**
4. Differential Equations with Applications and Historical Notes by G. F. Simmons,, TMH, 2nd Edition, 2003. **(R4)**
5. Introductory Probability and Statistical Applications by P. L. Meyer:, Oxford & IBH. **(R5)**

Course Evaluation:

COURSE INFORMATION SHEET

Course code: MT 123
Course title: Business Communication
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: 3 L: 2 T: 0 P: 2
Class schedule per week: 2
Class: All
Level: 1
Name of Teacher:

Course Objectives

This course enables the students:

A.	To analyze and demonstrate writing and speaking processes through invention, organization, drafting, revision, editing, and presentation.
B.	To understand the importance of specifying audience and purpose and to select appropriate communication choices.
C.	To interpret and appropriately apply modes of expression, i.e., descriptive, expositive, Narrative, scientific, and self-expressive, in written, visual, and oral communication
D.	To participate effectively in groups with emphasis on listening, critical and reflective thinking, and responding.
.E	To develop the ability to research and write a documented paper and/or to give an oral presentation.

Course Outcomes

After the completion of this course, students will be able to:

1.	Apply business communication strategies and principles to prepare effective communication for domestic and international business situations.
2.	Utilize analytical and problem-solving skills appropriate to business communication.
3.	Participate in team activities that lead to the development of collaborative work skills.
4.	Select appropriate organizational formats and channels used in developing and presenting business messages
5.	Communicate via electronic mail, Internet, and other technologies and deliver an effective oral business presentation.

MT 123: Business Communication Syllabus

Module I

Introduction to Business Communication: Importance and Objectives of Business communication, Process of communication, Barriers to effective communication, Techniques of effective communication. Forms of communication (Written, Oral, audio-visual communication).

Module II

Managing Business Communication: Formal and Informal communication, Non- verbal communication (Body language, Gestures, Postures, Facial expressions). The cross cultural dimensions of business communication. Techniques to effective listening, methods and styles of reading.

Module III

Other aspects of communication: Vocabulary: Single word substitution, Idioms and phrases, Precis writing, Comprehension. Group Discussions, Extempore, Principles of effective speech and presentations, Role playing.

Module IV:

Introduction to managerial writing:Business letters: Inquiries, Circulars, Quotations, Orders, Acknowledgement, Claims & adjustments, Collection letters, Sales letters, Drafting of different resumes, Covering letters Applying for a job, Social correspondence, Invitation to speak. Official Correspondence: Memorandum, Notice, Agenda, Minutes, Circular letters.

Module V:

Report writing: Business reports, Types, Characteristics, Importance, Elements of structure, Process of writing, Order of writing, the final draft, check lists for reports.

Text Books:

1. Communication Skills, Sanjay Kumar & PushpLata, Oxford University Press (T1).
2. Business Correspondence and Report Writing, R.C.Sharma, Krishna Mohan. McGraw Hill (T2).
3. Communication for Business, Shirley Taylor, V.Chandra, Pearson (T3).
4. Business Communication- HorySankar Mukherjee, Oxford University Press (T4).
5. Basic Business Communication- .Lesikar I Flatley, McGraw Hill. (T5).
6. Business Communication Today ,Bovee, Thill and Chaterjee, Pearson (T6).

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations.

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments

COURSE INFORMATION SHEET

Course code: EC 101
Course title: Basics of Electronics & Communication Engineering
Pre-requisite(s): Intermediate level Physics, Chemistry & Mathematics
Co- requisite(s):
Credits: L: 03T: 01P: 00
Class schedule per week:04
Class: IMSc
Semester / Level: II/01
Branch:All
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand PN Junction, diodes and their applications.
2.	To comprehend BJT, FET and their bias configurations.
3.	To grasp importance of feedback in amplifier circuits, op amp and its applications.
4.	To understand number system, Logic Gates and Boolean algebra.
5.	To apprehend fundamentals of communication technology.

Course Outcomes

After the completion of this course, students will be:

CO 1	Explain PN Junction, diodes and their applications.
CO 2	Appraise the BJT, FET and their biasing techniques.
CO 3	Comprehend feedback in amplifier circuits, op amp and its applications.
CO 4	Translate one number system into another, build circuits with Logic Gates, electronic components and OPAMP IC 741 and analyze the measurement results using CRO.
CO 5	Appraise the fundamentals of communication technology.

EC 101: Basics of Electronics & Communication Engineering SYLLABUS

Module1: (9L)

Diodes and Applications: Introduction to PN junction diodes; Characteristics of semiconductor diodes: V-I characteristics, diode-resistance, temperature-dependence, diode-capacitance; DC & AC load lines; Breakdown Mechanisms; Zener Diode – Operation and Applications; Diode as a Rectifier: Half Wave and Full Wave Rectifiers with and without C-Filters.

Module2: (9L)

Bipolar Junction Transistors (BJT): PNP and NPN Transistors, Basic Transistor Action, Input and Output Characteristics of CB, CE and CC Configurations, dc and ac load line analysis, operating point, Transistor biasing: Fixed bias, emitter bias/self-bias, Low-frequency response of CE amplifier. Field Effect Transistors: JFET, Idea of Channel Formation, Pinch-Off and saturation Voltage, Current-Voltage Output Characteristics; MOSFET: Basic structure, operation and characteristics.

Module3: (9L)

Sinusoidal Oscillators: Concept of positive and negative feedback, Barkhausen criterion for sustained oscillations, Determination of Frequency and Condition of oscillation, Hartley and Colpitt's oscillator. Operational Amplifiers: Characteristics of an Ideal and Practical Operational Amplifier (IC 741), Inverting and non-inverting amplifiers, Offset error voltages and currents; Power supply rejection ratio, Slew Rate and concept of Virtual Ground, Summing and Difference Amplifiers, Differentiator and Integrator, RC phase shift oscillator.

Module4: (9L)

Logic Gates and Boolean algebra: Introduction to Boolean Algebra and Boolean operators, Symbolic representation, Boolean algebraic function and Truth table of different Digital logic, Gates (AND, OR, NOT, NAND, NOR, EX-OR, EX-NOR); Realization of Basic logic gates using universal gates, Adder, Subtractor, adder/subtractor.

Module5: (9L)

Electronic communication: Introduction to electronic communication system, Electromagnetic Communication spectrum band and applications, Elements of Electronic Communication System; Merits and demerits of analog and digital communication, Modes of communication; Signal radiation and propagation; Need for modulation; Introduction to Amplitude modulation and Angle modulation.

Text Books:

1. Integrated Electronics: Analog and Digital Circuits and Systems by Millman J., Halkias C.C., Parikh Chetan., 2nd Edition, Tata McGraw-Hill.
2. Digital Logic and Computer Design by Mano M.M., Pearson Education, Inc, Thirteenth Impression, 2011.
3. Analog and Digital Communications by Singal T. L., 2nd Edition, Tata McGraw-Hill.
4. Introduction to Analog & Digital Communications by Haykin S., Moher M., 2nd Edition, Wiley India Pvt. Ltd.

Reference Book:

1. Electronic Devices and Circuit Theory by Boylestad R.L., Nashelsky L., 10th Edition Pearson Education, Inc.

COURSE INFORMATION SHEET

Course code: BE 201
Course title: Microbiology Lab
Pre-requisite(s):
Co- requisite(s): Microbiology
Credits:1.5 **L: 00T: 00P: 03**
Class schedule per week: 03
Class: IMSc
Semester / Level: II/01
Branch: Food Technology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand terms and safety procedure of microbiological applications.
2.	To know microscopy techniques, media preparation & methods of inoculation of different microbes
4.	To grasp the knowledge of Pure Culture Techniques like streak plate method, pour plate method.
5.	To understand the fundamentals of identification of microbes by use of staining methods

Course Outcomes

After the completion of this course, students will be able to:

CO 1	Explain microbiological safety procedure and their applications in industry.
CO 2	Able to translate effects of microbes in human health
CO 3	Able to handle the microbiological tools and equipments.
CO 4	Able to assess the microbial quality of products by different techniques.
CO 5	Able to do Quantitative and qualitative analysis of samples for microbial test.

BE 201: Microbiology Lab

Syllabus

1. General terms and safety procedure of microbiology Laboratory
2. Microscopy- Brightfield, Darkfield Microscopy, Phase-Contrast Microscopy, Fluorescence Microscopy & Microscopic Measurements
3. Aseptic Technique- Transfer from broth culture to another broth, Transfer of bacteria from slant to slant, Working with agar plates (Inoculating a slant from a Petri plate)
4. Media preparation & methods of inoculation of different microbes in selective media.
5. Smear Preparation- from liquid and solid media
6. Pure Culture Techniques- streak plate method, pour plate method
7. Bacterial Population Counts- Quantitative plating method, Pipette Handling, Diluting and Plating Procedure
8. Identification of microorganisms from the habitats [simple staining, differential staining, acid fast staining, capsule staining, Gram staining, spore staining and motility]
9. Observation of morphology - shape and arrangement of cells.
10. Bacteria and its general properties
11. Bacteriology of air, soil and water
12. General properties of The Fungi: Yeasts and Molds
13. Study of yeast and mold
14. Motility determination- Soft agar deeps and Hanging drop method

COURSE INFORMATION SHEET

Course code: CH 102
Course title: Chemistry Lab
Pre-requisite(s): Intermediate level Chemistry
Co- requisite(s):
Credits: 1.5 L: 0T: 00P: 03
Class schedule per week: 03
Class: B. Tech.
Semester / Level: II/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand Quantitative and Gravimetric methods of analysis and their applications.
2.	1.To know FTIR and NMR, extraction process and analysis of compounds using FTIR and NMR
4.	To grasp the knowledge on the effect of a catalyst on the rate of reaction.
5.	To understand the fundamentals of identification and detection of special elements in organic compounds

Course Outcomes

After the completion of this course, students will be able to:

CO 1	Explain the FTIR and NMR and their applications.
CO 2	Able to handle the tools and equipments used in chemical analysis.
CO 3	Able to translate effects of catalysts on the rate of chemical reactions
CO 4	Able to assess the chemical quality of products by different techniques.
CO 5	Able to do Quantitative and qualitative analysis of samples for chemical compounds.

CH 102: Chemistry Lab Syllabus

2. Gravimetric estimation of Nickel by Dimethylglyoxime.
3. Quantitative estimation of Ca^{2+} and Mg^{2+} ions by complexometric titration using $\text{Na}_2\text{-EDTA}$.
4. To verify Beer's Law using Fe^{3+} solution by spectrophotometer/colorimeter and to determine the concentration of a given unknown Fe^{3+} solution.
5. Separation of binary organic mixture by acid-base extraction and analysis using given FTIR and NMR spectrum.
6. Preparation of Diazoamino Benzene and report the melting point and yield of product.
7. Draw melting point-mass percent composition diagram for two component mixture and determine the Eutectic Temperature.
8. To study the kinetics of acid-catalyzed hydrolysis of ethyl acetate and to evaluate the value of the rate constant.
9. To determine the rate law for the reaction between iodide and hydrogen peroxide in an acidic environment and to determine the effect of a catalyst on the rate of reaction.
10. To determine the strength of the given strong acid by strong base Potentiometrically.
11. To determine the transition temperature of the given salt hydrate.
12. Qualitative detection of special elements in organic compounds.
13. To draw the pH-titration curve of strong acid vs strong base.

Reference book:

1. Experimental Physical Chemistry, By B. Viswanathan, P. S. Raghavan, Narosa Publishing House (1997).
2. Vogel's Textbook of Practical Organic Chemistry
3. Experiments in General chemistry, by C. N. R. Rao and U. C. Agarwal
4. Experimental Organic Chemistry Vol 1 and 2 by P R Singh, D S Gupta, K S Bajpai,
5. Tata McGraw Hill

**EC 102: Electronics & Communication Lab
Syllabus**

List of Compulsory experiments:

1. Measurement of voltage, time period and frequency of different signals on CRO.
2. Measurement of frequency and phase of two different signals using Lissajous pattern.
3. To determine the forward and reverse bias characteristics of PN junction diode.
4. To determine the reverse bias characteristics of Zener diode and application as a voltage regulator.
5. Measurement of rectification efficiency and ripple factor of Half-wave and Full-wave rectifier Circuits with and without C-Filter.
6. To determine the frequency response of CE transistor amplifier and finding its gain bandwidth product.
7. To determine the transfer characteristics of JFET and measurement of its voltage gain.
8. Design of RC phase shift oscillator using IC-741 Op-Amp and finding its frequency of oscillation.

COURSE INFORMATION SHEET

Course Code: FT 201
Course title: Food Chemistry
Pre-requisite(s): CH 101 Chemistry
Co- requisite(s): FT206 Food Chemistry Laboratory
Credits: L: 04T:00P:00
Class schedule per week: 04
Class: IMSc
Semester / Level: III/02
Branch: Food Technology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To interpret chemical interactions and reactions of food components and their effect on sensory, nutritional, and functional properties of foods, and how processing influences these properties
2.	To identify the structure of food constituents and relate the structure to the constituents function and importance in foods with respect to food quality, nutrition, safety, processing, etc.
3.	To classify and compare the various food groups; the nutrient components (macro and micro), proximate composition.
4.	To explain how environmental factors such as temperature, pH, ionic characteristic and strength, bonding, light, etc. affect chemical changes in food systems and judge how to adjust these conditions to improve or minimize chemical and biochemical deterioration of food systems.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to develop the knowledge in the basic area of Food Chemistry
CO 2	Able to discover the functional role of food components and their interaction in food products in terms of colour, flavour, texture and nutrient composition
CO 3	Able to combine chemistry and biochemistry principles into real-world food science and nutritional problems
CO 4	Able to discover the functional application of major food components
CO 5	Able to predict the changes of food quality with respect to compositional change

SYLLABUS

Module I: (9L)

Introduction to different food groups and importance of food chemistry; Proximate composition of foods; Water: Definition of water in foods, physical properties of water and ice, structure of water and ice, interaction of water with solutes, sorption phenomenon, types of water; water activity, Methods to determine moisture content in food.

Module II: (9L)

Carbohydrate: Sources of food carbohydrates, definition, classification, structure of monosaccharides, disaccharides, oligosaccharides polysaccharides (starch, glycogen, cellulose, hemi-cellulose, lignins, pectins, gums and mucilages); Chemical reactions of carbohydrates; gelatinization and retrogradation of starch, Effect of processing and storage condition on carbohydrates: Modified starches; Role of carbohydrates in the food industry. Methods to determine carbohydrate content in food.

Module III: (9L)

Fats: Sources, definition, classification, structures, physical and chemical properties of lipids and fatty acids; Effect of processing and storage on fats and oils; PUFA, hydrogenation, polymerization, polymorphism and rancidity; Crude oils refining, hydrogenation and winterization, vegetable and animal fat, margarine, lard, butters, and shortening; Saponification number, iodine value, Reichert-Meissl number, Polenske value; Biological important lipid like cholesterol and phospholipids; Methods to determine fat content in food.

Module IV: (9L)

Proteins : Sources , primary & secondary structures, amino-acids - classification, essential and non-essential amino-acids, structures and properties; Peptides -peptide bonds and some important peptides; Purification and denaturation of proteins; Protein interaction and degradation, protein-lipid complexes and protein-carbohydrate complex; Major protein systems and factors affecting them; Modified protein, important food proteins; changes of proteins on processing and storage with special emphasis on enzymatic and non-enzymatic browning such as Maillard reactions and Strecker degradation; Methods to determine protein content in food

Module V: (9L)

Enzymes: specificity, simple and inhibition kinetics, coenzymes, enzymatic and non-enzymatic browning, enzymes in food processing, immobilization of enzymes, removal of toxicants through enzymes. Minerals and Vitamins: Sources and structures of minerals & vitamins; Effect of processing and storage of vitamins; Pro vitamins A & D; Vitamins as antioxidants. Pigments: carotenoids, chlorophylls, anthocyanins, tannins and myoglobin. Food flavours: terpenes, esters, aldehydes, ketones and quinines. Flavor and Aroma of foods - Taste, odor, feeling, blends, control of aroma in processed food.

Text books:

- 1.M.S. Swaminathan. Essentials of Food & Nutrition by, Vol. 1 & 2(T1)
- 2.L. H. Moyer Food Chemistry (T1)
- 3.S. Damodaran, K. Parkin, O. Fennema Eds. CRC Press. Fennema's Food Chemistry, 2007. 4th Edition.(T1)
- 4.J. deMan. Principles of Food Chemistry, 1999. 3rd Edition. Aspen Publishers, New York. (T1)

Reference books:

- 1.S. Ranganna. Hand Book of Analysis of fruits & vegetables (R1)
- 2.Linhinger, Food Chemistry (R2)
- 3.RS Kirk and R Sawyor. Composition and Analysis of Foods, (1991). Longman Scientific and Technical, UK(R3)

COURSE INFORMATION SHEET

Course code: FT 202
Course title: Introduction to Food Engineering
Pre-requisite(s):-
Co- requisite(s):-
Credits: L: 03T: 0 P: 00
Class schedule per week: 03
Class: IMSc
Semester / Level: III/02
Branch: Food Technology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To develop fundamental knowledge of chemical engineering for food applications
2.	To develop knowledge in dimensions, units, dimensionless ratios
3.	To interpret the principles of material and energy balance
4.	To relate the physico chemical properties of gases, liquids, solids
5.	To discover the basic of reaction kinetics and process control

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to understand basis of calculations pertaining to unit processes and unit operations.
CO 2	Able to perform material and energy balance for various food applications
CO 3	Able to develop knowledge in the physic-chemical properties of gases, liquids, solids
CO 4	Able to perform calculations pertaining to reaction kinetics in food application.
CO 5	Able to understand and apply the knowledge of process control in food industries

SYLLABUS

FT 202 Introduction to Food Engineering

Module I: (9L)

Units and Dimensions, Unit consistency and unit conversion, dimensional analysis, Buckingham Pi-theorem, Example of common non-dimensional parameters and their physical significance: Reynolds number, Froude number and Mach number; Concept of steady state, unsteady state, and equilibrium. Concept of system and surroundings, extensive and intensive properties, additive and non-additive properties, Graphical differentiation and graphical integration, Treatment and Interpretation of data, Error analysis in connection with computation.

Module II: (9L)

Introduction to Material Balance-Law of Conservation of Mass-total mass and component mass balance, General mass balance equation for batch, semi-batch and continuous process, Process Flow Diagrams, Material Balance problems without chemical reaction-problems involved in dilution, concentration, and dehydration, volume changes on mixing, Material Balance with chemical reaction, Material Balances with recycle, bypass and purge. Material Balance with Chemical Reaction, stoichiometry, conversion and yield of reaction.

Module III: (9L)

Ideal gas-law calculations, real-gas relationships-van der Waal's equation, Vapor pressure of liquids-Antoine's equation. vapour pressure of immiscible liquids, solutions and problems based on Raoult, Henry & Dalton's Law. Gibbs' Phase Rule, The Kinetic Theory of Gases, Absolute Temperature and Pressure, Mass and energy balance for open systems. Energy Balance for closed and open system, heat of formation, heat of vaporization, heat of fusion and sublimation, Standard heat of reaction, formation and combustion, numerical problems using Hess Law. Numerical problems using steam table.

Module IV: (9L)

Kinetics: Law of mass action, Rate of chemical reaction, Equilibrium rate constant, Le-Chatelier's principle, Effect of Temperature on Rate Constant, Arrhenius equation, Collision Theory, Transition State Theory, Order and Molecularity of a Chemical reaction, Elementary Reactions, First, Second and Third order reactions, Non Elementary Reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction, Half life method, Fractional order reactions.

Module V: (9L)

Elements of Process Control: Basic control structures, Feedback control, Feed-forward control, Comparative merits of control strategies, The block diagram, Input, output and process dynamics, First order response, Second order systems, Control modes (control algorithms), On-off (binary) control, Proportional (P) control, Integral (I) control, Proportional-integral (PI) control, Proportional-integral-differential (PID) control, Physical Elements of the Control System- sensors (Temperature, pressure, flowrate, composition, level, color, shape), controllers, and actuators, Automatic control, Computer-based systems-Programmable logic controllers (PLCs).

Text books:

1. Elements of Food Engineering by R.T. Toledo, (T1)
2. R. Paul Singh. Introduction to Food Engineering,, , Dennis R. Heldman, Academic Press, 2009.(T2)
3. Basic Principles and Calculations in Chemical Engineering: Himmelblau, 6th Ed. Prentice Hall (T3)

Reference books:

1. Chemical Process Principles by Hougen and Watson, (Part one): 2nd ed, John Wiley.(R1)

COURSE INFORMATION SHEET

Course code:FT 203

Course title: Food Microbiology

Pre-requisite(s):Microbiology

Co- requisite(s):

Credits: L: 04T: 00P:00

Class schedule per week:04

Class: IMSc

Semester / Level:III/02

Branch:Food Technology

Name of Teacher:

Course Objectives

This course enables the students:

1	To interpret the principles of Food Microbiology.
2.	To experiment with the microbes in relation to food spoilage, food-borne diseases and food preservation
3.	To interpret the role and significance of intrinsic and extrinsic factors on growth and response of microorganisms in foods.
4.	To identify ways to control microorganisms in foods.
5.	To infer the conditions under which the important pathogens and spoilage microorganisms are commonly inactivated, killed or made harmless in foods.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to develop knowledge in the basic area of Food Microbiology.
CO2	Able to explain to role of microbes in food spoilage, preservation of foods and food borne infections.
CO3	Able to predict the role of microbes in health and diseases
CO4	Able to analyze and explain the characteristics of important pathogens and spoilage microorganisms in foods.
CO5	Able to develop success skills in communication, critical thinking, interaction, information acquisition and interpretation, organization, professionalism, leadership, auto-didactics and life-long-learning.

SYLLABUS

Module I:

Food microbiology and its scope; History of microbiology of food; Types of microorganism normally associated with food: bacteria, fungi, yeast & mold; Characteristics of predominant microorganisms in Food: morphology of bacteria, yeast, mold and actinomycetes, spores and vegetative cells, gram-staining; Sources of microorganisms in food: Plants, Animals, Air, soil, sewage, waters, humans, food ingredient, equipment; Intrinsic and extrinsic factors on growth and response of microorganisms in foods, Microbial control, Importance of microorganism in food industry. (9L)

Module II:

Microbial growth: growth and death kinetics; Inactivation conditions for food borne pathogens and spoilage microorganisms; Thermal Process Calculations: Processes and systems for stabilization of foods for shelf-stable storage-Microbiological inactivation rates at constant temperature, effect of temperature on thermal inactivation of microorganisms, determination & importance of TDT, F, Z & D values, inactivation of microorganisms and enzymes in continuously flowing fluids; Sterilizing value of processes expressed as F₀, thermal process calculations for canned foods, broken heating curves, quality factor degradation; Factors affecting heat resistance; Pasteurization and sterilization. (9L)

Module III:

Microbiology of milk & milk products like cheese, butter, ice-cream, milk powder; Fermented milk and milk products: curd, yoghurt, cheese; Microbiology of meat, fish, poultry & egg and their products; Fermented meat, fish, and poultry products; Microbiology of fruits & vegetable and products like jam, jelly, sauce, juice; Microbiology of cereal and cereal products like bread, biscuits, confectionary; Fermented fruit, vegetable and cereal products pickles, soya-sauce, sauerkraut, idli, dosa, vinegar, alcoholic beverages. (9L)

Module IV:

Food Contamination and Spoilage Food microbiology and public health - Food poisoning, food poisonings due to pathogens, important features - A brief account of various organisms related with food poisoning; Food Borne diseases: Toxins from microbes: pathogens and non-pathogens including Staphylococcus, Salmonella, Shigella, Escherichia, Bacillus, Clostridium, and Aspergillus genera; Beneficial roles of microorganisms: Introduction to prebiotics and probiotics. (9L)

Module V:

Fermented fish; Fermented meats; Fermented beverages: Beer, Vinegar and Wine; Production of baker's yeast, food yeast, Single cell protein, bread, beer, wine, cider, vinegar, organic acids (eg. Citric, lactic, Acetic acids, Fumaric and Gluconic acid) and enzymes (eg. Amylases, protease, lipases, pectinases, celluloses, hemicellulose etc.). IMFL/ distilled spirits (eg. Rum, gin, whisky). Mushroom cultivation. (9L)

Text books:

1. Essentials of Microbiology by K. S. Bilgrami; CBS Publishers, Delhi (T1)
2. Food Microbiology by WC Frazier; Tata McGraw Hill, Delhi(T2)
3. Modern Food Microbiology by James M Jay; CBS Publishers, Delhi(T3)
4. Food Microbiology by M. R. Adams (T4)

Reference books:

1. Fundamental Food Microbiology by Bibek Ray, Arun Bhunia, Fifth Edition (R1)

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments

COURSE INFORMATION SHEET

Course code: FT 204
Course title: Basics of Food Processing & Preservation
Pre-requisite(s): BE203 Microbiology
Co- requisite(s): FT 203 Food Microbiology, FT 207 Food Preservation Lab.
Credits:4 L:04 T:00 P:00
Class schedule per week: 04
Class: IMSc
Semester / Level: III/02
Branch: Food Technology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To develop knowledge of preserving food to prevent wastages and losses
2.	To make use of information on the scientific mechanism of food preservation
3.	To build practical knowledge to various methods of food processing.
4.	To apply variety in the diet by providing a range of attractive flavors, colors, aromas and textures in food (collectively known as eating quality, sensory characteristics or organoleptic quality)

Course Outcomes

After the completion of this course, students will be:

CO1	Able to justify with the need for processing food
CO2	Able to discover the various processing techniques;
CO3	Able to understand the various methods by which foods could be preserved
CO4	Able to discuss on the methods to extend the shelf life to allow time for distribution, sales and home storage.
CO5	Able to measure the shelf life of the food

SYLLABUS
FT 204 Basics of Food Processing & Preservation

Module I: (9L)

Introduction to food processing: Basic principles, importance of food processing and preservation, classification of foods, types of food spoilage, viz. microbiological, enzymatic, chemical and physical spoilages and their effects on food quality; Objectives and techniques of preservation by using high temperature, using low temperature, using chemicals, and removing moisture.

Module II: (9L)

Water activity (aw) in foods: Role of water activity in food preservation, control of aw by addition of solutes and moisture removal, moisture sorption isotherm, measurements of water activity, intermediate moisture food (IMF); Processing by Moisture Removal: Evaporation, Concentration and Dehydration, Drying operation, Drying of solid and liquid foods, Types of dryers, their advantages and disadvantages, Concentration of liquid food by evaporators, Continuous, Multiple effect, Falling and rising film evaporators, Principles of freeze concentration, Membrane processes for liquid food concentration.

Module III: (9L)

High temperature processing: Principles of thermal processing, Blanching, Pasteurization and Sterilization, microbial destruction in batch and continuous sterilization, methods of heat transfer, heat resistance of micro-organisms, factors affecting heat resistance of micro-organisms, TDT curve, canning of foods, categories of foods for canning, heat penetration into food containers, calculating the process time for canned food, UHT processing, Microwave and radio frequency processing of foods.

Module IV: (9L)

Low temperature processing: refrigeration, chilling and freezing of food, freezing principles, low and fast freezing, freezing process, determining freezing load, ammonia refrigeration systems, freezing rate, estimation of freezing time of foods, Types of freezers, thawing of frozen food; Freezing damage-osmotic damage, Refrigeration, Food preservation by packaging: role, function and impact assessment, shelf life of packaged foods: factors affecting product quality and shelf life. Controlled Atmosphere Storage (CAS), Modified Atmosphere Storage (MAS).

Module V: (9L)

Food Preservation by Irradiation: Introduction, units of radiation, kinds of ionizing radiations used in food irradiation, mechanism of action, uses of radiation processing in food industry, concept of cold sterilization. Food preservation by sulphating, smoking, and pickling; Food Preservation by Fermentation - Principles, Types of fermentation, Advantages Food Preservation by Chemicals: Use of preservative in foods: Class I and Class II preservative, Chemical Food Preservatives & their acceptable daily intake, bio preservatives.

Text books:

1. Food Science by Norman, N.P. and Joseph, H.H. (1997).. Fifth edition, CBS Publication, New Delhi. (T1)
2. Food Microbiology by Frazier, W.C. and Westhoff, D.C. (1996). 4th edn, Tata McGraw Hill Pvt. Ltd., New Delhi. (T2)
3. Food Processing Technology by Fellows, P.J. (2002).: Principles and Practice, 2nd edn, Woohed Pub. Ltd. (T3)
4. Principles of Food Science, Part II, Physical Principles of Food Preservation by Marcel Dekker, Inc. (T4)

- 5.M. Shafeiur Rahman (1999). Handbook of Food Preservation, Marcel Dekker, Inc. **(T5)**
- 6.Vickie A. Valdavik and Elizabeth, W. Christian (2003). Essentials of Food Science. Springers. **(T6)**

Reference books:

- 1.Food storage and preservation by Vijayakhader**(R1)**
- 2.Food science by B. Srilakshmi**(R2)**
- 3.Food preservation by Desrosier**(R3)**
- 4.Physical principles of food preservation Fennema**(R4)**
- 5.Fruit & vegetables preservation and practice by K. Sanjeev & Srivastava R.P**(R5)**

COURSE INFORMATION SHEET

Course code: FT 205
Course title: Introduction to Agricultural Practice
Pre-requisite:
Co- requisite(s):
Credits: 4 L:4T:00P:00
Class schedule per week: 04
Class: IMSc
Semester / Level: IV/02
Branch: Food Technology

Course Objectives

This course enables the students:

1.	To develop knowledge of physical, chemical and biological properties of different types of soils
2.	To provide information on the agricultural problems, scientific and technological methods for stabilizing agriculture production
3.	To build practical knowledge of crops, cropping patterns for different agro-climatic zones of the country.
4.	To develop knowledge of technologies for the cultivation of Seed crops and processing of Seed

Course Outcomes

After the completion of this course, students will be:

CO1	Able to justify the soils and soil conditions needed for agricultural production
CO2	Able to discover the scientific and technological methods for cultivation of various useful crops
CO3	Able to discuss on the crops, cropping patterns and their importance in agriculture
CO4	Able to evaluate the package of practices for production of important cereals, pulses, oil seeds, fibres, sugar, commercial and fodder crops
CO5	Able to understand the use of techniques by which agricultural production can be increased

SYLLABUS

FT 205 Introduction to Agricultural Practices

Module I: (9L)

Soil - physical, chemical and biological properties. Processes and factors of soil formation. Soils of India. Ecology and its relevance to agriculture, natural resources, their sustainable management and conservation. Physical and social environment as factors of crop distribution and production. cropping pattern. Environmental pollution and associated hazards to crops, animals and humans. Climate changes, Green house effect and global warming. Advance tools for ecosystem analysis.

Module II: (9L)

Principles of soil fertility, soil testing and fertilizer recommendations, integrated nutrient management. Bio-fertilizers. Soil conservation, integrated watershed management. Soil erosion and its management. Dry land agriculture and its problems. Technology for stabilizing agriculture production in rain fed areas.

Module III: (9L)

Water - use efficiency in relation to crop production, criteria for scheduling irrigations, ways and means of reducing run-off losses of irrigation water. Rain water harvesting. Drip and sprinkler irrigation. Drainage of waterlogged soils, quality of irrigation water, effect of industrial effluents on soil and water pollution. Irrigation projects in India.

Module IV: (9L)

Cropping patterns in different agro-climatic zones of the country. Impact of high yielding and short-duration varieties on shifts in cropping patterns. Concepts of various cropping and farming systems. Organic and Precision farming. Package of practices for production of important cereals, pulses, oil seeds, fibres, sugar, commercial and fodder crops. Agro forestry and value addition.

Module V: (9L)

Seeds: Seed production and processing technologies. Seed certification, seed testing and storage. DNA fingerprinting and seed registration. Role of public and private sectors in seed production and marketing. Intellectual Property Rights (IPR) issues, WTO issues and its impact on Agriculture. Weeds, their characteristics, dissemination and association with various crops; their multiplications; cultural, biological, and chemical control of weeds.

Books:

Handbook of Postharvest Technology edited by Amalendu Chakraverty Arun S. Mujumdar
G. S. Vijaya Raghavan Hosahalli S. Ramaswamy.CRC Press.

COURSE INFORMATION SHEET

Course code: FT 206
Course title: Food Chemistry Laboratory
Pre-requisite(s):-
Co- requisite(s): FT 201 Food Chemistry
Credits:2 L: 00T: 00P: 04
Class schedule per week: 04
Class: IMSc
Semester / Level: III/02
Branch: Food Technology

Course Objectives

This course enables the students:

1.	Recognize the important reactions in food chemistry and their consequences.
2.	Be familiar with methods to measure these reactions.
3.	Be capable of reporting their results in an appropriate format.
4.	Be capable of designing and conducting an experiment to understand a simple food chemistry problem.

Course Outcomes

After the completion of this course, students will be:

CO1	Conduct appropriate laboratory experiments common to basic and applied food chemistry and interpret the results.
CO2	Work cooperatively in a team to identify a food chemistry problem, design and conduct the experiments, and analyze and interpret the data.
CO3	Clearly communicate research results using appropriate written, oral, and visual communication techniques.
CO4	Conduct appropriate laboratory experiments common to basic and applied food chemistry and interpret the results.
CO5	Work cooperatively in a team to identify a food chemistry problem, design and conduct the experiments, and analyze and interpret the data.

List of experiments

1. Carbohydrate – test for starch and reducing sugar
2. Maillard Browning Reaction – To evaluate the aroma and color of heated amino acid- glucose solutions
3. Ester as Food Flavorings
4. Qualitative analysis of proteins and demonstration of color reactions of proteins
5. Quantitative test for protein by Biuret Test
6. Protein Denaturation: Milk
7. Effect of pH and temperature on pigments
8. Determination of Saponification Value
9. Dietary fibres – solubility and gelling characteristics as function of temperature and pH
10. Determination of effect of temperature and antioxidation rancidity of lipids by calculating Peroxide Value
11. Estimation of ash content of food (total ash, acid soluble, insoluble ash)
12. Determination of calorific value of food sample
13. Maillard Browning Reaction
14. Structure and properties of proteins-primary structure of proteins (chromatographic method).
15. Ways of irreversible precipitation of protein from solutions. (protein denaturation)
16. Quantitative determination of ascorbic acid in various food-stuffs.

COURSE INFORMATION SHEET

Course code:	FT 207
Course title:	Food Preservation Laboratory
Pre-requisite(s):-	
Co- requisite(s):	FT 204 Basics of Food Processing and Preservation
Credits:2	L: 00T: 00P: 04
Class schedule per week:	04
Class:	IMSc
Semester / Level:	III/02
Branch:	Food Technology

Course Objectives

This course enables the students to:

1.	Demonstrate deep understanding and knowledge of principles of advanced food processing technologies
2.	Identify and critically analyse main advantages and disadvantages of emerging food processing technologies
3.	Compare and contrast conventional and emerging food processing technologies in real-life food processing
4.	Apply selected novel processing technologies to preserve and improve microbiological, nutritional or functional characteristics of foods

Course Outcomes

After the completion of this course, students will be:

CO1	To gain proficiency in the use of computers (i.e., spreadsheets) to solve food science problems
CO2	To apply critical thinking skills to new food processing situations

List of experiments

- 1.Preservation of liquid food by thermal processing & microbial survivor curve
- 2.Preservation by Fluidized bed Drying, microwave and Tray drying
- 3.Preservation of Drying: Spray drying & Freeze Drying.
- 4.Rehydration kinetics of dried products-comparison of methods of drying
- 5.Effect of blanching on frozen vegetable quality
- 6.Pasteurization of milk
- 7.Preservation by curing & pickling : Indian pickle preparation and quality control
- 8.Preservation by Osmo Drying
- 9.Preservation by canning
- 10.Preparation of fruit candy
- 11.Preservation by Retort processing
- 12.Preservation by intermediate moisture food (IMF) preparation
- 13.Preservation by natural and chemical preservative
- 14.Determination of Water Activity

COURSE INFORMATION SHEET

Course code: FT 208
Course title: Food Microbiology Laboratory

Pre-requisite(s):-

Co- requisite(s): FT 203 Food Microbiology
Credits: 2 L: 00T: 00P: 04
Class schedule per week: 04
Class: IMSc
Semester / Level: III/02
Branch: Food Technology

Course Objectives

This course enables the students:

1.	Recognize and describe the characteristics of important pathogens and spoilage microorganisms in foods.
2.	Understand the role and significance of intrinsic and extrinsic factors on growth and response of microorganisms in foods.
3.	Describe the beneficial role of microorganisms in fermented foods and in food processing.
4.	Utilize laboratory techniques to detect, quantify, and identify microorganisms in foods.
5.	Acquire, discover, and apply the theories and principles of food microbiology in practical, real-world situations and problems.

Course Outcomes

After the completion of this course, students will be:

CO1	Understand the principles of microorganisms during various food-processing and preservation steps.
CO2	Isolation, identification, and enumeration of the most common microorganisms found in specific food products
CO3	Recognize specific types of microbial spoilage during various food shelf life stages.
CO4	Analyze different foods for presence of hazardous microorganisms using traditional and modern food microbiology technology
CO5	Describe the situations where improper food handling and storage may lead to the spoilage or contamination of food.
CO6	Identify desirable microorganisms and their effects in preservation and fermentation.
CO7	Identify desirable microorganisms and their effects in preservation and fermentation

List of experiments

1. Food Microbiology Laboratory Safety and Notebook Record
2. Staining Technology and Bright-Field Microscope Use
3. Enumeration of Bacteria in Broth Suspension by Spread and Pour Plating
4. Isolation of Foodborne Pathogens on Selective, Differential, and Enriched Medium by Streak Plating
5. Enumeration of Aerobic Plate Counts, Coliforms, and *Escherichia coli* of Organic Fruit Juice on Petrifilm
6. Enumeration and Identification of *Staphylococcus aureus* in Chicken Salads
7. Enumeration and Identification of *Listeria monocytogenes* on Ready-to-Eat (RTE) food
8. Isolation and Identification of *Salmonella* and *Campylobacter* spp. on Broiler Carcasses
9. Isolation and Identification of *Salmonella* and *Campylobacter* spp. on Broiler Carcasses
10. Cultivation of Anaerobic Bacteria in Canned Food
11. Observation and Enumeration of Molds from Spoiled Bread
12. Environmental Influences and Control of Microbial Growth
 - Temperature: Effects on Growth and Lethal Effects
 - pH and Microbial Growth
 - Osmotic Pressure and Bacterial Growth
 - Oligodynamic Action
13. Ultraviolet Light Lethal Effects
14. Evaluation of Disinfectants and antimicrobial action
 - The Use-Dilution Method
 - Alcohol Its Effectiveness as a Skin Degerming Agent
 - Evaluation of Antiseptics: The Filter Paper Disk Method
15. Antimicrobial Sensitivity Testing: The Kirby-Bauer Method

COURSE INFORMATION SHEET

Course code:	FT 209
Course title:	Food Analysis
Pre-requisite(s):	FT 201 Food Chemistry & FT203 Food Microbiology
Co- requisite(s):	FT Food Analysis Lab I
Credits: 4	L:04T:00P:00
Class schedule per week:	04
Class:	IMSc
Semester / Level:	IV/02
Branch:	Food Technology
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To build knowledge of prepare samples of various foods products prior to analysis.
2.	To identify the various principles used to determine moisture, carbohydrate, lipid, proteins, ash, mineral, and vitamin content of a food
3.	To develop knowledge on the different modern analytical techniques and associated instruments required for the test.
	To familiarize with the conventional analysis of raw and processed food products of all commodity technologies used for routine quality control in food industry, and their role on nutritional labelling

Course Outcomes

After the completion of this course, students will be:

CO1	Able to explain the reasons for determining composition and characteristics of food
CO2	Able to evaluate the role of food analysis in food standards and regulations for the manufacture and sale of food products
CO3	Able to develop oral and written communication skills to effectively communicate scientific ideas related with food analysis
CO4	To build an ability to assess the most appropriate analytical procedure required for a particular food analysis problem
CO5	To perceive knowledge on the different modern analytical techniques and associated instruments required for the test.

SYLLABUS

FT 209 Food Analysis

Module I: (Lectures 5)

Evaluation of analytical data accuracy, precision, source of errors, specificity, sensitivity. Sampling techniques; Water activity, its measurements and significance in food quality; Calibration and standardization of different instruments.

Module II: (Lectures 10)

Spectroscopic techniques using UV/Vis, fluorescence, IR, FTIR, NIR, NMR, atomic absorption, ICP, polarimetry, refractometry, microscopic techniques in food analysis (light microscopy, SEM, TEM, XRD, particle size analysis, image analysis etc.).

Module III: (Lectures 10)

Chromatographic techniques: Adsorption, column, partition, affinity, ion exchange, size exclusion, GC, GLC, HPLC, HPTLC, GCMS, LCMS.

Module IV: (Lectures 5)

Separation techniques: Gel filtration, dialysis, electrophoresis, sedimentation, ultrafiltration and ultracentrifugation, solid phase extraction, supercritical fluid extraction, isoelectric focusing, isotopic techniques, manometric techniques.

Module V: (Lectures 10)

Special techniques: Immunoassay techniques; Isotopic, non-isotopic and enzyme immunoassays; surface tension; enzymatic methods of food analysis; thermal methods in food analysis (Differential scanning calorimetry, TGA, Analysis of Vitamins, Enzymes, Pigments, Flavours, Pesticides).

Suggested Readings

1. AOAC International. 2003. Official methods of analysis of AOAC International. 17th Ed, Gaithersburg, MD, USA, Association of Analytical Communities.
2. Nielsen S. (Eds.). 1994. Introduction to Chemical Analysis of Foods. Jones & Bartlett.
3. Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill.

COURSE INFORMATION SHEET

Course code:	FT 210
Course title:	Food Biochemistry and Human nutrition
Pre-requisite(s):	FT201 Food Chemistry
Co- requisite(s):	
Credits: 4	L:04 T:00 P:00
Class schedule per week:04	
Class:	IMSc
Semester / Level:	IV/02
Branch:	Food Technology
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To develop knowledge in different aspects of nutrition and the functions of food
2.	To analyze the relationship between food and the nutrients as well as function and contribution of nutrients to health of individuals
3.	To develop the physiological and metabolic functions of nutrients
4.	To discover the methods of nutritional assessment, RDA and Dietary Recommendations & Guidelines.
5.	To interpret the food classification, nutrition during special conditions and role of special functional food

Course Outcomes

After the completion of this course, students will be:

CO1	Able to judge physiological and metabolic functions of nutrients
CO2	Able to evaluate with nutritional assessment, RDA and Dietary Recommendations & Guidelines.
CO3	Able to develop effective understanding of diet planning principles, exchange lists, food labels and nutrition facts for balanced nutrition and healthy diets.
CO4	Able to combine and use effectively, diet planning principles, exchange lists, food labels and nutrition facts for balanced nutrition and healthy diets.
CO5	Able to analyze functions of specific nutrients in maintaining health, identifying nutrient specific foods and apply principles from the various facets of food science and related disciplines to solve practical as well as real-world problems

SYLLABUS
FT 210 Food Biochemistry and Human nutrition

Module I: (9L)

Definition, six classes of nutrients, energy values calculation from food; RDA, nutritional status, nutritional requirement, malnutrition, nutritional assessment of individuals and populations, dietary recommendations; research methods in nutrition; Balanced diet; Healthy Diet: Diet planning principles, dietary guidelines; diet planning guides such as food groups, exchange lists, personal diet analysis; Food labels: serving sizes, nutrition facts, daily values, descriptive terms, health claims; Digestion, Absorption and Transport: Anatomy and physiology of the digestive tract, mechanical and chemical digestion, absorption of nutrients.

Module II: (9L)

Digestion and absorption of carbohydrates, lactose intolerance; Glycemic and Non-glycemic carbohydrates, blood glucose regulation, recommendations of sugar intake for health, health effects of fiber and starch intake, artificial sweeteners; Nutrition and Diabetes: Complications of diabetes mellitus, importance of blood sugar regulation, dietary recommendations for NIDDM and IDDM; Prebiotics.

Module III: (9L)

Food Sources, Lipid digestion, absorption and transport; Functions of the triglycerides; essential fatty acids- n-3 and n-6 fatty acids; trans fatty acids, Medium Chain Triglycerides, phospholipids and sterols; Health effects and recommended intakes of lipids. Digestion and absorption of proteins; Functions of proteins; amino acids; Protein quality, methods of assessing protein quality; Recommended intakes of proteins; protein and amino acid supplements; Protein Energy Malnutrition, Marasmus and Kwashiorkor; Chronic Energy; Deficiency- short term and long term effects.

Module IV: (9L)

Review of catabolic and anabolic pathways of glucose, fats and amino acids; Definition, units, calorific value of foods – bomb calorimeter; energy requirements – basal metabolism, specific dynamic action of foods, energy balance, direct and indirect calorimetry, physiological energy value of foods; Energy Balance and Body Composition: Energy balance; body weight and body composition; health implications; obesity, BMR and BMI calculations; Weight Control: Fat cell development; hunger, satiety and satiation; dangers of weight loss; how to identify unsafe weight loss schemes; treatment of obesity; attitudes and behaviors toward weight control.

Module V: (9L)

Water Soluble Vitamins: B vitamins (Thiamine, Riboflavin, Niacin, Pyridoxine, Biotin, folate B12, choline, pantothenic acid, and carnitine) and in concert, deficiencies, toxicities, and food sources; vitamin C roles and recommended intake, deficiency, toxicity and food sources. Fat Soluble Vitamins: A, D, E, and K: Function, recommended intakes, toxicities, Food sources; Water and Major Minerals: Water balance and recommended intakes; fluid/electrolyte balance, acid-base balance; function, recommended intakes, and regulation of sodium, potassium, and calcium. Trace Minerals: Food sources, function, recommended intakes, toxicities, deficiencies and transport of iron and zinc; importance of selenium, copper, fluoride, and chromium. co-factors, anti-nutrients, nutraceuticals, Beneficiary microbes and their metabolism for improving health

Text books:

1. Essentials of Human Nutrition by Mann, Jim and Stewart Truswell “3rd Edition. Oxford University Press, 2007.(T1)
2. Introduction to Human Nutrition by Gibney, Michael J., et al 2nd Edition. Blackwell, 2009.(T2)

3. Advanced Nutrition and Human Metabolism, Gropper, Sareen S. and Jack L. Smith 5th Edition. Wadsworth Publishing, 2008. **(T3)**

Reference books:

1. Food Science by Charley, H, "John Wiley and Sons Inc., New York 1982. **(R1)**
2. The Sensory Properties of Foods by Birch, G.G., Brennan, J. G. and Parker, K. J, "Applied Science Publication, London 1977. **(R2)**
3. Food – Biochemistry and Nutritional Value by Robinson, D. S, Longman Scientific and Technical, London 1987. **(R3)**

COURSE INFORMATION SHEET

Course code:	FT-211
Course title:	Fruits and Vegetable Processing Technology
Pre-requisite(s):	FT 204 Basics of Food Processing & Preservation
Co- requisite(s):	FT 213 Fruits and Vegetable Processing Laboratory
Credits:	L:04T:00P:00
Class schedule per week:	04
Class:	IMSc
Semester / Level:	IV/2
Branch:	Food Technology
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To develop the knowledge of students in the area of vegetable and fruit processing and technology
2.	To interpret the specific processing technologies used for vegetables and fruits and the various products derived from these materials
3.	To apply the application of scientific principles in the processing technologies specific to the materials

Course Outcomes

After the completion of this course, students will be:

CO1	Able to develop thorough knowledge of the specific processing technologies used for vegetables and fruits and the various products derived from these materials.
CO2	Able to adapt better understand of the application of scientific principles in the processing technologies specific to the materials
CO3	Able to understand the changes in the composition of foods with respect to the type of processing technology used.
CO4	To propose the application of scientific principles in the processing technologies specific to the materials
CO5	To Explainthe changes in the composition of foods with respect to the type of processing technology used.

SYLLABUS

FT-211 Fruits and Vegetable Processing Technology

Module I: (9L)

Difference in between fruits and vegetable; availability of Fruits and vegetables in India, season of maturity; Climatic and non climatic fruits, ripening process, phytonutrients in fruits and vegetables; General properties of fruit and vegetables; chemical composition and nutritional aspects; structural features. Importance of fruits & vegetables in the diet.

Module II:(9L)

Fruits and vegetables as living products, Deterioration factors and their control- enzymic changes, chemical changes, physical changes, biological changes during ripening process; Methods of reducing deterioration (Physical, chemical, biological and combined technique), Post harvest handling and storage of fresh fruits and vegetables-handling, grading, cleaning, pre-treatments, modified and controlled atmosphere packaging, chilling, transportation.

Module III(9L)

Fruits and vegetable preservation by low temperature; General pre-processing, Types of cold preservation; Types of freezers and freeze concentrators, processes and impacts of cooling methods below and above freezing point. Processing methods of frozen fruits and vegetables, different freezing methods and equipments, problems associated with specific fruits and vegetables IQF products, packaging, storage and thawing.

Module IV (9L)

Fruits and vegetable preservation by high temperature: extraction, clarification, concentration and packaging of fruit juice; Thermal processing and process time evaluation for canned products, process optimization, aseptic canning, methods for canning of different fruits, and vegetables; Dehydration and associated quality changes during drying and storage of dehydrated products. Methods of drying including sun, tray, spray drying and low temperature, osmotic dehydration and other modern methods. Application of membrane technology in fruits juice processing.

Module V (9L)

Jam, jelly, marmalade, squash, candies, tomato sauce, ketchup, puree, paste and sauce, potato chips; Chemistry and manufacture of pectin, role in gel formation and products like jellies and marmalades. Technology of pickles, chutney's and soup, nature and control of spoilage. Preparation and utilization of fruits and vegetables juices in non-fermented/ fermented/ aerated beverages, health drinks. Utilization of by-products of fruits and vegetable Industry. Fermented fruits and vegetable product (wine, pickles, soya-sauce, sauerkraut etc.)

Text books:

- 1.Fruit and vegetable processing by Mircea EnachescuDauthy Consultant FAO Agricultural services bulletin No.119 Food and Agriculture Organization of the United Nations Rome, 1995
- 2.Preservation of Fruits & Vegetables by Girdhari Lal, Sidhapa and Tandon

Reference books:

- 1.Fruit and Vegetable Preservation by Srivastava and Sanjeev Kumar
- 2.Food Science by Mudambi
- 3.L. Somogyi, D.M. Barette and Y.H. Hui, Processing Fruits:Science and Technology, Vol II:
- 4.Major Processed Products,Woodhead Publishing, 1996.
- 5.Y. H. Hui, S. Ghazala, D.M. Graham, K.D. Murrell and W.K.Nip,Handbook of Vegetable
- 6.Preservation and Processing, MarcelDekker,2003

Course Delivery Methods

COURSE INFORMATION SHEET

Course code: FT 212
Course title: Fluid Mechanics and Mechanical Operations
Pre-requisite(s): FT 202 Introduction to Food Engineering
Co- requisite(s):-
Credits: L:03T:01P:00
Class schedule per week: 04
Class: IMSc
Semester / Level: IV/02
Branch: Food Technology
Name of Teacher:
Course Objectives

This course enables the students:

1.	To understand the principles and applications of fluid mechanics
2.	To review the practical importance and relevance of unit operations used for crushing, grinding and size separation in Food industry.
3.	To develop the concepts of size reduction, conveying and mixing criteria of food materials.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to make use of knowledge of basic principles of fluid mechanics
CO 2	Able to apply the knowledge of fluid mechanics in various fluid flow problems
CO 3	Able to explain solid–fluid separation techniques
CO4	Able to explain process of food materials handling, size reduction and transportation.
CO 5	Able to explain mixing and extrusion processes involved in food processing

SYLLABUS

FT 212 Fluid Mechanics and Mechanical Operations

Module I:(9L)

Fluid Properties -viscosity, Newton's law of viscosity, Continuity equation, Reynolds number, Laminar and turbulent flow, Entrance region and fully developed flow, flow through circular pipe, Friction factor, Bernoulli equation, frictional energy loss, Flow characteristics of Non-Newtonian Fluids. Viscosity measurement :Capillary tube viscometer, Rotational viscometer.

Module II:(9L)

Pump theory, Centrifugal and Positive displacement pumps, pump selection & performance evaluation. Flow measurements: Manometers, Pitot tube, orifice meter, venturi meter, Rotameter etc. Agitated and mixing of liquids: Types of impellor, Power Requirement

Module III:(9L)

Flow past immersed objects, Motion of particles through fluids, Stokes law, Fluidization, Gravity decanter, Gravity and Centrifugal settling, Separation and concentration of food components: Filtration, Expression, Membrane concentration (microfiltration and ultrafiltration).

Module IV:(9L)

Raw material preparation: Cleaning, Sorting, Grading, Peeling; Particle size analysis; Size Reduction of solid foods: Theory, equipment, Effect on foods; Size reduction in liquid foods (emulsification and homogenisation): Theory, equipment, effect on foods. Materials storage and handling equipment for raw materials, ingredients and processing- Silos, belt, screw, vibrated conveyors etc. Elevator and hoists, fork lifts, Pneumatic and water flume transportation etc

Module V:(9L)

Mixing: Theory of mixing of solids and pastes, Mixing Index, Mixing equipment – masticator, kneader etc., effect on foods;

Basic Principles of Extrusion, Extrusion Systems- Cold extrusion, extrusion cooking, single screw extruders, twin-screw extruders, extrusion system design.

Text books:

1. R. Paul Singh. Introduction to Food Engineering,, , Dennis R. Heldman, Academic Press, 2009.(T1)
2. Elements of Food Engineering by R.T. Toledo, (T2)
3. Food Process Engineering and Technology, Zeki Berk), Academic Press.(T3)
4. Food Processing Technology, Principles and Practice, P. Fellows, CRC Press.(T4)

Reference:

1. Unit Operations In Food Engineering by Albert Ibarz and Gustavo V. Barbosa-Cánovas, CRC Press, 2003. (R1)
2. Unit Operations in Food Processing by R. L. Earle, 2nd Edition, Pergamon Press,Oxford,U.K, 2003. (R2)
3. Physical Properties of Foods &Foods Processing Systems by M. J. Lewis, EllisHorwood, England, 1987. (R3)
4. Unit Operations of Chemical Enggby McCabe and Smith (R4)

COURSE INFORMATION SHEET

Course code:	FT 213
Course title:	Fruits and Vegetables Laboratory
Pre-requisite:	
Co- requisite(s):	FT211 Fruits and Vegetable Processing Technology
Credits:	L:0T:00P:04
Class schedule per week:	02
Class:	IMSc
Semester / Level:	IV/02
Branch:	Food Technology

Course Objectives

This course enables the students:

1.	To train the students in the field of Fruit and Vegetable Processing
2.	.To make aware a student with knowledge of the basic post harvest biological, chemical, physiological and metabolic processes and changes in fruits and vegetables
3.	To enable the students learn different preservation techniques to curb post-harvest losses in the field of agriculture.
4.	To explain processing technology of jam, jelly and marmalades

Course Outcomes

After the completion of this course, students will be:

CO1	Understand the structure and composition of fruits and vegetables and their role in nutrition.
CO2	Apprehend different operations like cleaning, grading, peeling concentration and different aroma recovery systems etc involved in processing fruits and vegetables
CO3	Grasp the concept of quality in relation to fruit and vegetable based products.
CO4	Understand the processing and preservation techniques for fruits and vegetables to improve the shelf life.

List of experiments:

1.Introduction to fruits and vegetable processing

A: Study on Role of FSSAI

B: Food processing facilities in the Laboratory

C: Determination Benzoic acid

2.Preparation of (A) Sauerkraut (B) Pickled cucumber by (i) Brine process (ii) Fresh pack Process

3.Preparation and quality control of fruit (a)jelly& (b)marmalade

4.Studies on pre-treatment of fresh cut and vegetable

5.Preparation of fruit juice beverage

6.Preparation and quality control of Tomato ketchup

7.Preparation of nectar (Mango / guava/ Peach)

8.Preparation of Fruit bar (Mango)

9.Preparation of Tropical fruit jam (Pineapple, Guava, Papaya etc.)

10.Preparation of Orange marmalade

11.Preparation of Fruit in syrup (Pineapple/Peaches/ Guava halves and slices)

12.Preparation of Pickled chili peppers

13.Preparation of Tomato juice

14.Preparation of Tomato Juice/puree/ simple concentrate

15.Preparation of Dried tomatoes, Whole peeled tomatoes,/ bananas

COURSE INFORMATION SHEET

Course code:	FT 214
Course title:	Food Analysis Laboratory I
Pre-requisite:	
Co- requisite(s):	FT 209 Food Analysis
Credits: 2	L:00T:00P:04
Class schedule per week:	04
Class:	IMSc
Semester / Level:	IV/02
Branch:	Food Technology

Course Objectives:

This course enables the students will be able to :

1.	Be familiar with the current state of knowledge on food composition
2.	Understand the principles behind analytical techniques associated with food
3.	Know methods of selecting appropriate analytical techniques when presented with a practical problem
4.	Demonstrate practical proficiency and teamwork in a food analysis laboratory
5.	Use library and internet resources pertaining to food analysis

Course Outcomes

After the completion of this course, students will be able to:

CO1	Get acquainted with analytical methods used for quality control analysis of raw material and processed food commodities.
CO2	Conduct appropriate laboratory experiments common to basic and applied food analysis and interpret the results.
CO3	Work cooperatively in a team to identify a food Analysis problem, design and conduct the experiments, and analyze and interpret the data.
CO4	Clearly communicate research results using appropriate written, oral, and visual communication techniques.

List of Experiments

1. Determination of Calorific value of food
2. Determination of moisture by using conventional oven, Vacuum oven, IR moisture balance
3. Determination of Nitrogen content in food by Kjeldahl method
4. Determination of fat content by Solvent extraction
5. Determination of Ash and Crude Fibre
6. Determination of dietary Fibre.
7. Determination of unknown concentration by UV-Visible spectroscopy
8. Determination of Chemical Oxygen Demand of waste water
9. Determination of Biological Oxygen Demand of waste water
10. HPLC analysis of food sample

COURSE INFORMATION SHEET

Course code: FT 301
Course title: Cereals Pulses & Oilseed Technology
Pre-requisite(s): FT 204 Basics of Food Processing & Preservation
Co- requisite(s): -
Credits: 4 L:04T:00P:00
Class schedule per week: 04
Class: IMSc
Semester / Level: V/03
Branch: Food Technology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To interpret the importance of cereals as foods, and appreciate their nutritional value
2.	To develop the basic knowledge and principles of cereal science, the production processes and technologies for cereal products, and the quality, sanitary control and assurance for cereal processing.
3.	To list the various components of cereals and their approximate levels, their functional roles in the various cereal foods, and methods of analysis
4.	To utilize the application of scientific principles in the processing of cereal and cereal based product.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to identify the importance of cereals as foods, and appreciate their nutritional value.
CO 2	Able to discover the proper methods of wheat and grain handling and storage
CO 3	Able to categorize the botanical, physical, and chemical criteria of wheat quality, their methods of evaluation, roles in wheat grading and processing.
CO 4	Able to explain the dry milling processes of bread and durum types of wheat, and how flour grades are obtained.
CO 5	Able to describe how bread, biscuits, pasta, and breakfast cereals are produced, and identify the parameters involved in their quality evaluation

Syllabus
FT 301 Cereals Pulses & Oilseeds Technology

Module I (9L)

Status, major growing areas and production of cereals and millets in India and in the world; Structure and composition of different grains (wheat, rice, barley, oat, maize and millets); Anti-nutritional factors in grains and oilseeds; Milling, storage and insect control; Wheat–classification, grain quality and milling, Atta and maida, quality aspects of flour, wheat proteins and their function, rheology; Wheat flour/semolina and its use in traditional/non-traditional foods like breads, biscuits, cakes, doughnuts, buns, pasta goods, extruded, confectionary products, breakfast and snack foods; Preparation of vital wheat gluten and its utilization; Instant ready mixtures; Enzymes (amylases and proteases) in milling and baking.

Module II (9L)

Varieties of rice grown in India and other countries; Storage, Insect control; Processing: Rice - Milling, and sorting; Parboiling, Polishing; Quick cooking rice, factors affecting quality of rice, Traditional Indian Products- Puffed Rice, flaked rice, Rheology rice flour; By-products of rice milling and their utilization; Processed products from rice; Bran, germ and novel products from wheat / rice.

Module III (9L)

Barley: Pearling, malting, brewing and preparation of malted milk feeds from barley. Significance of β - glucans. Corn - Wet and dry milling, Corn Products – Corn flakes, , corn syrup (HFCS); Corn starch, canned corn products, corn steep liquor and germ oil, puffed product; Oats- Milling, Oat Products – Steel cut, rolled oats, quick cooking; Processing into oat flakes, porridge and oatmeal; Rye bread-Traditional cereal products; Sorghum, Pearl Millet, Finger millet, Foxtail millet, Kodo Millet - storage, insect control; processing - Pearling, Milling, Malting, Malt based foods, flaked and fermented products; Traditional and Nutritional products based on finger millet.

Module IV (9L)

Pulses: Structure and composition of pulses and their importance in Indian diet; Milling and processing of pulses.. Use in traditional products, protein concentrates and isolates. Oilseeds: edible oilseeds, composition and importance in India; Oilseed processing; Oil extraction and its processing, byproducts of oil refining. Production, packaging and storage of vanaspati, peanut butter, protein concentrates, isolates and their use in high protein foods. Export of oilseed cakes. International market and consumer preferences for quality in cakes for use in textured vegetable proteins; Modified starches and proteins.

Module V (9L)

Dairy analogues based on plant milk. Spices Processing: Oleoresin and essential oil extraction; Baked foods - chemical dough development, mechanical dough development, sheeting extrusion other rapid methods; Bread staling – theory, manifestation, retardation measures; Indian Confectionery. Extrusion processes for foods- principles of extrusion, Extrusion systems – cold extrusion, extrusion cooking, single and twin screw extruders. Technology of Macaroni and pasta products, extrusion cooking. Fermented cereal and pulse based product (Beer, rice beer, Papads, wari, Idli, Dosa, Dhokla, soy sauce etc.) ; Idli/Dosa/vada mixes and other instant products.

Text books:

1. Post Harvest Technology Of Cereals, pulses And Oilseeds by Chakraverty A. 3rd Ed. 2008. (T1)
2. The Chemistry and Technology of Cereals as Food and Feed by Matz, Samuel A. 2nd Edition, CBS, 1996. (T2)
3. Principles of Cereal Science and Technology By Delcour, Jan A. and R. Carl Hosney. 3rd Edition. American Association of Cereal Chemists, 2010. (T3)
4. Handbook of Cereal Science and Technology by Kulp, Karel. 2nd Edition, CRC Press, 2000. (T4)

5.Cereal Biotechnology by Morris, Peter C. and James H Bryce CRC / Woodhead, 2000(**T5**)

Reference books:

1.Technology of Cereals by N.L.Kent. pergaman Press,1966(**R1**)

2.Food Facts and Principles by Mannay;New age International (P) Ltd.(**R2**)

3.Food Science by Norman N.Potter;CBS Publications.(**R3**)

4.Development in Milling & Baking Technology by AFST (I), CFDRI, Mysore, India.(**R4**)

COURSE INFORMATION SHEET

Course code: FT 302
Course title: Heat Transfer in Food Processing
Pre-requisite(s): FT 202 Introduction to Food Engineering
Co- requisite(s):
Credits: L:03T:0P:00
Class schedule per week: 03
Class: IMSc
Semester / Level: V/3
Branch: Food Technology
Name of Teacher:

1.	To interpret and apply the principles in heat transfer.
2.	To apply the knowledge of heat transfer in design calculation of heat transfer equipment.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to apply the knowledge of conduction heat transfer in steady and unsteady state
CO2	Able to explain the concepts of heat transfer by convection and radiation
CO3	Able to solve the design problems for various types of heat exchanger
CO4	Able to understand and apply concepts of heating process using radiation
CO5	Able to apply the basic concepts of evaporation, condensation, steam generation.

Syllabus

FT FT 302 Heat Transfer in Food Processing

Module I: (9L)

Introductory concepts, modes of heat transfer, thermal conductivity of materials. General differential equation of conduction, One dimensional steady state conduction through plane and composite walls, tubes and spheres without heat generation; Insulation materials, critical thickness of pipe insulation; Transient heat conduction, lumped capacity, Biot number, Fourier number; use of charts to determine time required for heating/cooling of solid food.

Module II: (9L)

Free and forced convection. Dimensional analysis of free and forced convection; Useful non-dimensional numbers and empirical relationships for free and forced convection; laminar boundary layer on flat plate and in a tube. Radiation: Absorptivity, reflectivity and transmissivity of radiation; Black body and monochromatic radiation, Planck's law, Stefan-Boltzmann law, Kirchoff's law, grey bodies and emissive power, solid angle, intensity of radiation; Radiation exchange between black surfaces, geometric configuration factor.

Module III: (9L)

Introduction to heat exchangers, types of heat exchangers in food processing industries – Double pipe, Triple pipe, Steam infusion, Plate, shell and tube Heat Exchange, estimation of overall heat transfer coefficient, fouling of heat transfer surfaces, Cocurrent and Counter current flow, Log mean temperature difference, Design of a tubular heat exchanger, the effectiveness-NTU method for designing heat exchangers, Design of a plate heat exchanger.

Module IV: (9L)

Unsteady state heat transfer in batch vessels– heating and cooling; Microwave, Radio frequency, Ohmic, and Infrared heating: Theory, Equipment, Applications, Effect on foods; Freezing: Theory, Time of Freezing, Plank's Equation, Renewable energy for food processing - solar energy, wind energy.

Module V: (9L)

Heat transfer to fluid with phase change: Film condensation and drop condensation, Heat transfer to boiling liquids, pool boiling, forced convection boiling. Evaporation: Boiling-Point elevation, Types of evaporators: Batch type pan evaporator, natural circulation evaporators, Rising film evaporator, Falling-film evaporator, Forced circulation evaporator, Agitated thin-film evaporator; Design of a single-effect and multiple effect evaporator, Steam generation systems, steam table, steam utilization, fuel utilization, Furnace and hot air oven.

Text books:

1. R. Paul Singh. Introduction to Food Engineering,, , Dennis R. Heldman, Academic Press, 2009.(T1)
2. Elements of Food Engineering by R.T. Toledo, (T2)
3. Food Process Engineering and Technology, **Zeki Berk**), **Academic Press**.(T3)
4. FOOD PROCESSING TECHNOLOGY, Principles and Practice, P. Fellows, CRC Press.(T4)

Reference:

1. Unit Operations In Food Engineering by Albert Ibarz and Gustavo V. Barbosa-Cánovas, CRC Press, 2003. (R1)
2. Unit Operations in Food Processing by R. L. Earle, 2nd Edition, Pergamon Press, Oxford, U.K, 2003. (R2)

3. Physical Properties of Foods & Foods Processing Systems by M. J. Lewis, Ellis Horwood, England, 1987. **(R3)**
4. Unit Operations of Chemical Engineering by McCabe and Smith **(R4)**
5. Unit operations in Agricultural processing by Sahay and Singh **(R5)**

COURSE INFORMATION SHEET

Course code:	FT 303
Course title:	Meat, Fish and Poultry Product Technology
Pre-requisite(s):	FT204 Basics of Food Processing & Preservation
Co- requisite(s):	
Credits:	L:04T:00P:00
Class schedule per week:	04
Class:	IMSc
Semester / Level:	V/03
Branch:	Food Technology
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To define the composition and structure of various meat, poultry, and seafood.
2.	To interpret and choose the specific processing technologies used for meat, fish & poultry
3.	To apply the scientific principles in the processing technologies specific to meat, fish & poultry relating to value addition and extension of shelf life
4.	To explain the specific processing technologies used for meat, fish & poultry and the various products derived from these materials

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to develop better understanding on composition and structure of Meat, Fish & Poultry products
CO 2	Able to explain different muscle structure related to physical and chemical properties.
CO 3	Able to utilize different processing methods to preserve and value add such product.
CO 4	Able to choose different processing machineries for preservation and value addition
CO 5	Identify, explain and demonstrate effective sanitation techniques for ensuring consumer safety.

Syllabus
FT 303 Meat Fish and Poultry Product Technology

Module I (9L)

Scope of meat, fish and poultry processing in India; Process flow sheet of meat, fish and poultry processing; Sources of meat and meat products in India, its importance in national economy; Chemistry and microscopic structure of meat tissue; Methods of grading meat; Ante mortem inspection- effect feed, breed, stress, and management on meat production and quality. Methods of stunning, slaughter and dressing of various animals, Poultry handling and dressing: inspection of birds, poultry slaughter and dressing, factors affecting quality of poultry; Methods of scalding, defeathering, evisceration, inspection and grading; Mechanical deboning, meat tenderization and associated equipments.

Module II (9L)

Physical and chemical changes in meat; Post mortem examination; Factors affecting post-mortem changes, properties and shelf life of meat; Rigor mortis; Meat tenderization and role of enzymes in meat processing; Retail and wholesale cuts; Microbial factors influencing keeping quality of meat; Meat plant sanitation and safety, meat quality evaluation; Factors affecting meat quality; Packing of meat.

Module III (9L)

Basic preparatory procedures like comminution, emulsification; Meat preservation: smoking, canning, irradiation, dehydration and curing; Poultry and their products. Meat products- meat emulsion, sausages, comminuted meat products, ham, bacon. Zoonotic diseases., Meat plant sanitation and waste disposal. Meat plant sanitation and safety, Byproduct utilization; Recent trends in meat processing; MMPO, MFPO ; meat safety. Kosher and Halal certification, safety issues, regulation and quality assurance.

Module IV (9L)

Structure and composition of egg and factors effecting quality; Quality measurement, Preservation of eggs using oil coating, refrigeration, thermo stabilization and antibiotics; Packing, storage and transportation of eggs; Technology of egg products viz. egg powder, albumen, flakes and calcium tablets. Classification of fresh water fish and marine fish; Commercial handling, storage and transport of raw fish; Average composition of fish; Freshness criteria and quality assessment of fish; Spoilage of fish; Methods of Preservation of fish: Canning, Freezing, Drying, Salting, smoking, curing, fermentation (fish sauce).

Module V (9L)

Value added fish products-fermented fish, fish soups, fish powder, prawn powder and cutlets; Fish products - production of fish meal, fish protein concentrate, fish liver oil, fish silage and fish sauce and other important by-products; Production of chitin, chitosan; Production of non-food items from fish processing wastes. Quality control of processed fish; Fish processing industries in India, Processing of crab, prawns, seaweeds; Freezing techniques and irradiation process; Seaweed products like pickles, hydrocolloids and oil.

Text books:

1. Essentials of food science by Vaclavik V.A. and Christian E.W. (2003). 2nd edition, Springer International. (T1)
2. Egg science and technology by Stadelman W.J. and Cotterill O.J. (2001) CBS Publishers. (T2)
3. Fish Processing Technology, Rogestein & Rogestein (T3)
4. Egg Science & Technology; Stadelman WJ & Cotterill OJ; 1973, AVI Pub. (T4)
5. Food science by Potter (T5)

Reference books:

- 1.Improving the Sensory and Nutritional Quality of Fresh Meat byKerry, J.P. CRC/Wood Head, 2009(**R1**)
- 2.Seafood Processing: Adding Value through Quick Freezing, Retort able Packaging and Cook-Chilling & other methodsby Venugopal, V. (Food Science and Technology Vol. 13), CRC press, 2006(**R2**)

COURSE INFORMATION SHEET

Course code: FT 304
Course title: Cereal Technology Laboratory
Pre-requisite(s):
Co- requisite(s): FT301 Cereals Pulses and Oilseeds Technology
Credits: L:00T:00P:04
Class schedule per week: 04
Class: IMSc
Semester / Level: V/03
Branch:Food Technology
Name of Teacher:

This course enables the students will be able to:

1.	Understand of the uniqueness of wheat as a cereal grain in the world food supply and the scientific nature of the functionality and inter-relationships of the key constituents in wheat for food utilization.
2.	Interpret the importance of cereals as foods, and appreciate their nutritional value
3.	Develop the basic knowledge and principles of cereal science, the production processes and technologies for cereal products, and the quality, sanitary control and assurance for cereal processing.
4.	List the various components of cereals and their levels, their functional roles in the various cereal foods, and methods of analysis
5.	Utilize the application of scientific principles in the processing of cereal and cereal based product.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Discover the proper methods of wheat and grain handling and storage
CO2	Categorize the botanical, physical, and chemical criteria of wheat quality, their methods of evaluation, roles in wheat grading and processing.
CO3	Explain the dry milling processes of bread and durum types of wheat, and how flour grades are obtained.
CO4	Describe how bread, biscuits, pasta, and breakfast cereals are produced, and identify the parameters involved in their quality evaluation
CO5	Work cooperatively in a team to identify a food chemistry problem, design and conduct the experiments, and analyze and interpret the data.
CO6	Clearly communicate research results using appropriate written, oral, and visual communication techniques.

List of experiments:

1. Physical Characterization of wheat
2. Determination of wet and dry gluten
3. Gluten content and protein quality of wheat flour
4. Studies on gliadin and glutenin in wheat flour
5. Physicochemical and cooking characteristics of rice :
6. Hulling recovery, (b) Milling recovery, (c) Head rice recovery Test weight, Kernel length, breadth, Length/breadth ratio and grain classification, seed grade, water uptake, volume expansion ratio, kernel elongation after cooking and kernel elongation ratio, Alkali spreading value/gelatinization temperature Gel consistency, Amylose content,
7. Determination of hectolitre weight
8. Determination of grain hardness
9. Determination of sedimentation value
10. Determination of β -carotene
11. Estimation of starch
12. Estimation of true and non-protein
13. Phenol test for cereals
14. Determination of tryptophan content in maize flour by papain hydrolysis
15. Determination of lysine content

COURSE INFORMATION SHEET

Course code: FT 305
Course title: Food Product Development Laboratory
Pre-requisite(s):
Co- requisite(s):
Credits: L:00T:00P:04
Class schedule per week: 04
Class: IMSc
Semester / Level: V/03
Branch: Food Technology
Name of Teacher:

This course enables the students:

1.	Demonstrate deep understanding and knowledge of principles of advanced food processing technologies
2.	Identify and critically analyse main advantages and disadvantages of emerging food processing technologies
3.	Compare and contrast conventional and emerging food processing technologies in real-life food processing
4.	Apply selected novel processing technologies to preserve and improve microbiological, nutritional or functional characteristics of foods

Course Outcomes

After the completion of this course, students will be:

CO1	To describe food Processing in terms of unit operations, both conceptually and in the pilot plant
CO2	To understand the use of mass and energy balances for food processing
CO3	To apply critical thinking skills to new food processing situations
CO4	Work cooperatively in a team to identify a food chemistry problem, design and conduct the experiments, and analyze and interpret the data.
CO5	Clearly communicate research results using appropriate written, oral, and visual communication techniques.

List of experiments:

1. Development of fried snacks from cereals
2. Development of vegetables based snacks(RTE)
3. Preparation of food spreads as per FSSA standards
4. Preparation of ready to cook “kheer mix”
5. Role of salt in preservation of pickles
6. Extension of shelf life of fresh agro-produce by post-harvest treatment (application of wax and packaging)
7. Development of a prebiotic food product
8. Development of sundried products from cereal, legumes and vegetables
9. Preparation of green chilli sauce
10. Preparation of fruit juice concentrates
11. Development of spices powder and their quality analysis
12. Sensory tests of developed Prebiotic foods
13. Extraction of oils from red chilli using organic solvents
14. Production of food colours from natural resources
15. Extraction of orange flavour and oil from orange peel

COURSE INFORMATION SHEET

Course code:	FT 306
Course title:	Food Analysis Laboratory II
Pre-requisite(s):	FT214 Food Analysis Laboratory I
Co- requisite(s):	
Credits:	L:00T:00P:04
Class schedule per week:	04
Class:	IMSc
Semester / Level:	V/03
Branch:	Food Technology
Name of Teacher:	

Course Objectives:

This course enables the students will:

1.	Be familiar with the current state of knowledge on food composition
2.	Understand the principles behind analytical techniques associated with food
3.	Know methods of selecting appropriate analytical techniques when presented with a practical problem
4.	Be able to demonstrate practical proficiency and teamwork in a food analysis laboratory
5.	Be able to use various instrument and protocols for food analysis

Course Outcomes

After the completion of this course, students will be:

CO1	Acquainted with analytical methods used for quality control analysis of raw material and processed food commodities.
CO2	Able to conduct appropriate laboratory experiments common to basic and applied food analysis and interpret the results.
CO3	Able to Work cooperatively in a team to identify a food Analysis problem, design and conduct the experiments, and analyze and interpret the data.
CO4	Able to clearly communicate research results and tell the quality of food products using appropriate techniques.

List of experiments

1. Determination of concentration of metal ion by colorimeter
2. Conductometric titration of acid/base, precipitation and metal ion complex
3. Acid base titrations by pH meter
4. Kinetic study of mutarotation of glucose by polarimeter
5. Determination of metal ion concentration by Atomic absorption spectroscopy
6. Microwave digestion of food sample and determination of metal ion concentration by ICP-OES
7. Texture Analysis of Food sample
8. Rheology of CMC solution by Brookfield viscometer
9. Differential Scanning Calorimetry
10. Thermogravimetric analysis
11. Ion Chromatography analysis of digested food sample

COURSE INFORMATION SHEET

Course code:	FT 308
Course title:	Dairy Technology
Pre-requisite(s):	FT 212 Fluid Mechanics and Mechanical Operations, FT302 Heat Transfer in Food Processing FT203 Food Microbiology
Co- requisite(s):	FT312 Dairy Technology Laboratory
Credits:	L:04T:00P:00
Class schedule per week:	04
Class:	IMSc
Semester / Level:	VI/03
Branch:	Food Technology
Name of Teacher:	
Course Objectives	

This course enables the students:

1.	To develop understanding in milk chemistry and interpret the role of the various components of milk as functional components of different dairy products.
2.	To contrast knowledge on the specific processing technologies used for milk and the various products derived from milk and their quality attributes.
3.	To Make use of the understandings on physical, chemical, microbiological properties of milk and their interaction in food products in terms of color, flavor, texture and nutritional composition of milk.
4.	To interpret the significance and role of homogenization, pasteurization, sterilization and UHT in quality of milk and processed products.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to build knowledge in dairy chemistry and discover the role of the various components of milk as functional components of different dairy products.
CO 2	Able to adapt specific processing technologies used for milk and the various products derived from milk.
CO 3	Able to evaluate the quality attributes of dairy and dairy based product
CO 4	Able to apply starter culture technology and select starters for production of different dairy products.
CO 5	Able to develop competency in the students for adopting dairy processing and product manufacturing as an enterprise.

FT 308 Dairy Technology

Module I: (9L)

Present status of dairy processing in India and Abroad; Importance of milk processing in India: NDDDB & Operation flood. Milk: Definition, types, composition, nutritive value; Physical properties and chemical composition of different milch animal (cow, buffalo and other species); Checks for quality of milk: different tests associated with purity, contaminations & adulterants; Dairy plant operations viz. receiving, separation, clarification, pasteurization, standardization, homogenization, sterilization, storage, transport and distribution of milk; Centrifugal separation, clarification and bactofugation and factors affecting their efficiency; Homogenization process and its implications in dairy processing; efficiency of homogenization and factors affecting it.

Module II: (9L)

Pasteurization (LTLT and HTST), sterilization, UHT processing and aseptic packaging; Special milks: Principles of production, processing and marketing of toned, double toned, reconstituted, recombined, flavoured and filled milks; Packaging of fluid milk; Different dairy plant equipments its handling and maintenance. Concentrated and Dried Milk Products: Principles and methods of manufacture, storage and defects in sweetened condensed milk; Evaporated milk, UHT sterilized concentrated milk; Whole milk powder, Skim milk powder, high-fat powders, and ice-cream powder. Instantization of milk powder. Newer technologies and formulations for infant foods and weaning foods, malted milk and malted milk foods.

Module III: (9L)

Fat rich dairy products:- principles and concepts in production and processing of different types of cream, butter, margarine, fat spreads, butter oil and ghee; fractionation of fat and its application, health aspects of milk fat, cholesterol reduced and cholesterol-free dairy products. Frozen Milk Products: Definition, classification and composition of ice-cream and other frozen desserts, role of milk constituents and other ingredients, processing steps, packaging and storage methods on quality of ice cream, Technological aspects of manufacture of plain, fruit, soft-serve, low fat and dietic ice-creams and novelties; Indigenous frozen desserts, kulfi, malai-ka-baraf etc.; their production techniques and quality, distribution of frozen desserts. Newer ingredients for use in the ice-cream industry.

Module IV: (9L)

Cheese and Fermented Milk Products: their nutritional and therapeutic value, definition and classification of cheese and fermented milks; Milk in relation to cheese making, Manufacture of Cheddar, Gouda, Mozzarella and Swiss cheeses, role of starter cultures, storage and defects. Types of rennet, Physical and chemical changes during cheese ripening, Manufacture of processed cheese, cheese spread and cheese foods; Mechanization of cheese-making process, accelerated cheese ripening, Cheese spreads by spray and roller drying techniques. EMC (Enzyme modified cheese), Enzymes in dairy processing. Production and storage of dahi, yoghurt, shrikhand, lassi and mistidohi. Probiotic dairy products.

Module V: (9L)

Cleaning and sanitization of dairy plant: properties of important dairy detergents and sanitizers, choice of detergents and sanitizers, guiding principles and limiting factors, Basic principles in formulating the cleaning and sanitizing procedures for dairy equipments, automation in cleaning and sanitization processes including CIP, Quality of water in detergency, Dairy waste disposal; Safety aspects of milk with reference to mycotoxins, antibiotics, pesticides, weedicides and heavy metals; PFA, BIS and Agmark standards for milk and milk products; Quality systems such as HACCP, ISO certification, etc; Packaging application in dairy products.

Text books:

- 1.Smit, G. (2003) Dairy processing - improving quality. Woodhead Publishing.(T1)
- 2.Walstra P., Geuits T.J., Noomen A., Jellema A. and Van Boekel(T2)
- 3.M.A.J.S. (1999) Dairy technology- Principles of milk properties and processes. Marcel Dekker Inc.(T1)
- 4.Spreer E. (1998) Milk and dairy product technology. Marcel Dekker Inc.(T3)
- 5.Gupta R.P. (2003) Dairy India year Book 2007(T4)
- 6.Robinson R.K. Modern dairy Technology, Vol I Advances in Milk processing.(T5)
- 7.Outlines of Dairy Technology by Sukumar Dey, 1990, Oxford Univ. Press.(T6)

Reference books:

1.Lampert, Lincoln M. “Modern Dairy Products: Composition, Food Value, Processing, Chemistry,Bacteriology, Testing, Imitation Dairy Products”. Chemical Publishing Company, 1998.(R1)

2.Selia, dos Reis Coimbra and Jose A. Teixeir “Engineering Aspects of Milk and Dairy Products” , CRC Press, 2009(R2)

COURSE INFORMATION SHEET

Course code: FT 309
Course title: Mass Transfer in Food Processing
Pre-requisite(s): FT 212 Fluid Mechanics and Mechanical Operations
FT 302 Heat Transfer in Food Processing
Co- requisite(s):
Credits: L:03T:01P:00
Class schedule per week: 04
Class: IMSc
Semester / Level: VI/03
Branch: Food Technology
Name of Teacher:
Course Objectives

Course Objectives

This course enables the students:

1.	To understand the mechanism of mass transfer
2.	To understand the various separation unit operation in food industries
3.	To Interpret the design and operation of the mass transfer equipments

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to understand various modes of mass transfer
CO 2	Able to perform design calculation of distillation column
CO 3	Able to apply the knowledge of liquid-liquid and solid-liquid separation technology in food industries
CO 4	To apply the knowledge of crystallization and adsorption in food industries
CO 5	Able to understand the principles Psychrometry and apply knowledge of drying operation in food processing.

Syllabus

FT 309 Mass Transfer in Food Processing

Module I: (9L)

Diffusion- Molecular diffusion of fluids, Ficks' Law, diffusivity Unsteady state diffusion in solids. Convective Mass transfer coefficient. Interphase mass transfer, individual and overall mass transfer coefficient.

Module II: (9L)

Distillation- Raoult's law, Henry's law, Vapour liquid equilibrium for ideal and non-ideal binary systems, Estimation of VLE using vapour pressure data and relative volatility. Batch distillation, Flash distillation, continuous distillation in Plate column. Design calculation by McCabe Thiele method. Steam distillation. Extractive distillation, azeotropic distillation, Alcohol distillation stills and columns.

Module III: (9L)

Liquid- Liquid Extraction - Equilibrium for immiscible and partially miscible systems, Use of triangular diagram. Liquid-liquid extraction equipment – mixer settlers and Extraction columns. Solid liquid Extraction – Leaching equipment with special reference to extraction of edible oil and sugar beet. Equilibrium curve, Cross flow/counter flow operation. Determination of number of stages, Supercritical fluid extraction – principles and application in food industry.

Module IV: (9L)

Crystallization: Supersaturation, Miers theory, Nuclei formation, Types of nucleation, Ostwald ripening, Kelvin equation Crystal growth , Theory of crystallization, Calculation of crystal yield, Batch and continuous crystallization, Fractional crystallization. Application in salt and sugar industry, Adsorption – Adsorbents and application in food processing, Adsorption isotherms Henry's, Langmuir, BET, Freundlich, Chemisorption, Single stage Multistage cross current adsorption. Adsorption Unit- Fixed bed equations, Breakthrough curve and analysis of fixed bed adsorption.

Module V: (9L)

Psychrometry: Humidity, wet and dry bulb temperature, adiabatic saturation temperature, humid volume of air. Psychrometric charts. Measurement of humidity. Methods of humidification and dehumidification, Cooling towers and spray ponds.

Drying: Principle rate of drying. Moisture content on dry and wet basis, bound and unbound moisture, equilibrium and free moisture. Drying rate. Time required for drying, Calculation of heat load, Mass and energy balance in dryer. Operation and application in food processing: Tray dryer, vacuum tunnel dryer, freeze drying, puff drying, rotary dryer, fluidized bed dryer, spray drying.

Text books:

1. R. Paul Singh. Introduction to Food Engineering,, , Dennis R. Heldman, Academic Press, 2009.(T1)
2. Elements of Food Engineering by R.T. Toledo, (T2)
3. Food Process Engineering and Technology, **Zeki Berk**), **Academic Press**.(T3)
4. FOOD PROCESSING TECHNOLOGY, Principles and Practice, P. Fellows, CRC Press.(T4)

Reference:

1. Unit Operations In Food Engineering by Albert Ibarz and Gustavo V. Barbosa-Cánovas, CRC Press, 2003. (R1)

2. Unit Operations in Food Processing by R. L. Earle, 2nd Edition, Pergamon Press, Oxford, U.K., 2003. **(R2)**
3. Physical Properties of Foods & Foods Processing Systems by M. J. Lewis, Ellis Horwood, England, 1987. **(R3)**
4. Unit Operations of Chemical Engineering by McCabe and Smith **(R4)**
5. Unit operations in Agricultural processing by Sahay and Singh **(R5)**

COURSE INFORMATION SHEET

Course code: FT 310
Course title: Thermodynamics and Refrigeration
Pre-requisite(s):
Co- requisite(s):
Credits: L:03T:00P:00
Class schedule per week: 03
Class: IMSc
Semester / Level: VI/06
Branch: Food Technology
Name of Teacher:
Course Objectives

This course enables the students:

1.	To explain thermodynamic terminology and concepts appropriately
2.	To define appropriate system boundaries for analyzing a variety of thermodynamic components and systems
3.	To apply the basic of refrigerating and its applications in food engineering
4.	To develop knowledge in thermodynamic properties of food in relation to different unit operations.
5.	To use tables, charts, equations, and software, in conjunction with appropriate property diagrams, to fix states of a pure substance and determine relationships among pressure, temperature, specific volume, internal energy, enthalpy and entropy

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to demonstrate the principles of conservation of mass, conservation of energy, and the second law of thermodynamics to thermodynamic cycles.
CO 2	Able to build the ability to analyze the performance of vapor and gas power cycles
CO 3	Able to develop the ability to analyze the performance of vapor and gas refrigeration and heat pump cycles.
CO 4	Able to utilize states and performance parameters for vapor power cycles based on the Rankine cycle with superheat, reheat, and regeneration
CO 5	Able to collaborate and communicate with fellow students and the instructor in a professional manner

Syllabus

FT 310 Thermodynamics & Refrigeration

Module -I : (10L)

Zeroth & First law of thermodynamics-concept of temperature, Energy balance for closed system. Thermodynamic state and state functions. The reversible process. The adiabatic process. The constant volume and constant pressure process. Enthalpy, heat capacity. Mass and energy balance for open systems. Second law of thermodynamics and its application: Limitations of the first law of thermodynamics, statements of the law. Heat engine and heat pump / refrigerator. Mathematical statement of second law. Carnot cycle and Carnot Theorems. criterion of irreversibility, Clausius inequality, entropy and its change calculation for ideal gases. Liquefaction process.

Module II : (9L)

Refrigeration : Basic refrigeration cycles and concepts: Elementary vapour compression refrigeration cycle with reciprocating, rotary and centrifugal compressor. Theoretical vapour compression cycle, Departure from theoretical vapour compression cycle, representation on T-S and P-H diagrams, Mathematical analysis of vapour compression refrigeration system. Refrigerants : Primary and secondary refrigerants, common refrigerant, Brine, their properties and comparison Multiple evaporation and compressor system: Application, on compressor system: dual compression, comparison of systems, control of multiple evaporator system.

Module III: (10L)

Refrigeration equipment : Compressor, condenser, evaporator, expansion valve, cooling tower. Basic elements of design, construction, operation and maintenance. Balancing of different components of the system, ice-bank –tank system. Refrigeration control: low and high side float valves, capillary tube, thermostatic expansion valve, automatic expansion valve, solenoid valve, high pressure and low pressure cutouts. Thermostat, overload protector, common defects and remedies. Refrigeration piping: Purpose, material, joints and fittings, water and brine pipe size selection. Refrigerated vehicle: truck, trawler. Working principle of Ice-flaker.

Module V : (9L)

Ultra low temperature refrigeration. Production of dry ice. Absorption refrigeration system: simple vapour absorption refrigeration systems, Practical absorption system, refrigerant combinations, Absorption cycle analysis. Cooling load calculation: Types of load, design conditions for air cooling, air conditioning loads. Cold storage: Types of cold storage, types of load in cold storage, construction and maintenance of cold storage, insulating materials and vapour barrier. Cold storage: Types of cold storage, types of load in cold storage, construction and maintenance of cold storage, insulating materials and vapour barrier.

Module V: (7L)

Thermal properties of frozen and unfrozen food: Introduction to thermal properties, importance of thermal properties, experimental approach to measure thermal properties, modeling of thermal properties of frozen and unfrozen foods. Systems for Freezing of solid and liquid food – Indirect contact and Direct contact Freezers.

Books

Text books:

1. R. Paul Singh. Introduction to Food Engineering,, , Dennis R. Heldman, Academic Press, 2009.(T1)
2. Elements of Food Engineering by R.T. Toledo, (T2)
3. Food Process Engineering and Technology, Zeki Berk), Academic Press.(T3)

COURSE INFORMATION SHEET

Course code: FT 311
Course title: Food Business Management
Pre-requisite(s):
Technology
Co- requisite(s):
Credits: L:03T:00P:00
Class schedule per week: 03
Class: IMSc
Semester / Level: VI/06
Branch: Food Technology
Name of Teacher:
Course Objectives

This course enables the students:

1.	To Identify emerging issues that could change or enhance the agri and food business in the coming decades
2.	To understand the industry's main drivers of innovation, customers, technology and the environment and how to leverage them
3.	To Identify emerging opportunities for growth in both domestic and international markets Position the individual and his help to position his organization to compete effectively in food production and supply systems
4.	To extend the participants network by making new connections with peers from across the global food business industry.

Course Outcomes

After the completion of this course, students will be:

CO 1	Able to analyze emerging issues that could change or enhance the agri and food business in the coming decades
CO 2	Able to evaluate the organization and function of the food industry
CO 3	Able to develop understanding in the industry's main drivers of innovation, customers, technology and the environment and how to leverage them
CO 4	Able to construct the participants network by making new connections with peers from across the global food business industry.
CO 5	Able to collaborate and communicate with fellow students and the instructor in a professional manner

Syllabus FT 311 Food Business Management

Module I: (8L)

Organisation & Management: Introduction to Organisation, Role of Managers, Managerial Skills, Basic Management Functions – Planning, Organising, Staffing, Directing (Leadership and Communication), Controlling, Executive Functions

Module II: (6L)

Human Resource Management: The HRM Process, Introduction to Manpower Planning, Recruitment, Selection, Training & Development, Performance Appraisal and Compensation Management.

Module III: (8L)

Marketing Management: Core Concepts of Marketing, Identifying a Marketing opportunity, Segmentation, Targeting and Positioning decisions, Dynamics of Consumer Behaviour, Significance of Marketing Research and Marketing Research Process, Introduction to Distribution & Logistics functions.

Module IV: (10L)

Financial Management: Goals of Financial Management- Profit Maximization Vs Wealth Maximization, Introduction to Accountancy, Accounting Principles and Conventions, Double Entry system, Journal, Ledger, Trial Balance and Preparation of Final Account. Statement of Changes in Financial Position; Preparation of Funds Flow Statement, Preparation of Cash Flow Statement, Introduction to Financial ratios.

Module V: (8L)

Entrepreneurship & IPR: Concept of Entrepreneurship & Intrapreneurship, Characteristics and skills of entrepreneurs, **Sources of Finance** - Equity vs. Debt Capital, Sources of Equity Finance, Institutional finance, Venture Capital, Lease Finance, **Forms of Business Ownership** - Sole Proprietorship, Partnership, Corporations and other forms of ownership, Intellectual **Property Management:** Importance of innovation, Patents & Trademarks in Small Businesses, Introduction to laws relating to IPR in India

Text books:

1. Principles of Agri Business Management by D. David and S Erickson 1987. Mc Graw Hill Book Co., New Delhi.
2. Agricultural Marketing in India by Acharya S S and Agarwal N L 1987. Oxford & ISH Publishing Co., New Delhi.
3. Marketing in the International Environment by Cundiff Higler 1993, Prentice Hall of India, New Delhi.
4. GAD implications of Denkel proposals - G S Batra & Narindev kumar (1994) Azmol Publications Pvt., New Delhi.

Reference Books

1. Management Process and Perspectives by Chhabra TN & Suria RK. 2001. Kitab Mahal.

COURSE INFORMATION SHEET

Course code:	FT 312
Course title:	Dairy Technology Laboratory
Pre-requisite(s):	
Co- requisite(s):	FT 308 Dairy Technology
Credits:	L:00T:00P:04
Class schedule per week:	04
Class:	IMSc
Semester / Level:	VI/03
Branch:Food Technology	

Course Objectives:

This course enables the students:

1.	Imparting knowledge about some indigenous dairy products
2.	Measurements, analysis and isolation of milk components.
3.	Experimental demonstration of chemical and physical reactions of milk components during typical processing conditions.
4	Knowledge about standardization and preparation procedures of indigenous dairy products

Course Outcomes

After the completion of this course, students will:

CO1	Have Skill of Sampling milk and milk products
CO2	Be able to conduct Physical, Chemical & Microbial analysis of milk and milk products
CO3	Be able to understand Development of different milk products.
CO4	Be able to Conduct Characterization of milk products.
CO5	Have knowledge of Quality control of milk & milk products.

List of experiments

1. Sampling of milk and milk products
2. Platform tests of milk:
 - a. Organoleptic test
 - b. Sediment test
 - c. COB test
 - d. Alcohol test
 - e. Alcohol-Alizarin test
 - f. Titratable acidity and
 - g. pH milk
3. Determination of specific gravity of milk
4. Total solids and solid-not-fat using lactometer
5. Detection of milk adulterant
 - a. Added water
 - b. Starch
 - c. Cane sugar
 - d. Neutralizers and
 - e. Preservatives (formalin and hydrogen peroxide)
 - f. Synthetic milk (urea test, detergent test, common salt)
6. Alkaline phosphatase test to determine adequacy of pasteurization
7. Estimation of casein in milk, lactose, chlorides, Reichert-Meissel number and Polensky value
8. Curd/salt/Moisture in butter (Dean and Stark distillation)/Colouring matter in butter
9. Acid Value/Peroxide value/ Iodine value/ Saponification value of ghee
10. Fat in cream
11. Total solids in cream
12. Development of some indigenous dairy products. Standardization and preparation of khoa/ice cream/ rasogulla
13. Microbial quality control in milk
14. Preparation and quality control of (a) curd (b) Paneer (c) Lassi
15. Preparation and testing of Cheese.

COURSE INFORMATION SHEET

Course code: FT 313
Course title: Food Engineering Laboratory
Pre-requisite(s): FT 212 Fluids Mechanics and Mechanical Operation
FT 302 Heat Transfer in Food Processing
Co- requisite(s): FT 309 Mass Transfer in Food Processing
Credits: L:00T:00P:04
Class schedule per week: 04
Class: IMSc
Semester / Level: VI/03
Branch: Food Technology

Course Objectives

This course enables the students to:

1.	Learn chemical engineering principles of various operations in Food Processing Industries
2.	Develop knowledge about practical applications of Chemical Engineering Unit Operations in Food Processing
3.	Learn experimental methods in Food Engineering
4.	

Course Outcomes

After the completion of this course, students will be:

CO1	Conversant with various fluid moving machineries and flow measurements
CO2	Familiar with various mechanical operations in Food Processing Industry.
CO3	Able to plan experiments and present, analyse and interpret the experimental data meaningfully
CO4	Capable to visualize and understand chemical engineering unit operations related to heat and mass transfer with application in Food Processing industry
CO5	Develop expertise in writing report to present their results and conclusions in a clear, concise and effective manner

List of experiments

- 1.Characterization of solids: size shape and density of solid food, Flowing characteristics- Bulk density, angle of repose of granular and powder food.
- 2.Calibration of Rotameter, Venturimeter and Orifice meter
- 3.Particle size analysis of granular/powder food.
- 4.Filters: Plate and Frame Press and Ultrafiltration
- 5.Steam distillation of essential oils
- 6.Power requirement in agitated vessel
- 7.Batch heating and cooling
- 8.Plate Heat Exchanger
- 9.Mixing of solids and paste: Determination of mixing index
- 10.Freezing of Food – plotting temperature vs time.
- 11.Heat penetration in food – Determination of lethality of a thermal process
- 12.Drying rate curve in Tray dryer
- 13.Drying rate curve in Fluidized bed dryer
- 14.Size reduction experiment
- 15.Humidity chart and cooling tower.