Syllabus for the program of Integrated Master of Technology in Chemical Engineering

Preamble

The program, Integrated Master of Technology in Chemical Engineering is offered by Institute of Chemical Technology (ICT) Mumbai Campuses at Bhubaneshwar and Marathwada, Jalna.

About ICT Mumbai

The Institute of Chemical Technology (ICT) Mumbai, formerly UDCT, University of Bombay (Mumbai now) was established on October 1, 1933 as a department of the University by the desire of industry and support of the government of Province of Bombay, particularly to lend support to the textile (a staple industry in Western India) and chemical industry, an infant industry. Over the years the UDCT grew in its status and extended its programs to sectors of chemical and allied industry, pharmaceuticals, materials and energy and became a role model for its contributions to industrial connectivity and growth. ICT was granted Deemed to be University by MHRD on 12th September 2008 and an elite status and Centre of Excellence on par with IITs/IISc/IISERs which was granted by the State Assembly on October 20, 2012; a unique distinction in history of India. ICT's track record of 85 years is phenomenal. ICT is ranked among the best in India having the highest NAAC rank of A++ with CGPA of 3.77. It was declared at Category I institute by MHRD/UGC Notification (The Gazette of India dated Feb. 12, 2018). On 3rd April, 2018, The National Institutional Ranking Framework (NIRF) of MHRD placed ICT at No. 10 in Engineering, No. 4 in Pharmacy, No. 19 among Universities and No. 30 among all. In QS BRICS 2019 ranking, ICT secured 115th rank among all with 100/100 marks for research and innovation. Once again in the Scopus Survey November 2018, ICT is found to be the top in Chemical Engineering and in top 5 overall in the country based on the Weighted Average Citation Impact (Sci-Val, Scopus). In the latest list of Institute of Eminence, ICT figures in 12 public institutes which will be considered by UGC/MHRD for special funding.

Over the years, ICT has produced more than 750 first generation entrepreneurs, 19 Padma awardees (3 PV, 8 PB, 8 PS), India's first 5 Ph Ds in Engineering and Technology. This sectorial excellence has been due to the students and faculty coming from all over India. ICT runs 9 UG, 18 PG, 29 Ph D, 1 PG Diploma in Chemical Technology Management and 1 Certificate Course in Chemical Safety and Risk Management, with a student strength of over 2300 among which currently there are 575 PG and 700 Ph D students in all branches of Engineering and Sciences.

Because of the Category I and Deemed to be status, it was possible for ICT to go out of Maharashtra. In view of massive investment in energy, petrochemicals, chemicals, polymers, textiles, minerals, materials, biotechnology and pharmaceutical industries in Odisha, ICT was requested to open a campus in Bhubaneswar. Indian Oil Corporation Ltd took a historic decision to support fully a campus of ICT in Bhubaneswar. It was officially launched at the hands of Hon'ble Shri Ram Nath Kovind, the President of India on 18th March 2018. Similarly, the Marathwada Campus was instituted at the behest of the Government of Maharashtra and was inaugurated by The Hon. Chief Minister Shri Devendra Phadnavis on 28 May 2018, Government of Maharashtra.

About Integrated Master of Technology Program

The unique features of the Integrated M. Tech. are

1. Integrated M. Tech. after 12th Standard (HSSC) of 5-year duration consisting of 15 trimesters with alternate term in industry, with major in Chemical Engineering and minor in 6 different disciplines.
2. To ensure improved quality and industry relevance in curricula development for integrated M. Tech. (9 stduy trimesters in the Institute and 6 trimesters in the industry) in the field of Chemical Engineering as major branch with minor in Petrochemicals, Textiles, Polymers and Materials, Pharmaceuticals, and Energy Engineering, Food Engineering and Lipid Engineering (in Marathwada, Jalna).
3. The last two trimesters will be for promotion of experimental and design project to promote entrepreneurship and start-up companies.
4. Four-month Trimester pattern with studies and In-plant training (IPT) alternate term.
5. Simultaneous 2 years' experience in various Industries.
6. Vibrant syllabus with option to include case studies and IPT experiences in courses.
7. Collaborative projects with Industry by involving Ph.D. Fellows and faculty.

8. Student is continuously monitored and participates in class room discussions, home assignments and research project.
9. Student will be evaluated based on in-term evaluation (50%) and end-term examination (50%).
10. Many new subjects and choice based learning courses and some of them are
    a. Environmental Science and Sustainability
    b. Ethics and Industrial Practices
    c. Experimental Design and Research Methodology
    d. Finance and Profit Management
    e. Green Chemistry and Engineering
    f. Industrial and Labour Laws in India
    g. Industrial Management
    h. Intellectual Property Rights, Valuation and Management
    i. Materials Management
    j. Perspective of Global Industry
    k. Research and Innovation Methodology
    l. Sustainability and life cycle assessment

This concept/curriculum of Integrated M. Tech. is new and being introduced in India for the first time. During the industrial internship the student may receive stipend from industry making the education affordable to one and all. Along with the teaching, both these campuses will be equipped modern equipment for carrying out high class research and innovation at Centres of Excellence to develop Technology and to support Research & Development in industry and Skill Development in Chemical Engineering, Petrochemicals, Textiles, Polymers, Pharmaceuticals, Energy, etc. Thus, students will also work on some of the research ideas during one of the internship period in collaboration with the industry. One of the faculty will be mentor the students during this period. Students will get hands on analytical instruments during this period.

Course instruction and Grading System

1. The course will be trimester based each of 4-month duration. There will be 3 trimesters in each year.
2. The scheme of study and IPT terms is given below:

Year	Trimester	Scheme of trimesters
1	T1	Theory
1	T2	Theory
1	T3	In-plant
2	T4	Theory
2	T5	In-plant
2	T6	Theory
3	T7	In-plant
3	T8	Theory
3	T9	In-plant
4	T10	Theory
4	T11	In-plant
4	T12	Theory
5	T13	In-plant
5	T14	Theory
5	T15	Theory

3. The grading system will be as per R.26 of ICT. (Annexure I)
4. The in-term assessment will be of 50% weightage and end-term exam will be of 50% weightage.
5. The in-term assessment would consist of at least three assessments.

Program Education Objectives

1. Prepare students for career in chemical and allied industry leveraging their technical expertise
2. Build leadership capabilities amongst students to meet the needs of society and industry
3. Create awareness amongst students about the social/industrial demands and role of chemical engineer in the society
4. Incorporate a culture of research and innovation by providing students with guidance and opportunities
5. Provide a platform to the students to interact with leading teachers, scientists and industry practitioners

Program Outcomes

The students completing Int. M. Tech. program in Chemical Engineering will

1. have sound knowledge of engineering, sciences, mathematics, and programming fundamentals
2. be able to solve complex problems by applying principles of engineering, sciences, mathematics and programming
3. be able to design, conduct experiments and analyze the data generated
4. have knowledge of fundamentals and innovation to solve the problems related to energy, food, environment, healthcare, etc.
5. have ability to keep abreast with the scientific literature, new technologies and new developments
6. work on complex problems in team and multidisciplinary situations
7. help government, society and industry to do technology development related activities for chemical and allied industries
8. cater to the needs of chemical industry, research organizations and academic institutes
9. set-up their own ventures and generate employment
10. promote awareness in society about Chemical Engineering profession

Graduate Attributes

1. Problem analysis and solving skills
2. Experience with industry practices and
3. Familiar with usage of modern tools, techniques
4. Communication Skills
5. Capacity to analyze new concepts
6. Capacity to analyze and interpret experimental data
7. Capacity to analyze business trends
8. Capacity to design, optimize and operate equipment and plants safely, economically and effectively
9. Design and Development of solutions to industrial and societal needs
10. Skills related to Project Management and Economics
11. Skills to analyze scientific literature including patents
12. Ethics

List of subjects

Study 1 (T1)										
Sr. No.	Type of course	IOCB Code (3)	Jalna Code (4)	Subjects	Credits	Hrs/Week				
						L	T	P	E. S.	Total
1	BS	BST3101	BST4101	Chemistry - I	4	3	1	0	50	100
2	BS	BST3102	BST4102	Physics – I	4	3	1	0	50	100
3	BS	BST3103	BST4103	Mathematics-I	4	3	1	0	50	100
4	HU	HUT3101	HUT4101	Communication Skills/English	3	2	1	0	50	100
5	CE	CET3101	CET4101	Introduction to Chemical Engineering and Chemical Industries.	3	2	1	0	50	100
6	ES	ESP3101	ESP4101	Engineering Graphics-I	3	1	0	4	50	100
7	ES	ESP3102	ESP4102	Engineering Applications of Computers-I	2	0	0	4	50	100
8	BS	BSP3101	BSP4101	Chemistry Laboratory -I	2	0	0	4	50	100
				TOTAL	**25**	**14**	**5**	**12**	**400**	**800**
Study 2 (T2)										
			Code	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
9	BS	BST3104	BST4104	Chemistry-II	4	3	1	0	50	100
10	BS	BST3105	BST4105	Physics -II	3	2	1	0	50	100
11	BS	BST3106	BST4106	Mathematics-II	4	3	1	0	50	100
12	CE	CET3102	CET4102	Material & Energy Balance Calculations	4	3	1	0	50	100
13	CE	CET3202	CET4103	Chemical Engineering Thermodynamics - I	3	2	1	0	50	100
14	HU	BSP3102	BSP4102	Chemistry Laboratory-II	2	0	0	4	50	100
15	BS	ESP3102	ESP4102	Engineering Applications of Computers-II	3	1	0	4	50	100
16	ES	BSP3103	BSP4103	Physics Laboratory	2	0	0	4	50	100
				TOTAL	**25**	**14**	**5**	**12**	**400**	**800**
IPT 1 (T3)										
17	IP	IPP3101	IPP4101	In-Plant Training	8					
Study 3 (T4)										
			Code	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
18	BS	BST3201	BST4201	Chemistry - III	4	3	1	0	50	100
19	BS	BST3202	BST4202	Introduction to Biological Sciences & Bioengineering	4	3	1	0	50	100
20	CE	CET3201	CET4201	Momentum Transfer	4	3	1	0	50	100
21	CE	CET3202	CET4202	Chemical Engineering Thermodynamics- II	3	2	1	0	50	100
22	ES	EST3201	EST4201	Engineering and solid Mechanics	3	2	1	0	50	100
23	ES	EST3202	EST4202	Electrical Engineering and Electronics	3	2	1	0	50	100
24	ES	ESP3201	ESP4201	Engineering Laboratory	2	0	0	4	50	100
25	ES	ESP3202	ESP4202	Engineering Applications of Computers-III	3	1	0	4	50	100
				TOTAL	**26**	**16**	**6**	**8**	**400**	**800**
IPT 2 (T5)										
	IP	IPP3102	IPP4102	In-Plant Training	8					
Study 4 (T6)										
			Code	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
26	ES	EST3203	EST4203	Energy Engineering	4	3	1	0	50	100
27	CE	CET3203	CET4203	Heat Transfer	4	3	1	0	50	100
28	CE	CET3204	CET4204	Mass Transfer Operations	4	2	2	0	50	100
29	S	S*x*T3101	S*x*T4101	Special Subject I	3	2	1	0	50	100

30	HU	HUT3201	HUT4201	IPR and Laws	3	2	1	0	50	100
31	CE	CEP3201	CEP4201	Mathematical Methods in Chemical Engineering	4	2	0	4	50	100
32	CE	CEP3202	CEP4202	Chemical Engineering Laboratory-I	4	0	0	8	50	100
				TOTAL	**26**	**14**	**6**	**12**	**350**	**700**
IPT 3 (T7)										
	IP	IPP3103	IPP4103	In-Plant Training	8					
Study 5 (T8)										
				Subjects	Credits	Hrs/week			E. S.	Total
						L	T	P		
31	ES	EST3404	EST4304	Material Science and Engineering	3	2	1	0	50	100
32	S	ST	xxTxxxx	Special II	3	2	1	0	50	100
33	CE	CET3301	CET4301	Chemical Reaction Engineering	4	3	1	0	50	100
34	CE	CET3304	CET4304	Separation Processes	4	3	1	0	50	100
35	CE	CET3302	CET4302	Biochemical Engineering	3	2	1	0	50	100
36	CE	CEP3301	CEP4301	Chemical Engineering Laboratory-II	4	0	0	8	50	100
37	CE	CEP3311	CEP4311	Process Simulation Lab – I	2	0	0	4	50	100
38	S	SP	XxP4301	Special Lab -I	2	0	0	4	50	100
				TOTAL	**25**	**12**	**5**	**16**	**400**	**800**
IPT 4 (T9)										
	IP	IPP3104	IPP4104	In-Plant Training	8					
Study 6 (T10)										
				Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
39	S	ST	xxT4xxx	Special Elective-III	3	2	1	0	50	100
40	S	ST	xxT4xxx	Special Elective-IV	3	2	1	0	50	100
41	CE	CET3403	CET4403	Environmental Engineering and Process Safety	3	2	1	0	50	100
42	CE	CET3405	CET4405	Chemical Process Control	4	3	1	0	50	100
43	CE	CEE3408	CET4408	Industrial and Engineering Chemistry	4	3	1	0	50	100
44	CE	CEP3402	CEP4402	Chem. Eng. Laboratory-III	4	0	0	8	50	100
45	CE	CEP3412	CEP4412	Process Simulation Lab-II	2	0	0	4	50	100
46	S	SP	xxP4402	Special Lab-II	2	0	0	4	50	100
				TOTAL	**25**	**12**	**5**	**16**	**400**	**800**
IPT 5 (T11)										
	IP	IPP3105	IPP4105	In-Plant Training	8					
Study 7 (T12)										
			No.	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
47	CE	CE3409	CET4409	Project Management and Economics in Chemical Industry	3	2	1	0	50	100
48	CE	CET3406	CET4406	Process Development and Engineering	3	2	1	0	50	100
49	CE	CET3407	CET4407	Multiphase Reaction Engineering	4	2	0	2	50	100
50	ES	ESP3501	ESP4501	Equipment Design and Drawing	4	2	0	4	50	100
51	S	ST	xxT4xxx	Special Elective - V	3	2	1	0	50	100
52	CE	CEP3471	CEP4471	Seminar	3	0	0	6	50	100
				TOTAL	**20**	**10**	**3**	**12**	**300**	**600**
IPT 6 (T13)										
	IP	IPP3106	IPP4106	In-Plant Training	8					
Study 8 (T14)										

				Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
53	CE	CET3541	CET4541	Advanced Transport Phenomena	3	2	1	0	50	100
54	CE	CET3543	CET4543	Advanced Mass Transfer	3	2	1	0	50	100
55	CE	CET3543	CET4543	Advanced Separation Processes	3	2	1	0	50	100
56	ES	EST3501	EST4501	LCA and Sustainability/ NPTEL/ MOOC	3	2	1	0	50	100
57	S	ST	xxT4xxx	Advanced Special Elective - VI	3	2	1	0	50	100
58	HU	HUT3501	HUT4501	Research Methodology	4	3	1	0	50	100
59	CE	CEP3571	CEP4571	Design / Research Project - I	4	0	0	8	50	100
				TOTAL	**23**	**13**	**6**	**8**	**350**	**700**
Study 9 (T15)										
				Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
60	HU	HU3402	HUT4402	Perspectives of Society, Science and Technology	3	2	1	0	50	100
61	HU	HU3501	HU4501	Industrial Psychology and Management	3	2	1	0	50	100
62	CE	CET3407	CET4407	Advanced Chemical Reaction Engineering	3	2	1	0	50	100
63	CE	CEE3xx	CET4xxx	Advanced Chemical Eng. Elective - I	3	2	1	0	50	100
64	S	ST	xxT4xxx	Advanced Special Elective - VII	3	2	1	0	50	100
65	CE	CEP3572	CEP4572	Design / Research Project - II	9	0	0	18	50	100
				TOTAL	**24**	**10**	**5**	**18**	**300**	**600**

List of Minor Degrees and Minor Electives:

Lipids

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1		SLT4302	Theory	Introduction to Lipid Technology
2		SLT4303	Theory	Chemistry of Lipids and their applications
3		SLT4403	Theory	Lipid Processing Technology I
4		SLT4404	Theory	Production and Applications of Soaps, Surfactants and Detergents
5		SLT4405	Theory	Lipid Processing Technology II
6		SLT4506	Theory	Essential Oils and Cosmetics
7		SLT4507	Theory	Technology of Oleochemicals
1		SFP4301	Laboratory	Lipids Laboratory-I
2		SLP4402	Laboratory	Lipids Laboratory-II

Foods

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SFT3202	SFT4202	Theory	Introduction to Food Technology
2	SFT3301	SFT4301	Theory	Biochemistry/Microbiology
3	SFT3403	SFT4403	Theory	Food Chemistry
4	SFT3404	SFT4404	Theory	Food Processing and Technology I
5	SFT3405	SFT4405	Theory	Food Ingredients and Additives
6	SFT3506	SFT4506	Theory	Food Processing and Technology II
7	SFT3507	SFT4507	Theory	Food Packaging Science and Technology
1	SFP3302	SFP4302	Laboratory	Food Analysis Laboratory
2	SFP3402	SFP4402	Laboratory	Food Processing Laboratory

Pharmaceuticals

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SRT3302	SRT4302	Theory	Introduction to Pharmaceutical Technology
2	SFT3201	SFT4201	Theory	Biochemistry and Microbiology
3	SRT3403	SRT4403	Theory	Pharmaceutical Chemistry
4	SRT3507	SRT4507	Theory	Formulation Technology and Drug Delivery
5	SRT3506	SRT4506	Theory	Pharmaceutical Technology and Drug Design
6	SRT3404	SRT4404	Theory	Process Development for Fine Chemicals and API
7	SRT3405	SRT4405	Theory	Natural Product based Pharmaceuticals
1	SRP3401	SRP4401	Laboratory	Pharmaceutical Analysis Laboratory
2	SRP3403	SRP4403	Laboratory	Pharmaceutical Chemistry and Formulation Technology Laboratory

Energy

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SET3302	SET4302	Theory	Conventional Energy and Utilization
2	SET3303	SET4303	Theory	Renewable Energy Systems
3	SET3403	SET4403	Theory	Combustion and Chemistry of Fuels
4	SET3404	SET4404	Theory	Energy Conversion and Storage
5	SET3405	SET4405	Theory	Advanced Thermodynamics of Energy Systems
6	SET3506	SET4506	Theory	Materials for Energy Applications
7	SET3507	SET4507	Theory	Energy Management

1	SEP3301	SEP4301	Laboratory	Energy Lab-I
2	SEP3402	SEP4402	Laboratory	Energy Lab-II

Petroleum and Petrochemicals

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SPT3302	SPT4302	Theory	Introduction to petroleum technology
2	SPT3403	SPT4403	Theory	Petroleum refining processes
3	SPT3404	SPT4404	Theory	Refinery engineering
4	SPT3506	SPT4506	Theory	Reservoir Technology
5	SPT3405	SPT4405	Theory	Petrochemicals technology
6	SPT3507	SPT4507	Theory	Industrial Catalysis
7	SPT3508	SPT4508	Theory	Petroleum economics and management
1	SPP3402	SPP4402	Laboratory	Petroleum Characterization Laboratory-I
2	SPP3403	SPP4403	Laboratory	Petroleum Laboratory-II

Materials and Polymers

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SMT3201	SMT4201	Theory	Introduction to Material Technology
2	SMT3302	SMT4302	Theory	Polymer science and Technology-I
3	SMT3403	SMT4403	Theory	Structure-Property Relationships
4	SMT3404	SMT4404	Theory	Polymer science and technology -II
5	SMT3405	SMT4405	Theory	Materials processing
6	SMT3506	SMT4506	Theory	Nanomaterials
7	SMT3507	SMT4507	Theory	Functional materials
1	SMP3303	SMP4303	Laboratory	Materials Characterization Laboratory
2	SMP3402	SMP4402	Laboratory	Materials processing and characterization laboratory

Textiles

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	STT3201		Theory	Technology of Fibres and Polymers
2	STT3302		Theory	Technology of Textile Dyeing
3	STT3403		Theory	Technology of Textile Printing
4	STT3404		Theory	Chemistry & Applications of Specialty Chemicals
5	STT3405		Theory	Technology of Finishing
6	STT3507		Theory	Effluent Characterisation and Treatment
7	STT3506		Theory	High-tech and Industrial Fibres
1	STP3401		Laboratory	Analysis of Fibres and fabrics
2	STP3402		Laboratory	Treatment of textiles

Detailed Syllabus

Study 1 (T1)										
Sr. No.	Type of course	IOCB Code (3)	Jalna Code (4)	Subjects	Credits	Hrs/Week				
						L	T	P	E. S.	Total
1	BS	BST3101	BST4101	Chemistry - I	4	3	1	0	30	100
2	BS	BST3102	BST4102	Physics – I	4	3	1	0	30	100
3	BS	BST3103	BST4103	Mathematics-I	4	3	1	0	30	100
4	HU	HUT3101	HUT4101	Communication Skills/English	3	2	1	0	15	50
5	CE	CET3101	CET4101	Introduction to Chemical Engineering and Chemical Industries.	0	2	1	0	15	50
6	ES	ESP3101	ESP4101	Engineering Graphics-I	3	1	0	4	25	50
7	ES	ESP3102	ESP4102	Engineering Applications of Computers-I	2	0	0	4	25	50
8	BS	BSP3101	BSP4101	Chemistry Laboratory -I	2	0	0	4	25	50
				TOTAL	**22**	**14**	**5**	**12**	**195**	**550**

				L	T	P	Tot
Course code			**BST4101**				
Course title			**Chemistry I**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			10+2 level chemistry				
Objectives of the course	**1**		To introduce the students to the fundamentals of analytical chemistry				
	2		To understand different qualitative and quantitative analytical techniques				
	3		To make the students understand organometallic chemistry and its applications				
Detailed contents							
	1		**Analytical Chemistry**	**24**	**8**		**32**
		1.1	Introduction to analytical Chemistry: Accuracy precision, Errors, Qualitative and Quantitative analysis, Analytical Perspective, Chemical concentrations. Good laboratory practices.				
		1.2	Correlation between quality and analysis. Evaluation and validation of analytical methods.				
		1.3	Statistical treatment of analytical data and presentation of results.				
		1.4	Conventional methods of analysis - Titrimetric : Principles; Equivalence point and endpoint; detection of end point.				
		1.5	Electrochemical Methods : : General principles and application of pH meter, Conductometer, Potentiometer.				
		1.6	Spectroscopic methods : Principle, Instrumentation, Applications of UV-Vis spectrophotometer and Atomic absorption spectroscopy				
		1.7	Chromatographic separation methods: General principle of chromatography, classification of chromatographic techniques. Principle, technique and applications of paper, thin layer, Ion exchange chromatographic techniques.				

		1.8	Modern Chromatographic Techniques : HPLC, GC: Principle, Instrumentation, Applications,				
	2		**Inorganic chemistry**	**6**	**2**		**8**
		2.1	*Organometallics:* Metal-ligand bonding, Concepts of sigma and pi bond formation. types of ligands, CO and PPh_3 lignads.				
		2.2	*Basic reactions of organometallic compounds:* insertion, migration, oxidative addition, reductive elimination. E.g. Wilkinsons, Grignard Reagent etc.				
			Total	**36**	**12**		**48**
Suggested books	**1**		Skoog and West's Fundamental of Analytical Chemistry, F. James Holler and Stanley R. Crouch, Cengage Learning				
	2		Instrumental methods of Chemical Analysis, E.W. Ewing, McGraw Hill.				
	3		Instrumental methods of analysis, D.A. Skoog and D.M. Wes				
	4		Concise Inorganic Chemistry, J.D. Lee, Wiley India Edition				
	5		Basic Inorganic Chemistry, F.A. Cotton and G. Wilkinson, John Wiley and Sons				
	6		New Instrumental Methods in Electrochemistry, P.D. Delaha				
	7		Radiochemistry and nuclear chemistry: G.R. Choppin, J. Rydberg, J.O. Lilgenzin, C. Ekberg, AP				
Outcomes			Students will learn				
	CO1		Students will learn basic principles of chemical analysis				
	CO2		Student will able to select chemical and instrumental methods for qualitative and quantitative analysis				
	CO3		Student will learn concept of organometallic chemistry and its application in organic transformation				
Course code			**BST4102**				
Course title			**Physics – I**				
Scheme and Credits			**3L: 1T: 0P 4 credits**				
Pre-requisites			10+2 level Physics				
Objectives of the course	**1**		To understand basic concepts of Solids and Semiconductors, Fluid Mechanics, Optics and its applications and ultrasonics.				
			Detailed contents				
	1		**Solid State Physics**	**9**	**3**		**12**
		1.1	Crystal structure of solids: unit cell, space lattices and Brava is lattice, Miller indices, direction sand crystallographic planes, Cubic crystals: SSC,BCC,FCC,				
		1.2	Diamond cubic structure, hexagonal crystals: HCP, atomic radius, packing fraction, Bragg's law of x-ray diffraction, determination of crystal structure using Bragg spectrometer, liquid crystals: introduction, types, phases and applications				
		1.3	Semiconductor Physics: Formation of energy bands in solids, concept of Fermi level,				
		1.4	Classification of solids: conductor, semiconductor and insulator, intrinsic and extrinsic semiconductors, effect of doping, mobility of charge carriers, conductivity, Hall effect.				
	2		**Fluid Mechanics**	**6**	**3**		**9**
		2.1	Basic concepts of density and pressure in a fluid, ideal and real fluids				
		2.2	Pascal's law, absolute pressure and pressure gauges				

		2.3	Basic concepts of surface tension and buoyancy				
		2.4	Equation of continuity, Bernoulli's equation				
		2.5	Viscosity, Newton's Law of viscosity, non newtonian fluids				
	3		**Optics and Fibre Optics**	**6**	**3**		**9**
		3.1	Diffraction: Introduction to interference and example; concept of diffraction, Fraunhofer and Fresnel diffraction Fraunhofer diffraction at single slit, double slit, and multiple slits; diffraction grating, characteristics of diffraction grating and its applications, magnification and resolution.				
		3.2	Polarisation: Introduction, polarisation by reflection, polarisation by double refraction, scattering of light, circular and elliptical polarisation, optical activity.				
		3.3	Fibre Optics: Introduction, optical fibre as a dielectric wave guide: total internal reflection, numerical aperture and various fibre parameters, losses associated with optical fibres, step and graded index fibres, application of optical fibres.				
	4		**Lasers**	**6**	**3**		**9**
		4.1	Introduction to interaction of radiation with matter, principles and working of laser: population inversion, pumping, various modes, threshold population inversion, types of laser: solid state, semiconductor, gas; application of lasers, applications:				
		4.2	Introduction to interaction of radiation with matter, principles and working of laser				
		4.3	population inversion, pumping, various modes, threshold population inversion				
		4.4	types of laser: solid state, semiconductor, gas				
		4.5	Holography and engineering applications				
	5		**Ultrasound**	**6**	**3**		**9**
		5.1	Generation of ultrasound: mechanical, electromechanical transducers				
		5.2	Propagation of ultrasound, attenuation, velocity of ultrasound and parameters affecting it, measurement of velocity				
		5.3	Applications of ultrasound				
			Total	**33**	**15**	**0**	**48**
Suggested books	**1**		Physics: Vols. I and II– D. Halliday and R. Resnick,Wiley Eastern.				
	2		Lectures on Physics: Vols. I, II and III –R.P. Feynman, R.B. Leighton and M. Sands, Narosa.				
	3		Concepts of Modern Physics– A. Beiser, McGraw-Hill.				
	4		Introduction to Modern Optics – G.R. Fowles, Dover Publications.				
	5		A Course of Experiments with LASERs– R. S. Sirohi, Wiley Eastern.				
	6		Optical Fibre Communication – G. Keiser, McGraw-Hill.				
	7		Optoelectronics –J. Wilson and J.F.B. Hawkes, 2nd ed, Prentice-HallIndia.				
	8		Ultrasonics: Methods and Applications–J.Blitz, Butterworth.				
	9		Applied Sonochemistry –T. J. Mason and J.P. Lorimer, Wiley VCH.				

Outcomes			**Students will be able to**				
	CO1		Understand structures of solids and semiconductors, apply Bragg's law.				
	CO2		Apply Bernoulli equation in simple pipe flows.				
	CO3		Calculate resolving power of optical instruments.				
	CO4		Describe principles of optical fibre communication.				
	CO5		Introduced to the principles of lasers, types of lasers and applications.				
	CO6		Understand application of acoustic cavitation of Chemical Engineering Processes				

Course code			**BST4103**				
Course title			**Mathematics-I**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			10+2 level Mathematics				
Objectives of the course	**1**		To introduce basic concepts of Linear algebra				
	2		Differential calculus				
	3		Integral calculus				
	4		Vector calculus				
			Detailed contents				
	1		Differential calculus:	**6**	**2**		**8**
		1.1	Higher order derivatives, Mean value theorems, Taylor's theorem and error calculations, convexity of functions, Local Maxima/Minima.				
		1.2	Functions of two or more variables, Limit and continuity, Partial differentiation, Directional derivatives, Total derivatives, Chain Rules of partial derivatives, Taylor's theorem for multivariable functions and its application to error calculations, Local and absolute Maxima/Minima				
	2		Improper integrals, beta and gamma functions, differentiation under the integral sign, multiple integrals and its application, Error function	**6**	**2**		**8**
	3		Vector differential calculus	**9**	**3**		**12**
		3.1	Vectors in 2-Space and 3-Space: Systems of linear equations, matrices and Gauss elimination, Vectors in IRn, notion of linear independence and dependence.				
		3.2	Inner Product (Dot Product), Vector Product (Cross Product), Vector subspaces of IRn, basis of a vector subspace., row space, null space, and column space, rank of a matrix. Determinants and rank of matrices.				
		3.3	Abstract vector spaces, linear transformations, matrix of a linear transformation, change of basis and similarity, rank-nullity theorem and its applications				
		3.4	Vector and Scalar Functions and Fields, Derivatives				
		3.5	Gradient of a scalar field, Directional Derivative				
		3.6	Divergence of a vector field				
		3.7	Curl of a vector field				
	4		Inner product spaces, orthonormal bases, Gram-Schmidt orthogonalization process, Eigenvalues and eigenvectors, characteristic polynomials, eigenvalues of special matrices (orthogonal, unitary, Hermitian, symmetric, skew- symmetric, normal), Orthogonal projection and its application to least methods Diagonalization of matrices and its applications stochastic matrices, Matrix Factorization, Applications such as SVD, PCA etc.	**5**	**2**		**7**

	5		Vector integral calculus	**7**	**3**		**10**
		5.1	Line Integrals, Path Independence of Line Integrals				
		5.2	Green's Theorem in the Plane				
		5.3	Stokes' theorem and Surface Integrals				
		5.4	Divergence theorem and volume integral				
	6		First-Order ODEs-Introduction, formation and solutions of 1st order ODEs	**2**	**1**		**3**
			Total	**35**	**13**	**0**	**48**
Suggested books	**1**		Advanced Engineering Mathematics, Erwin Kreyszig, John-Wiley.				
	2		Advanced Engineering Mathematics S. R. K. Iyengar, R. K. Jain, Narosa.				
	3		Vector Calculus 4th Edition by Susane Jane Colly, Pearson				
	4		Advanced Engineering Mathematics by D. S. Zill and W. S. Right, Jones & Bartlett Student Edition, 2011.				
	5		Textbook of Engineering Mathematics, N. P. Bali and Dr. Manish Goyal, 8/e, Laxmi Publications, New Delhi				
Outcomes			**Students will be able to solve problems related to**				
	CO1		Matrix and vector operations				
	CO2		Differential and integral calculus				
	CO3		Vector calculus and applications				

Course code			**ESP4101**				
Course title			**Engineering Graphics-I**				
Scheme and Credits			**1 L: 1 T: 4 P 3 Credits**				
Pre-requisites			10+2 level chemistry				
Objectives of the course	**1**		Students will be able to understand different drawing view, assembly and working of different machines parts and understanding and preparing Computer aided drawings				
			Detailed contents				
	1		Orthographic views : Lines used, selection of views, spacing of views. ISI conventions used In drawing , dimensioning and sections. Drawing required views from given pictorial views (conversion of pictorial views in to orthographic views).	**3**		**9**	**12**
	2		Isometric projections : Isometric scale, Isometric projections and Isometric views / drawings. Circles in isometric view. Isometric views of simple solids and objects.	**3**		**9**	**12**
	3		Missing Views : Reading and understanding drawing views, Drawing third view when two views are given.	**3**		**9**	**12**
	4		Introduction to Assembly and detailed drawing. Preparation of assembly drawing from detailed drawing and vice versa. Assembly such as Plummer block, Stuffing box , valves and pipe joints etc.	**3**		**9**	**12**
	5		Introduction to solid works software for preparing part drawings, assembly drawings and drawing views.	**3**		**9**	**12**
			Total	**15**	**0**	**45**	**60**
Suggested books							
	1		N. D. Bhatt, Engineering Drawing, Charotor Publication House, Bombay				
	2		W. J. Luzadder, Fundamentals of Engineering Drawing, Prentice Hall of India.				

	3		N. D. Bhatt, Machine Drawing, Charotor Publication House, Bombay				
	4		K. Venugopal, Engineering Drawing and Graphics, New Age Publication				
	5		R. K. Dhawan, A text book of Engineering Drawing, S. Chand and Co.				
	6		K. L. Narayana, Machine Drawing, New Age Publication				
	7		N. B. Shaha and B. C. Rana, Engineering Drawing, Pearson Education.				
Outcomes							
			Students will be able to				
	CO1		Different drawing views and its interpretation.				
	CO2		Assembly of different machine parts and its working.				
	CO3		Computer aided drawing.				

Course code			**HUT4101**				
Course title			**Communication Skills**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			10+2 English				
Objectives of the course	**1**		This is an important course for the effective functioning of an Engineer. Communication skills are required in all courses				
			Detailed contents				
	1		Introduction to communication skills	**5**	**3**		
	2		Writing Skills: Technical report writing, scientific paper writing, Review paper writing, letter drafting, email writing, Resume Writing, Job Application/ Cover Letter Writing, etc.	**5**	**3**		
	3		Speaking Skills: Presentation skills- Planning and Preparation; Use of Body Language; Dealing with Mental Blocks & Stage Fright	**5**	**3**		
	4		Use of audio-visual facilities like powerpoint, LCD. for making effective oral presentation.	**5**	**3**		
	5		Group Discussions	**2**	**1**		
			Total	**0**	**0**	**0**	**36**
Suggested books			Elements of Style – Strunk and white				
			Raman, Meenakshi and Sangeeta Sharma. Technical Communication. New Delhi: Oxford University Press. 2018.				
			Sharma, S. D. A Textbook of Scientific and Technical Communication Writing for Engineers and Professionals. New Delhi: Sarup and Sons. 2007				
Outcomes			**Students will learn**				
	CO1		Students should be able to write grammar error free technical reports in MS Words or equivalent software.				
	CO2		Students should be able to make power point slides in MS PowerPoint or equivalent software.				

Course code			**BSP4101**				
Course title			**Chemistry Lab-I**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			10+2 level chemistry				
Objectives of the course	**1**		To learn to prepare standard solutions and volumetric titration				
	2		To learn the quality and quantitative of a sample through different analytical methods				

	3		To learn to collect, collate, and interpret results				
Detailed contents				**0**	**0**	**48**	
	1		Preparation and standardization of volumetric solutions.				
	2		Potentiometric titration: (i) Determination of the strength of weak and strong acids in a mixture of acids.				
	3		Conductometric titration: Determination of total dissolved sulphate in water sample				
	4		Use of pH meter- (i) Use of a pH meter to determine dissociation constant of an acid, isoelectric point of an amino acid.				
	5		UV-Vis spectroscopy: i) to find out the absorption maxima, ii) Beers Lambert Law verification and iii) concentration of a substance from a given sample.				
	6		Separation of compounds by Thin layer chromatography.				
	7		Gas Chromatography: (i) Determination of concentration of a known organic compound in a suitable solvent. (ii) Qualitative Analysis of Hydrocarbon by Gas Chromatography				
	8		High pressure liquid Chromatography (HPLC) Determining the concentration of an active ingredient in a marketed product, for Example: caffeine (food products), vitamin C, paracetamol (pharmaceutical product), and the like.				
			Total	**0**	**0**	**48**	**48**
Outcomes							
			Students will be able to				
	CO1		Able to prepare and standardized analytical solutions				
	CO2		Able to plan simple analytical experiments for analyte determination				
	CO3		Able to perform qualitative and quantitative analysis of given sample using chromatographic techniques				
	CO4		Able to clearly communicate the results of experimental work in oral and written formats.				

Course code			**ESP4102**				
Course title			**Engineering Applications of Computers-I**				
Scheme and Credits			**0 L: 0T: 4 P 2 Credits**				
Pre-requisites			10+2 level Mathematics				
Objectives of the course	**1**		To make students familiar with the use of computers for scientific calculations, use of programming languages and the logic for writing computer programs and algorithm development involving problems discussed in the theory.				
Detailed contents							
	1		Introduction to computer programming languages.	**0**	**0**	**12**	**12**
			Brief introduction to Python, Installation of python and Anaconda				
			Data types, variables, mathematical operations and expressions, Use of python as an advanced scientific calculator with **math** and **cmath** modules				
	2		Logical operators, Control Flow (if-else, switch case, etc.) and Loops	**0**	**0**	**12**	**12**
			Functions and Modules, Object Oriented Programing				
			Dealing with strings, Lists, tuples, Dictionaries				
			File management.				

	3		Algorithm development, arrays, matrices, and matrix algebra	**0**	**0**	**8**	**8**
	4		Plotting graphs in various format using Matplotlib	**0**	**0**	**4**	**4**
	5		Use of Numpy, Scipy and Sympy to solve problems related to matrices, solutions linear and nonlinear equations and single variable calculus.			**8**	
	6		GUI with Python			**4**	
			Total	**0**	**0**	**48**	**36**
Suggested books			Sandeep Nagar, Introduction to Python for Engineers and Scientists. Open Source Solutions for Numerical Computation-Apress (2018) Reema Thareja, Python Programming: Using Problem Solving Approach, Oxford University Press, 2017 Fangoh, Introduction to Python for Computational Science and Engineering, Open Source, available on github.				
Outcomes			Students will able to				
	CO1		use of Numpy, Scipy and Sympy to solve problems related to matrices, solutions linear and nonlinear equations and single variable calculus.				
	CO2		write Python programme to solve simple mathematical and numercial problems.				

Study 2 (T2)										
			Code	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
9	BS	BST3104	BST4104	Chemistry-II	4	3	1	0	50	100
10	BS	BST3105	BST4105	Physics -II	3	2	1	0	50	100
11	BS	BST3106	BST4106	Mathematics-II	4	3	1	0	50	100
12	CE	CET3102	CET4102	Material & Energy Balance Calculations	4	3	1	0	50	100
13	CE	CET3103	CET4103	Chemical Engineering Thermodynamics - I	3	2	1	0	50	100
14	HU	HUP3101	HUP4101	Chemistry Laboratory-II	2	0	0	4	50	100
15	BS	BSP3102	BSP4102	Engineering Applications of Computers-II	3	1	0	4	50	100
16	ES	ESP3102	ESP4102	Physics Laboratory	2	0	0	4	50	100
				TOTAL	**25**	**14**	**5**	**12**	**400**	**800**

				L	**T**	**P**	**Tot**
Course code			**BST4104**				
Course title			**Chemistry II**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			10+2 level chemistry				
Objectives of the course	**1**		To train the students in understanding the reactivity and mechanism of organic reactions				
	2		To train students for differentiate the organic symmetric and asymmetric compounds				
	3		To understand the well-known name reactions and its applications in Industry.				
	4		To determine the structures of unknown compounds using spectroscopic methods				
Course title			**Detailed contents**				
Chemistry-II	**1**		**IUPAC nomenclature of organic compounds**	**3**	**1**	**0**	**4**
	2		Stereochemistry: 2.1 Stereodescriptors: R, S, E, Z. Enantiomers and Diastereomers. 2.2 Racemates and their resolution. 2.3 Conformations of cyclic and acyclic systems. 2.4 Introduction to chiral synthesis	**5**	**2**	**0**	**7**
	3		Reactivity of organic molecules: 3.1 Structures and Chemical bonding, FMO 3.2 Factors influencing acidity, basicity, and reactivity of organic compounds. 3.3 Kinetic vs. thermodynamic control of reactions 3. 4 Principles of mechanism of organic reactions: intermediates, EPD.	**10**	**2**		**12**
	4		4.1 Aromaticity of carbocyclic and heterocyclic compounds structure and reactions 4.2 Mechanism of electrophilic and nucleophilic aromatic substitution reactions 4.3 Orienting influence of substituents.	**8**	**2**		**10**
	5		5.1 Friedel-Crafts and related reactions Gatterman,-Koch, Hoesch Reaction	**4**	**2**		**6**
	6		6.1 Polymerization of olefins, characteristic properties of polymers	**2**			**2**
	7		Organic Molecules Characterizations by	**4**	**2**		**6**
		7.1	NMR, 1H NMR				
		7.2	IR				
		7.3	Mass Spectrometry Simple NMR, Mass spectra and IR combined make quick identification possible				

			Total	**36**	**12**		**48**
Suggested books	**1**		Organic chemistry – T. W. G Solomons, C. B. Fryhle, John Wiley and Sons				
	2		Organic chemistry, Clayden, Greeves, Warren, Oxford publication				
	3		Organic Chemistry, Paula Y Bruce, Pearson Education				
	4		March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure 7 Edition (English, Paperback, Michael B. Smith)				
Outcomes			**Students will be able to solve problems related to**				
	CO1		Draw the chemical structures of organic molecules.				
	CO2		Determine the reactivity of organic compounds				
	CO3		Draw the 3D structures and stereochemistry of organic compounds				
	CO4		Solve the problems of how reaction takes place.				
	CO5		Write simple reaction mechanisms and justify the product				
	CO6		Find out the structures of unknown compound by using spectroscopic method				
				L	**T**	**P**	**Tot**
Course code			**BST4105**				
Course title			**Physics – II**				
Scheme and Credits			**2L: 1T: 0P 3 credits**				
Pre-requisites			10+2 level Physics				
Objectives of the course			To understand dual nature of matter, applications, properties of materials in engineering and processes.				
			Detailed contents				
	1		**Quantum Mechanics**				
			Introduction to quantum physics blackbody radiation, explanation using the photon concept, photoelectric effect, Compton effect, deBroglie hypothesis, wave-particle duality, Born's interpretation of the wave function, verification of matter waves, uncertainty principle, Schrodinger wave equation, particle in box, quantum harmonic oscillator, hydrogen atom (no detailed derivation), tunneling effect and scanning tunneling microscopy, probe microscopy	**7**	**2**		**9**
	2		**Electromagnetism**				
			Introduction to the 'del' operator and vector calculus, revision of the laws of electrostatics, electric current and the continuity equation, revision of the laws of magnetism.	**7**	**2**		**9**
	3		**Dielectric Properties of Materials**				
			Polarisation, permeability and dielectric constant, polar and non-polar dielectrics, internal fields in a solid, Clausius-Mossotti equation, applications of dielectrics.	**4**	**2**		**6**
	4		**Magnetic Properties of Materials**				
			Magnetisation, permeability and susceptibility, classification of magnetic materials, ferromagnetism, magnetic domains and hysteresis, applications.	**4**	**2**		**6**
	5		**Superconductivity**				
			Introduction of the superconductivity, behavior of perfect conductor, Meisner effect, London penetration depth, Heat capacity, Isotope effect, the BCS theory, Type-I superconductor, Type-II superconductor, Josephson Effect, Application, Josephson junction switch, Squids.	**4**	**2**		**6**
			Total	**26**	**10**	**0**	**36**

Suggested reference books			1) Physics: Vols. I and II– D. Halliday and R. Resnick, Wiley Eastern. 2) Lectures on Physics: Vols. I, II and III –R.P. Feynman, R.B. Leighton and M. Sands, Narosa. 3) Concepts of Modern Physics– A. Beiser, McGraw-Hill. 4) Introduction to Electrodynamics – D. J. Griffiths, 1999, Person Education. 5) Foundations of Electromagnetic Theory - Reitz, John R.; Milford, Frederick J.; Christy, Robert W. (2008), Addison Wesley. 6) Fundamentals of Modern Physics, Robert Martin Eisberg, 1961, John Wiley. 7) A Textbook of Engineering Physics, MN Avadhanulu, PG Kshirsagar, TVS Arunmurthy, S. Chand.				
Outcomes			**Students will be able to**				
	CO1		Perform simple quantum mechanics calculations.				
	CO2		Define various terms related to properties of materials such as, permeability, polarization, etc.				
	CO3		Understand the phenomenon of superconductivity and types of superconductor				
				L	**T**	**P**	**Tot**
Course code			**BST4106**				
Course title			**Mathematics-II**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			10+2 Mathematics				
Objectives of the course	**1**		To introduce basic concepts and some solution techniques of linear ordinary and partial differential equations				
	2		To introduce concept of eigen values and eigen vectors				
	3		To introduce concept of integral transforms and solution of some linear ordinary and partial differential equations				
			Detailed contents				
	1		Higher-Order Linear ODEs: Homogeneous / Non-homogeneous linear ODEs of second and higher order with constant coefficients. Concepts of initial and boundary value problems and some applications. Wronskian, fundamental solution, basis, linear dependence and independence of solutions. Solution by Variation of Parameters. Euler-Cauchy Equations	**9**	**3**		**12**
	2		Series Solutions of ODEs and Special Functions: Power Series Method (Frobinuous method)-Legendre's Equation, Legendre Polynomials, Bessel's Equation, Bessel Functions, Orthogonal and Orthonormal Functions	**9**	**3**		**12**
	3		Eigenvalues, Eigenfunctions, Applications of Eigenvalue problems, Symmetric, Skew-symmetric and Orthogonal matrices, Sturm-Liouville Problems	**3**	**1**		**4**
	4		Partial Differential Equations : Origin of partial differential equations, Classification of first order PDE. Solution of some first order PDEs-Lagrange's method. Classification of second order PDE and their solutions by Separation of Variables (Parabolic, Elliptic, Hyperbolic)	**6**	**2**		**8**

	5		Transforms : Laplace Transforms, Fourier Series and Transform, z-transforms Application of transforms to ODE and PDE	**8**	**4**		**12**
			Total	**35**	**13**	**0**	**48**
Suggested reference books			Advanced Engineering Mathematics, Erwin Kreyszig, John-Wiely. Advanced Engineering Mathematics S. R. K. Iyengar, R. K. Jain, Narosa				
Suggested reference books			• Elements of Partial Differential Equations by I. N. Sneddon, Dover Publications, INC. 2006 • An Introduction to Ordinary Differential Equations by Earl A. Coddington, Dover Publications • Advanced Engineering Mathematics by D. S. Zill and W. S. Right, Jones & Bartlett Student Edition, 2011. • William E. Boyce, Richard C. DiPrima, Elementary Differential Equation, Wiley				
Outcomes			Students will be able to solve				
	CO1		first and second order ODE by Analytical methods				
	CO2		second order ODEs by power series methods.				
	CO3		linear first and second order PDE by Analytical methods				
	CO4		ODE's and PDE's by using Laplace and Fourier Transforms.				

Course code			**CET4102**				
Course title			**Material and Energy Balance Calculations**				
Scheme and Credits			**3L: 1T: 0P 4 credits**				
Pre-requisites			XIIth Standard Mathematics, Chemistry, Physics, Applied Mathematics – I, Organic Chemistry – I, Applied Physics – I, Analytical Chemistry,				
Objectives of the course	**1**		This is a basic Chemical Engineering Course. This knowledge will be required in ALL subjects later on.				
			Detailed contents				
	1		Introduction to Chemical Engineering: Chemical Process Industries, Chemistry to Chemical Engineering, Revision of Units and Dimensions	**2**	**1**		**3**
	2		Mole concept, composition relationship and Stoichiometry, Behaviour of gases and vapors	**3**	**1**		
	3		Material balances for reacting and non-reacting chemical and biochemical systems including recycle, bypass and purge	**12**	**4**		
	4		Introduction to psychrometry humidity and air-conditioning calculations.	**8**	**2**		
	5		Introduction to Energy Balances, Energy Balances in systems with and without reactions	**8**	**2**		
	6		Unsteady State Material and Energy Balances	**3**	**2**		**5**
			Total	**36**	**12**	**0**	**48**
Suggested booksreference			1) Chemical Process Principles, Hougen O.A., Watson K. M. 2) Basic Principles and Calculations in Chemical Engineering, Himmelblau, 3) Stoichiometry, Bhatt B.I. and Vora S.M.				
Outcomes			**Students will be able to solve problems related to**				
	CO1		Students will be able to convert units of simple quantities from one set of units to another set of units				
	CO2		Students will be able to calculate quantities and /or compositions, energy usages, etc. in various processes and process equipment such as reactors, filters, dryers, etc.				

Course code			**CET4103**				
Course title			**Chemical Engineering Thermodynamics –I**				
Scheme and Credits			**3L: 1T: 0P 3 credits**				
Pre-requisites			XIIth Standard Mathematics, Chemistry, Physics, Applied Mathematics – I, Organic Chemistry – I, Applied Physics – I, Analytical Chemistry,				
Objectives of the course	**1**		Objectives of the course Principles and application of first and second law of thermodynamics, and phase equilibria. Students should be able to apply mass and energy balances to closed and open systems. They should be able to evaluate the properties of nonideal gases and solve problems involving liquefaction, refrigeration and different power cycles.				
			Detailed contents				
	1		Phases, phase transitions, PVT behaviour; description of materials: Ideal gas law, van der Waals, virial and cubic equations of state; Reduced conditions & corresponding states theories; correlations in description of material properties and behaviour	**4**	**2**		**6**
	2		State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V,T processes; Energy conservation & first law of thermodynamics; Mass and energy balances for open systems, nozzles, diffuser, turbines and pump	**4**	**2**		**6**
	3		Statements of the second law; Heat engines, Carnot's theorem, Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work	**4**	**2**		**6**
	4		Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties	**4**	**2**		**6**
	5		Thermodynamic analysis of flow process, steam power plants; Rankine cycle; Internal combustion engine, Otto engine, diesel engine; Jet engine.	**4**	**2**		**6**
	6		Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes.	**4**	**2**		**6**
			Total	**24**	**12**	**0**	**36**
Suggested reference books			1. Introduction to Chemical Engineering Thermodynamics: Smith, van Ness, Abbott 2. Chemical, Biochemical and Engineering Thermodynamics: S. I. Sandler 3. Phase Equilibria in Chemical Engineering: Walas 4. Molecular Thermodynamics of Fluid Phase Equilibria: Prausnitz				
Outcomes			**Students will be able to solve problems related to**				
	CO1		Perform energy balance calculations in accordance with the first law of thermodynamics				
	CO2		Perform entropy balance calculations ic accordance to the second law of thermodynamics				
	CO3		Perform P, V, T calculations and estimate other thermodynamic properties based on equations of state				
	CO4		Perform analysis of thermodynamic cycles, estimation of efficiency, etc.				

Course code			**BSP4102**				
Course title			**Chemistry Lab-II**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			10+2 level chemistry				
Objectives of the course	**1**		To train the students to identify simple organic compounds				
	2		To train the students to synthesize synthesis and , purify and analyse organic compounds				
Detailed contents			1. Identification of organic molecules based on physicochemical properties: Organic compounds contain different functional groups which undergo characteristic reactions. 1.1. Physical properties such as solubility and chemical reactivity in known reactions will also be used in the identification. 1.2. Identification of an organic compounds by physical constants methods (melting point and boiling point).				
			2. Purification of organic compounds, liquid-liquid, inorganic-organic, solid-liquid mixtures.				
			3. Organic Synthesis: 3.1. One-step synthesis of organic compounds 3.2. Common synthetic methods using in reactions for the synthesis of pharmaceutical and biological importance molecules and optimization of reaction conditions. 3.3. Progress of the reactions monitoring by thin layer chromatography (TLC) and IR analysis.				
			4. Organic Sample characterization IR, Mass Spectrometry, GC-MS, NMR 4.1. Spectroscopic techniques like IR and NMR will be utilized to elucidate the structure of organic compounds.				
			5. Size Exclusion Chromatography: determination of molecular weight of macromolecules				
			Total	**0**	**0**	**48**	**48**
Outcomes							
			Students will be able to				
	CO1		Identify simple organic compounds systematically				
	CO2		Determine the synthetic route of known organic compound.				
	CO3		Judge the chemical reactions with specific functional groups				
	CO4		Purify organic compound based on physical properties.				
Course code			**BSP4103**				
Course title			**Physics Laboratory**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			10+2 level chemistry				
Objectives of the course	**1**		Operating basic devices measurment of voltage, current and photocurrent. Exploring source of monochromatic light and its operation and applications.				
Detailed contents							
	1		LASER diffraction-grating experiment				
	2		Hall effect				
	3		Photoelectric effect				
	4		Ultrasonic-velocity of sound in liquid measurement				

	5		Thermistor				
	6		Viscosity of liquid-measurement				
	7		Determination of Angle of prism and angle of minimum deviation by using prism				
	8		Determination refractive index of prism using spectrometer				
	9		Dispersion of light and determination of Wavelength by using Prism				
	10		Newton's rings				
	11		Surface tension				
	12		Determination of nanoparticle size through diffraction grating technique				
			Total	**0**	**0**	**48**	**48**
Suggested books	**1**		Physics: Vols. I and II D. Halliday and R. Resnick, Wiley Eastern.				
	2		A Course of Experiments with LASERs– R. S. Sirohi, Wiley Eastern.				
	3		Optoelectronics –J. Wilson and J.F.B. Hawkes, 2nd ed, Prentice-Hall India.				
	4		Ultrasonics: Methods and Applications–J.Blitz, Butterworth.				
Outcomes			**Students will be able to**				
	CO1		Understand monochromatic light source and its applications.				
	CO2		Understand engineering applications of lasers				
	CO3		Measure thermal conductivity, photoelectric current, effect of magnetic field on electric current and its applications				

Study 3 (T4)										
			Code	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
18	BS	BST3201	BST4201	Chemistry - III	4	3	1	0	30	100
19	BS	BST3202	BST4202	Introduction to Biological Sci. & Bioeng.	4	3	1	0	30	100
20	CE	CET3201	CET4201	Momentum Transfer	4	3	1	0	30	100
21	CE	CET3202	CET4202	Chem Engg Thermodynamics - II	3	2	1	0	15	50
22	ES	EST3201	EST4201	Engineering and solid Mechanics	3	2	1	0	15	50
23	ES	EST3202	EST4202	Electrical Engineering and Electronics	3	2	1	0	15	50
24	ES	ESP3201	ESP4201	Engineering Laboratory	2	0	0	4	25	50
25	ES	ESP3202	ESP4202	Engineering Applications of Computers-III	3	1	0	4	25	50
				TOTAL	**26**	**16**	**6**	**8**	**185**	**550**

Course code			**BST4201**	**L**	**T**	**P**	**Tot**
Course title			**Chemistry III**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			10+2 level chemistry				
Objectives of the course	**1**		To train the students about reaction kinetics, electrochemistry, interfacial chemistry and catalysis, beyond +2 level				
Course title			**Detailed contents**				
	1		Kinetics	**8**	**2**		**10**
		1.1	Review of rate of reaction, rate constant, effects of the following on rate of reaction: concentration, temperature.				
		1.2	Derivation of rate expression for Second order reactions, Complex reactions: parallel, consecutive, reversible, chain, steady state reactions.				
		1.3	Kinetics and reaction mechanism				
		1.4	Theories of reaction rate				
	2		Electrochemistry	**8**	**2**		**10**
		2.1	Conductance and transport number				
		2.2	Electromotive force				
		2.3	Electrochemical methods of analysis: Controlled current and controlled potential principles, amplifiers, potentiostat, galvanostat, cyclic voltammetry, chronoamperometry, chronopotentiometry.				
		2.4	Fuels cells, batteries, corrosion				
	3		Surface and Interfacial chemistry	**10**	**4**		**14**
		3.1	Surfaces and interfaces: Surface/interfacial energy and surface/ interfacial tension. Measurement of surface tension				
		3.2	Thermodynamics of surfaces: Gibbs adsorption equation and isotherms. Curved surfaces: Young, Laplace, Kelvin and Thompson equation.				
		3.3	S-L interface: Contact angle, its measurement and wetting phenomena, adhesion, and cohesion.				
		3.4	L-L interface: Surface active agents: Types and applications. Surfactant aggregates. Emulsions, gels, foams, and microemulsions: preparation, stability and applications				
	4		Catalysis	**10**	**4**		**14**
		4.1	Heterogeneous catalysis				
		4.2	Preparation of catalysts, characterization of catalysts, catalyst deactivation.				
		4.3	Kinetics of reactions on solid surfaces				

		4.4	Enzyme and photo- catalysis				
			Total	**36**	**12**		**48**
Suggested books			1. Organic chemistry – T. W. G Solomons, C. B. Fryhle, John Wiley and Sons 2. Organic chemistry, Clayden, Greeves, Warren, Oxford publication 3. Organic Chemistry, Paula Y Bruce, Pearson Education				
Suggested books			1. Physical Chemistry, P.W. Atkins and J. D. Paula, 8th Edition, Oxford University Press. 2. Physical Chemistry, K.J. Laidler and J.M. Meiser, 2nd Edition, CBS Publishers 3. Physical Chemistry: A Molecular Approach, D.A. Mcquarrie and J.D. Simon				
Suggested reference books			1. Chemical Kinetics and Catalysis, R.J. Masel, John Wiley and Sons1 2. Chemical Kinetics and Reaction dynamics, Paul H. Houston, McGraw Hill 3. Catalytic Chemistry, Bruce C Gates, John Wiley and Sons 4. Principles of Heterogeneous Catalysis, J.M. Thomas and W.J. Thomas, John Wiley and Sons.				
Outcomes			**Students will be able to**				
	CO1		1. understand kinetics, write rate expressions and predict mechanism of simple reactions based on kinetics.				
	CO2		2. understand electrochemical phenomena and application of analytical methods based on them.				
	CO3		3. understand surface and interfacial phenomena and use them.				
	CO4		4. learn the principles, design, and applications of catalysis.				
Course code			**BST4202**				
Course title			**Introduction of Biological Sciences and Bioengineering**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Xth Standard Biology course, Physical Chemistry				
Objectives of the course	**1**		To understand basic principles of biochemistry, genetics, molecular biology, and cell biology. Biological function at the molecular level is particularly emphasized and covers the structure and regulation of genes, as well as, the structure and synthesis of proteins, how these molecules are integrated into cells, and how these cells are integrated into multicellular systems and organisms. The course also offers important contribution to understand chemical reactions present in living organisms. A cell is the smallest self-preserving and self-reproducing unit. Many complex chemical reactions and complex transport processes occur. A cell looks like a chemical plant.				
Course title			**Detailed contents**				
	1		Introduction to cells, Eukaryotes and prokaryotes, Microscopy and cell architecture	**3**	**1**		**4**
	2		Chemical Components of the cell, Chemical bonds and groups, The chemical properties of water, An outline of	**3**	**1**		**4**

			some of the types of sugar, Fatty acids and other lipids, The 20 amino acids found in proteins, A survey of the nucleotides, The principal types of weak noncovalent bonds				
	3		Energy, Catalysis, and Biosynthesis, Free energy and biological reactions	**3**	**1**		**4**
	4		Protein Structure and Function, A few examples of some general proteins, Four different ways of depicting a small protein, Making and using antibodies, Cell breakage and initial fractionation of cell extracts, Protein separation by chromatography, Protein separation by electrophoresis	**3**	**1**		**4**
	5		DNA and Charomosomes, DNA replication, repair and recombinations, From DNA to Protein: How Cells Read the Genome, Control of Gene Expression	**3**	**1**		**4**
	6		How Genes and genome evolve, analyzing genes and genomes	**3**	**1**		**4**
	7		Membrane Structure, Membrane Transport	**3**	**1**		**4**
	8		How Cell Obtain energy from food, Glycolysis, the complete citric acid cycle, Energy Generation in Mitochondria and Chloroplasts, Redox potentials	**6**	**2**		**8**
	9		Intracellular compartment and transport, cell communication, cytoskeleton, cell division	**3**	**1**		**4**
	10		Sex and Genetics	**3**	**1**		**4**
	11		Bioengineering, tissues, stem cells and cancer	**3**	**1**		**4**
			Total	**36**	**12**		**48**
Suggested books /reference books			1) Essential cell biology, Bruce Alberts et al, 3rd Edition, ISBN 978-0-8153-4129-1 Garland Science, Taylor & Francis Group 2) Lehninger Principles of Biochemistry, 3) David L. Nelson, Albert L. Lehninger, Michael M. Cox ISBN 071677108X, 9780716771081				
Outcomes			**Students will be able to**				
	CO1		Identify the general structure and function of carbohydrates, phospholipds, proteins, enzymes and nucleic acids.				
	CO2		Outline the general processes used by the cell to generate cellular energy from sugar and to generate the energy and reducing agent needed for the citric acid cycle.				
	CO3		Describe how DNA was shown to be the genetic material and how DNA is copied.				
	CO4		Describe the structure and regulation of genes, and the structure and synthesis of proteins.				
	CO5		Predict the results of genetic crosses involving two or more traits when the genes involved are linked or unlinked.				
	CO6		Describe how cell divides and mutation takes place.				
	CO7		Describe different microorganism and their reproduction cycles				

Course code			**CET4201**	**L**	**T**	**P**	**Tot**
Course title			**Momentum Transfer**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			XIIth Standard Physics and Mathematics, Applied Physics – I and II, Applied Mathematics – I and II				

Objectives of the course	**1**		This basic course introduces concepts of momentum transfer to students. Various concepts such as pressure, momentum, energy are introduced. Laws related to conservation of momentum, energy are taught. Applications of these laws to various engineering situations and process equipment is explained with the help of several problems				
Course title			**Detailed contents**				
	1		Fluid Statics and applications to engineering importance.	**3**	**1**		**4**
	2		Equations of Continuity and Motion (Cartesian, cylindrical, and spherical coordinates) in laminar flows and its applications for the calculation of velocity profiles, shear stresses, power, etc. in various engineering applications.	**8**	**3**		**11**
	3		Basics of Turbulent flows	**2**	**0**		**2**
	4		Bernoulli's Equation and engineering applications, Pressure drop in pipes and Fittings, Piping systems	**6**	**2**		**8**
	5		Fluid moving machinery such as pumps, blowers, compressors, vacuum systems, etc.	**7**	**2**		**9**
	6		Boundary Layer Flows: Blasius equations and solution, Von-Karman integral equations and solutions, Boundary layer separation: skin and form drag.	**3**	**1**		**4**
	7		Particle Dynamics, Flow through Fixed and Fluidised Beds,	**4**	**2**		**6**
	8		Gas – liquid Two phase flow: types of flow regimes, Regime maps, estimation of pressure drop and hold-up	**3**	**1**		**4**
			Total	**36**	**12**		**48**
Suggested reference books			1) Transport Phenomena, Bird R.B., Stewart W.E., Lightfoot E.N. 2) Fluid Mechanics, Kundu Pijush K. 3) Fluid Mechanics, F. W. White 4) 4. Unit Operations of Chemical Engineering, McCabe, Smith				
Outcomes			**Students will be able to**				
	CO1		Students should be able to calculate velocity profiles by simplification of equations of motion in simple 1-D flows				
	CO2		Students should be able to calculate boundary layer thicknesses, friction factor				
	CO3		Students will be able to calculate pressure drop, power requirements for single phase flow in pipes.				
	CO4		Students should be able to calculate two phase gas/liquid pressure drop.				
	CO5		Students should be able to calculate power requirements, NPSH requirements of pumps.				
	CO6		Students should be able to calculate drag force and terminal settling velocity for single particles				
	CO7		Students will be able to calculate pressure drop in fixed and fluidized beds.				
Course code			**CET4202**				
Course title			**Chem Engg Thermodynamics - II**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Applied Mathematics- I and II, Physical Chemistry, Chemical Engineering Thermodynamics-I	**L**	**T**	**P**	**Tot**
Objectives of the course	**1**		This course builds on the preceding course by developing the concept of non-ideal mixing and provides students with the formalism and insights necessary to tackle real industrial problems like liquid-liquid phase splitting, azeotropy, non-zero				

			heats of mixing, sparingly soluble gases and solids, electrolytes etc. Student who have taken this course may be expected to intelligently analyze practically the full spectrum of industrial chemical processes.				
Course title			**Detailed contents**				
	1		Review of first and second law of thermodynamics	**2**			**2**
	2		Vapor-liquid equilibrium: phase rule,simple models for VLE;VLE by modified Raoult's law; VLE from K-value correlations; Flash calculations.	**3**	**1**		**4**
	3		Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties.	**6**	**2**		**8**
	4		Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing.	**6**	**2**		**8**
	5		UNIFAC and UNIQUAC models	**2**	**1**		**3**
	6		Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria.	**6**	**3**		**9**
	7		Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multireaction equilibria.	**4**	**2**		**6**
			Total	**29**	**11**		**40**
Suggested reference books			1. Introduction to Chemical Engineering Thermodynamics: Smith, van Ness, Abbott 2. Chemical, Biochemical and Engineering Thermodynamics: S. I. Sandler 3. Phase Equilibria in Chemical Engineering: Walas 4. Molecular Thermodynamics of Fluid Phase Equilibria: Prausnitz				
Outcomes			**Students will be able to**				
	CO1		Use activity coefficient models to calculate excess properties of liquids				
	CO2		Use modified Raoult's law to calculate VLE of non-ideal mixtures				
	CO3		Calculate chemical equilibrium in non-ideal mixtures				
	CO4		Calcuate solubility of gases in liquids including aqueous solutions with electrolyes				
	CO5		Quantitatively describe salting out effect				
	CO6		Estimate mixture properties from group contribution methods				

Course code			**EST4201**				
Course title			**Engineering and Solid Mechanics**				
Scheme and Credits			**3 L: 1 T: 0 P** **3 Credits**				
Pre-requisites							
Objectives of the course			This subject will help students to understand use of basics of Applied Mechanics and Strength of Materials. This is the foundation course for a good Design Engineer.				
			In engineering equipments and structures, which different types of forces are to be considered and how to quantify them ?				
			What are different conditions of equilibrium? How to apply equilibrium condition to analyse the problems ?				
			Importance of centre of gravity and moment of Inertia in Engineering Design. Advantages and				

			disadvantages of various geometric sections available for engineering design.				
			Study of different types of stresses and strains occurring in various components of the structure. Understanding and calculating Shear force and Bending moment in the beams with simple and complex loading. Determination of Bending stresses and shear stresses in the beams. Evaluation of slopes and deflections in the beams with simple and complex loading.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		**Concepts of forces**, their types, Resolution of forces, Composition of forces, Steps in Engineering Design, Different types supports and free body diagram.	**3**	**1**		**4**
	2		Equilibrium of rigid bodies - Conditions of equilibrium. Determinant and indeterminate structures. Equilibrium of beams, trusses and frames problems on analysis of beams and truss. **(Both Analytical & Graphical Method)**	**4**	**2**		**6**
	3		Concept of moment of Inertia (Second moment of area) its use. Parallel axis theorem. Problems of finding centroid and moment of Inertia of single figures, composite figures. Perpendicular axis theorem, Polar M.I., Radius of gyration.	**3**	**1**		**4**
	4		Stresses and Strains - Tensile and compressive stresses, strains, modulus of elasticity, modulus of rigidity, bulk modulus. Relation between elastic constants. Lateral strain, Poisson's ratio, volumetric strain. Thermal stresses and strains. Problems based on stresses and strains. Stresses and Strains Relationship and Strain Deformation relationship.	**3**	**1**		**4**
	5		Shear Force and Bending Moment - Basic concept, S.F. and B.M. diagram for cantilever, simply supported beams (with or without overhang) under various loading. Problems with concentrated and U.D. loads.	**3**	**2**		**5**
	6		Bending stress & shear Stress: Derivation of basic formula for Bending, Shear stress, Bending stress Distribution and Shear stress distribution for various loading and geometric sections. Problems of Cantilever, simply supported and Beams with overhang.	**5**	**3**		**8**
	7		Slope and Deflection of beams - Basic concept, Slope and Deflection of cantilever and simply supported beams under standard loading. Macaulay's method. Simple problems of finding slopes and deflections.	**3**	**2**		**5**
	8		Thick and Thin cylinders - concept of radial, longitudinal stresses, behaviour of thin cylinders. Problems on thin cylindrical.	**5**	**2**		**7**
			Total	**24**	**12**		**36**
Suggested reference books							
		1	Engineering Mechanics Vol I Statics by B. N. Thadani, Publisher Wenall Book Corporation				
		2	Introduction to Mechanics of Solids by Egor Popov, Prentice Hall of India Pvt. Ltd				
		3	Mechanics of Materials by Ferdinand Beer and E. Russel Johnston, Tata McGraw Hill Publishing Co. Ltd.				
		4	Fundamentals of applied Mechanics by Dadhe, Jamdar and Walavalkar, Sarita Prakashan Pune				
		5	Engineering Mechanics by S. Timoshenko and D. H. Young, McGraw Hill Publications				

		6	Strength of Materials by Ferdinand Singer and Andrew Pytel, Harper Colins Publishers Ltd				
		7	Concrete Technology by A. M. Neville, Pearson Education				
		8	Fundamental of Fibre reinforced composite materials by A. R. Busell and J. Renard, Taylor & Francis				
Outcomes			**Students will be able to**				
	CO1		Understand conditions of equilibrium and how to apply conditions of equilibrium for engineering applications.				
	CO2		Understand use of centroid and moment of inertia for design problems.				
	CO3		Understand different stresses induced when structures subjected to various loadings.				
	CO4		Understand the concepts of shear force, bending moment and deflections in beams.				
	CO5		Understand design procedure for thin and thick cylinders.				
	CO6		Understand various materials used for structures and their properties.				
Course code			**EST4202**				
Course title			**Electrical Engineering and Electronics**				
Scheme and Credits			**3 L: 1 T: 0 P 3 Credits**				
Pre-requisites			XIIth Standard Physics and Mathematics courses, Applied Physics - II				
Objectives of the course			Students will get an insight to the importance of Electrical Energy in Chemical Plants . The students will understand the basics of electricity, selection of different types of drives for a given application process. They will get basic knowledge as regards to Power factor improvement and thyristor application in industries.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		**Basic Laws:** Ohm's law, Kirchhoff's circuit laws, Voltage divider rule and Current divider rule; Network theorems: Mesh Analysis, Nodal Analysis, Superposition, Thevenin's theorems.	**7**	**2**		**9**
	2		**A.C. Fundamentals:** Generation of sinusoidal voltage, frequency of generated voltage, definition and numerical values of average value, root mean square value, form factor and peak factor of sinusoidally varying voltage and current, phasor representation of alternating quantities, A.C. through resistance, inductance and capacitance, simple RL, RC and RLC circuits. Power, power factor, Phasor diagram solution of AC circuits. Series and parallel circuits	**7**	**2**		**9**
	3		**3-phase Power:** Advantages of 3-phase power, Generation of 3-phase power, Three-phase balanced circuits, voltage and current relations in star and delta connections. Measurement of three phase power using two wattmeter method	**2**	**2**		**4**
	4		**Single Phase Transformers**: Necessity of transformer, Principle of operation, Types and construction of transformers, EMF equation, Types of Losses.	**3**	**1**		**4**
	5		Power factor improvement methods, concept of most economical power factor.	**1**	**1**		**2**
	6		**Thyristor**: Introduction, Static I-V characteristics, Thyristor turn-on methods, Applications.	**2**	**2**		**4**

	7		**Electrical drives** in Industries, their characteristics and starting methods and speed control. and their suitability for various applications.	**2**	**2**		**4**
				24	**12**		**36**
Suggested books reference books	**1**		Electrical Engineering Fundamentals by Vincent Deltoro				
	2		Basic Electrical Engineering Machines by Nagrath, Kothari				
	3		Basic Electrical Engineering by D.C. Kulshreshtha				
	4		Principles of Electrical Engineering and Electronics by V.K.Mehta				
	5		Network Analysis and Synthesis by Ravish R Singh				
	6		Circuit Theory (Analysis And Synthesis by A. Chakrabarti				
	7		Electrical Machines by P.S. Bhimbra				
	8		Electrical Technology by B.L.Theraja, A.K.Theraja Vol I,II,IV				
	9		Electronic devices and circuits by Boylstead, Nashelsky				
	10		Principles of Electronics by V.K.Mehta and Rohit Mehta				
	11		Thyristors and their applications by M.Ramamurthy				
	12		Power Electronics by P.S. Bhimbra				
Outcomes			**Students will be able to understand**				
	CO1		The basic concepts of D.C., single phase and three phase AC supply and circuits Solve basic electrical circuit problems				
	CO2		The basic concepts of transformers and motors used as various industrial drives.				
	CO3		The concept of power factor improvement for industrial installations and concept of most economical power-factor				
	CO4		The basic concepts of electronic devices and their applications as thyristor's and speed control of drives.				

Course code			**ESP4201**				
Course title			**Engineering Laboratory**				
Scheme and Credits			**0 L: 1 T: 2 P 2 Credits**				
Pre-requisites							
Objectives of the course							
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		**Electrical Engineering Experiments**				
		1.1	Study of RLC circuits				
		1.2	Load test on transformer				
		1.3	Load test on induction motor				
		1.4	Study of 3 phase circuits with Star connected load				
		1.5	Study of 3 phase circuits with Delta connected load				
	2		**Electronics Engineering Experiments**				
		2.1	Study of C.R.O. and its applications.				
		2.2	Study of half wave, full wave and bridge rectifier circuits				
		2.3	Study of input and output characteristics of a transistor.				
		2.4	Study of various logic gates and their application in logic circuits.				
		2.5	Study of UJT and UJT relaxation oscillator.				
		2.6	Study of operational amplifier circuits.				
	3		**Mechanical Fabrication Experiments**				

		3.1	For learning the designs and fabrication of any mechanical/ electrical /design components , Lathe machines are necessary for learning operations such as Turning , Spot facing , chamfering, Knurling etc.				
		3.2	For learning the welding operations such as arc welding , butt welding, lap welding etc. which will be useful to develop their skills of Pressure vessel, heat exchanger etc. fabrication.				
	4		**Strength of Materials experiments**				
		4.1	Universal Testing Machine				
		4.2	Izod Impact Testing machine				
		4.3	Brinell Hardness testing				
			Total	**0**	**0**		**48**
Suggested reference books							
Outcomes			**Students will be able to understand**				
	CO1		Practically the tensile strength, flexural strength, hardness, modulus, % elongation of any material				

Course code			**ESP4103**				
Course title			**Engineering Applications of Computers-II**				
Scheme and Credits			**1 L: 0T: 4 P 3 Credits**				
Pre-requisites			10+2 level Mathematics				
Objectives of the course	**1**		To make students familiar with basic nemerical methods to solve simple problems arising in engineering. To devlop Python programmes to solve problems in numerical analysis and anlyse its qualitative behaviour.				
Detailed contents				**L**	**T**	**P**	**Tot**
	1		Review of Python basics: Control Flow, Loops and functions, matplotlib. Introduction to Pandas				
			Brief introduction to error analysis Numerical method of finding roots of nonlinear equations of one and two variables: Bisection, Secant, Regula-Falsi and Newton-Raphson methods, Newton's method for solving systems of nonlinear equations (Algorithm and python programme developments of these methods.)	**3**	**0**	**12**	**15**
	2		Solution of Linear Algebraic Equations: Methods like Gaussian elimination and matrix inversion, LU decomposition. Numerical solution of linear algebraic equations: Jacob, Gauss-Siedel methods, and relaxation iterative methods Convergence criteria for various iterative methods. (Algorithm and python programme developments of these methods.)	**3**	**0**	**12**	**15**
	3		Interpolation and Approximation: Newton's forward and backward interpolation, Lagrange interpolation and Linear Spline interpolation. (Algorithm and python programme developments of these methods.)	**3**	**0**	**12**	**15**
	4		Numerical Differentiation and Integration: Numerical differentiation using various interpolation formulae. Integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, Quadrature methods.	**3**	**0**	**12**	**15**

			(Algorithm and python programme developments of these methods.)				
			Total	**12**	**0**	**48**	**60**
Suggested books			Sandeep Nagar, Introduction to Python for Engineers and Scientists. Open Source Solutions for Numerical Computation-Apress (2018) Reema Thareja, Python Programming: Using Problem Solving Approach, Oxford University Press, 2017 Fangoh, Introduction to Python for Computational Science and Engineering, Open Source, available on github.				
Outcomes			Students will able to				
	CO1		use Numpy, Scipy and Sympy to solve problems related to matrices, solutions linear and nonlinear equations and single variable calculus.				
	CO2		write Python programme to solve simple mathematical and numercial problems.				

Study 4 (T6)										
			Code	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
26	ES	EST3203	EST4203	Energy Engineering	4	3	1	0	30	100
27	CE	CET3203	CET4203	Heat Transfer	4	3	1	0	30	100
28	CE	CET3204	CET4204	Mass Transfer Operations	4	2	2	0	30	100
29	S	S*x*T3101	S*x*T4101	Special Subject I	3	2	1	0	15	50
30	HU	HUT3201	HUT4201	IPR and Laws	3	2	1	0	15	50
31	CE	CEP3201	CEP4201	Mathematical Methods in Chemical Engineering	4	2	0	4	50	100
32	CE	CEP3202	CEP4202	Chemical Engineering Laboratory-I	4	0	0	8	50	100
				TOTAL	**26**	**14**	**6**	**12**	**220**	**600**

Course code			**CET4203**				
Course title			**Heat Transfer**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Momentum and Mass transfer, Applied Mathematics I and II, Material and Energy Balance				
Objectives of the course	**1**		This is a basic course that deals with heat transfer, heat exchangers and their design. Heat transfer forms one of the basic pillars of Chemical Engineering Education and is required in all future activities.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		Revision of Basics of Heat transfer: Steady state and unsteady state conduction, Fourier's law, Concepts of resistance to heat transfer and the heat transfer coefficient. Heat transfer in Cartesian, cylindrical and spherical coordinate systems, Insulation, critical radius . extended surfaces, fin performance evaluation, effectiveness of fins. Transient heat conduction.	**2**			**2**
	2		Convective heat transfer in laminar and turbulent boundary layers. Theories of heat transfer and analogy between momentum and heat transfer.	**3**	**1**		**4**
	3		Heat transfer by natural convection. Heat transfer outside various geometries in forced convection, such as, single spheres, banks of tubes or cylinders, packed beds and fluidised beds	**2**			**2**
	4		Heat transfer in laminar and turbulent flow in circular pipes: Double pipe heat exchangers: Concurrent, counter-current and cross flows, mean temperature difference, NTU – epsilon method for exchanger evaluation.	**3**	**1**		**4**
	5		Shell and tube heat exchangers: Basic construction and features, TEMA exchanger types, their nomenclature, choice of exchanger type, correction to mean temperature difference due to cross flow, multipass exchangers. Design methods for shell and tube heat exchangers such as Kern Method, Bell – Delaware method	**8**	**2**		**10**
	6		Finned tube exchangers, air-cooled cross flow exchangers and their process design aspects	**2**	**1**		**3**
	7		Compact Exchangers: Plate, Plate fin, Spiral, etc.: Construction, features, advantages, limitations and their process design aspects	**2**	**1**		**3**
	8		Condensation of vapours: theoretical prediction of heat transfer coefficients, practical aspects, horizontal versus vertical condensation outside	**6**	**2**		**8**

			tubes, condensation inside tubes, Process Design aspects of total condensers, condensers with de-superheating and subcooling				
	9		Heat transfer to boiling liquids: Process design aspects of evaporators, natural and forced circulation reboilers	**6**	**2**		**8**
	10		Heat transfer in agitated vessels: coils, jackets, limpet coils, calculation of heat transfer coefficients, heating and cooling times, applications to batch reactors and batch processes	**2**			**2**
	11		Basics of Radiative heat transfer	**2**			**2**
			Total	**38**	**6**		**48**
Suggested reference books			1. Process Heat Transfer, Kern D.Q. 2. Heat Exchangers, Kakac S., Bergles A.E., Mayinger F 3. Process Heat Transfer, G. Hewitt				
Outcomes			**Students will be able to**				
	CO1		Calculate temperature profiles in a slab at steady state				
	CO2		Calculate heat transfer coefficients in various equipment like double pipe heat exchangers, shell and tube heat exchangers, plate heat exchangers, condensation, evaporation, agitated tanks.				
	CO3		Calculate heat duty/outlet temperatures/pressure drops/area required for various equipment like double pipe heat exchangers, shell and tube heat exchangers, plate heat exchangers, condensation, evaporation, agitated tanks.				
	CO4		Identify and select type of shell and tube exchanger based on TEMA classification.				
Course code			**EST4203**	**L**	**T**	**P**	**Tot**
Course title			**Energy Engineering**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Chemical Engineering Thermodynamics-I, Material and Energy Balance Calculations, Applied Physics I and II, Applied Mathematics – I and II				
Objectives of the course	**1**		Students will be able to understand various equipments like steam turbine, gas turbine, pumps, compressors and power transmission system.				
Course title			**Detailed contents**				
	1		Properties of Steam Boilers	**4**	**2**		**6**
	2		Steam turbine	**3**	**1**		**4**
	3		Condenser	**3**	**1**		**4**
	4		Steam power plant cycles	**4**	**2**		**6**
	5		Pumps	**3**	**1**		**4**
	6		Compressors and blowers	**3**	**1**		**4**
	7		Steam nozzles	**3**	**1**		**4**
	8		Belt, chain and gear drive	**3**	**1**		**4**
	9		Bearings	**3**	**1**		**4**
	10		Refrigeration	**3**	**1**		**4**
	11		Internal combustion engine, Otto engine, diesel engine; Jet engine cycles	**3**	**1**		**4**
			Total	**35**	**13**		**48**
Suggested reference books			1. Thermodynamics by P.K.Nag 2. Power plant by Morse 3. Heat Engines by P.L.Balani				
Outcomes			**Students will be able to**				
	CO1		List the features and functions of steam power plant				

	CO2		List the features and functions of various power transmission system				
	CO3		List the features of refrigeration systems				
Course code			**CET4204**				
Course title			**Mass Transfer Operations**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Material & Energy Balance Calculations, Physical Cheiistry, Organic Chemistry-I and II, Chem. Eng. Thermodynamics-I, Momentum and Mass Transfer				
Objectives of the course	**1**		This is a basic Chem. Eng. course. The principles learnt in this course are required in almost all the courses and throughout the professional career of Chemical Engineer				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		Diffusion	**4**	**2**		**6**
	2		Convective mass transfer and mass transfer coefficient	**2**	**1**		**3**
	3		Interfacial mass transfer	**4**	**2**		**6**
	4		Single Equilibrium Stage, Flash Calculations and Cascade systems: Binary vapor–liquid systems, bubble-point, and dew-point calculations, Cascade configurations, co-current, counter-current, cross-current, and other configurations	**4**	**2**		**6**
	5		Absorption and Stripping of dilute mixtures: Fundamentals of absorption, equilibrium curves, Operating lines from material balances, Number of equilibrium stages, Kremser Equation, Stage efficiency and column performance, Trayed and packed columns, Rate based methods for packed columns (HTU, NTU), Design considerations: loading and flooding zones, pressure drop and column diameter	**8**	**2**		**10**
	6		Distillation of binary mixtures: Differential distillation, Flash or equilibrium distillation, Fractionating column and multistage column, design and analysis factors, degrees of freedom, specifications, reflux, reflux ratio, need for reflux, McCabe-Thiele, Lewis-Sorel methods of estimation of number of plates, Operating and feed lines, minimum and optimum reflux ratio, Tray and column efficiency , Packed column distillation: rate based methods: HETP, HTU, Ponchon Savarit method , Batch, azeotropic, and extractive distillation, Distillation equipment and sizing	**8**	**3**		**11**
	7		Drying of solids: Mechanism of drying, drying rate curves, Estimation of drying time , Drying Equipment, operation, Process design of dryers, material and energy balances in direct dryers, Drying of bioproducts	**4**	**2**		**6**
			Total	**34**	**14**		**48**
Suggested reference books		1	Richardson, J.F., Coulson, J.M., Harker, J.H., Backhurst, J.R., 2002. Chemical engineering: Particle technology and separation processes. Butterworth-Heinemann, Woburn, MA.				
		2	Seader, J.D., Henley, E.J., 2005. Separation Process Principles, 2 ed. Wiley, Hoboken, N.J.				
		3	Svarovsky, L., 2000. Solid-Liquid Separation. Butterworth-Heinemann, Woburn, MA.				

		4	McCabe, W., Smith, J., Harriott, P., 2004. Unit Operations of Chemical Engineering, 7 ed. McGraw-Hill Science/Engineering/Math, Boston.				
		5	McCabe, W., Smith, J., Harriott, P., 2004. Unit Operations of Chemical Engineering, 7 ed. McGraw-Hill Science/Engineering/Math, Boston.				
		6	Green, D., Perry, R., 2007. Perry's Chemical Engineers' Handbook, Eighth Edition, 8 ed. McGraw-Hill Professional, Edinburgh.				
		7	Dutta, B.K., 2007. Principles of Mass Transfer and Separation Process. Prentice-Hall of India Pvt. Ltd, New Delhi.				
Outcomes			**Students will be able to**				
	CO1		Know the significance and usage of different particulate characterization parameters, and equipment to estimate them				
	CO2		Describe Size reduction energy requirements, estimate performance of equipment, selection and sizing of equipment				
	CO3		Analyze filtration data and select systems based on requirements, estimate filtration area for given requirements, understand filter aids and their usage				
	CO4		Draw T-y-x diagrams, and y-x diagrams, operating lines, feed line, bubble point, dew point calculations, ternary phase diagrams, partition coefficient				
	CO5		Describe two common modes of drying, industrial drying equipment				
	CO6		Calculate mass transfer coefficient in various equipment, Calculate height and diameter required, minimum solvent required in absorption, calculate height and diameter required, minimum reflux required in distillation				
Course code			**HUT4201**				
Course title			**IPR and Laws**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**	**L**	**T**	**P**	**Total**
Pre-requisites							
Objectives of the course	1		To provide basic knowledge about all the branches of IPR viz. Copyrights, Trademarks, Patents, Geographical Indicators, Industrial Designs, etc				
	2		To provide the knowledge about national and international aspects of IPR				
	3		To provide advanced knowledge about Indian Patent Law				
	4		To impart knowledge about filing a patent, performing a patent search, drafting a patent and infringement analysis				
Course title			Detailed contents				
	1		Introduction, History of IPR (history of patents in particular), Rationale behind IPR, Economics of IPR, features of IPR.	**2**	**1**	**0**	**3**
	2		Introduction to patents, trademarks, copyrights, geographical indicators, industrial designs, trade secrets	**2**	**1**	**0**	**3**
	3		Definition of patent, Term of patent, patentabilty criteria, inventions not patententable, Process and product patents	**6**	**3**	**0**	**9**
			(Case studies), Patent Co operation Treaty: Basics, PCT time lines, Types of patents				
	4		Indian Patent Act	**8**	**4**	**0**	**12**

			History, Salient features of: Indian Patent Act 1970, 1999 amendment, 2002 amendment, 2005 amendment, WTO-TRIPs and Indian legislation				
			Use of TRIPS flexibilities in Indian Patent law				
			Section 3(d), Pre grant opposition, Compulsory licencing (with case studies)				
	5		Procedure for Patent application	**6**	**3**	**0**	**9**
			Who can file a patent, Where to file a patent, Patent office procedures				
			Practical aspects of patenting: Patent search, acquiring a patent, patent specification and it parts, patent claims , infringement analysis				
			Case studies/ additional information for patenting in various chemical technology fields – national and international. e.g. Salient features of patenting in the US: The Hatch Waxman Act with reference to generic Drugs, The Orange book, The contents of ANDA and bioequivalence. Patent Certification (Para-I, Para-II, Para-III and Para-IV)				
			Total	**24**	**12**	**0**	**36**
Suggested reference books	1		Indian Patent Act Handbook of Patenting: Parikshit Bansal				
Outcomes			**Students will be able to**				
	CO1		Distinguish between different types of intellectual property				
	CO2		List conditions for filing intellectual property protections				

Course code			**CEP4202**				
Course title			**Chemical Engineering Laboratory-I**				
Scheme and Credits			**0 L: 0 T: 8 P 4 Credits**				
Pre-requisites			Momentum Transfer, Chemical Engineering Thermodynamics 1, Mass transfer				
Objectives of the course	**1**		Chemical Engineering lab provides students the first hand experience of verifying various theoretical concepts learnt in theory courses				
	2		It also exposes them to practical versions of typical chemical engineering equipments and servers as a bridge between theory and practice				
	3		This particular lab focuses on fluid dynamics, thermodynamics and mass transfer				
Detailed contents				**L**	**T**	**P**	**Tot**
	1		Fluid Flow (9-11 experiments)			**50**	**50**
	2		Fluidization (1-2 experiments)			**10**	**10**
	3		Sedimentation (1-2 experiments			**10**	**10**
	4		Thermodynamics (3-4 experiments)			**16**	**16**
	5		Mass transfer (1-2 experiments)			**10**	**10**
			Total	**0**	**0**	**96**	**96**
Outcomes							
			Students will be able to				
	CO1		Learn how to experimentally verify various theoretical principles				
	CO2		Visualize practical implementation of chemical engineering equipments				

	CO3		Capability to visualize and understand chemical engineering unit operations related to fluid and particle mechanics, and mass transfer				
	CO4		Able to clearly communicate the results of experimental work in oral and written formats.				
Course code			**CEP4201**				
Course title			**Mathematical Methods in Chemical Eng.**				
Scheme and Credits			**2 L: 1 T: 2 P 4 Credits**				
Pre-requisites			Applied Mathematics – I and II, Momentum and Mass Transfer, Chem. Eng. Operations, Chem. Engg. Thermodynamics I and II				
Objectives of the course	**1**		In this course advanced mathematical tools are covered which will help students to solve complex problems in Chemical Engineering. This course will serve as a bridge between the applied mathematics courses and their application to Chemical Engineering problems. Specifically, the techniques learnt in this course will help problem formulation and solution in Chemical Reaction Engineering, Chemical Process Control, Heat Transfer and Transport Phenomena.				
Course title			Detailed contents	**L**	**T**	**P**	**Tot**
	1		Vector algebra: scalar & vector product (application to fluid flow problems)	**2**		**4**	**6**
	2		PDEs: Types, solution (penetration theory, 2D conduction, counter-current heat exchanger, reaction-diffusion, dispersion model, etc.)	**4**		**8**	**12**
	3		Fourier transforms (diffusion equations)	**2**		**4**	**6**
	4		Linear algebra (matrix theory) (stability analysis, scaling of equations)	**4**		**8**	**12**
	5		Bifurcation analysis (sensitivity analysis)	**4**		**8**	**12**
	6		Perturbation analysis (for boundary flow problems, solution of equations, model reduction etc.)	**4**		**8**	**12**
	7		Optimization (Linear)	**4**		**8**	**12**
			Total	**24**	**0**	**48**	**72**
Suggested reference books							
Outcomes			**Students will be able to**				
	CO1		Formulate a Chemical Engineering problem into a mathematical problem				
	CO2		Solve (analytically or numerically) ODE and PDE equations encountered in Chemical Engineering Applications				
	CO3		Assess stability of Chemical Engineering systems				

Study 5 (T8)										
				Subjects	Credits	Hrs/week			E. S.	Total
						L	T	P		
31			EST4304	Material Science and Engineering	3	2	1	0	15	50
32				Special II	3	2	1	0	15	50
33			CET4301	Chemical Reaction Engineering	4	3	1	0	30	100
34			CET4304	Separation Processes	4	3	1	0	30	100
35			CET4302	Biochemical Engineering	3	2	1	0	15	50
36			CEP4301	Chemical Engineering Laboratory-II	4	0	0	8	50	100
37			CEP4311	Process Simulation Lab – I	2	0	0	4	25	50
38				Special Lab -I	2	0	0	4	25	50
				TOTAL	**25**	**12**	**5**	**16**	**205**	**550**

Course code			**CET4301**				
Course title			**Chemical Reaction Engineering**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Physical Chemistry, Material & Energy Balance Calculations, Applied Mathematics I and II, Momentum and Mass Transfer, Chem Engg Thermodynamics I and II				
Objectives of the course	**1**		Chemical Reaction Engineering is concerned with the utilisation of chemical reactions on a commercial scale. This course is very relevant but not limited to the following industries: Inorganic chemicals, organic chemicals, petroleum & petrochemicals, Pulp & paper, Pigments & paints, rubber, plastics, synthetic fibres, Foods, Dyes and intermediates, Oils, oleochemicals, and surfactants, Minerals, cleansing agents, Polymers and textiles, Biochemicals and biotechnology, pharmaceuticals and drugs, Microelectronics, energy from conventional and non-conventional resources, Metals				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Chemical Reaction Engineering	**1**		Batch reactor (BR), continuous stirred tank reactor (CSTR), plug flow reactor (PFR), packed-bed reactor (PBR)				**2**
	2		Design equations for BR, CSTR, PFR, PBR, and applications of design equations to various series- and parallel- combinations of flow reactors				**6**
	3		Rate laws and stoichiometry				**4**
	4		Isothermal reactor design applied to BR, CSTR, PFR, PBR				**6**
	5		Analysis of rate data: differential method, integral method				**4**
	6		Multiple reactions				**4**
	7		Reaction mechanisms, pathways, bioreactions				**4**
	8		Catalysis and catalytic reactors, catalyst deactivation, external diffusion effects on heterogeneous reactions, diffusion and reaction in solid catalysts;				**6**
	9		Introduction to non-isothermal reactor design				**4**
	10		Residence time distribution in reactors; models for non-ideal reactors				**4**
	11		Mass transfer with chemical reaction in fluid-fluid and fluid-fluid-solid systems; Model contactors, pilot plants, and collection of scale-up data				**4**
			Total				**48**
Suggested books /reference books			Elements of Chemical Reaction Engineering – H. Scott FOGLER				

			Chemical Reaction Engineering – Octave LEVENSPIEL				
			The Engineering of Chemical Reactions – Lanny D. SCHMIDT				
			An introduction to Chemical Engineering Kinetics and Reactor Design – Charles HILL				
			Heterogeneous Reactions, Vol. I and II – L. K. Doraiswamy, M. M. Sharma				
Course code & title			**Outcomes** **Students will be able to**				
	CO1		design chemical reactors optimally, using minimum amount of data				
	CO2		design experiments in a judicious way to get the required data, if not available				
	CO3		fix some problems related to operability and productivity				
	CO4		maintain and operate a process in a safe manner				
	CO5		increase capacity and/or selectivity and/or safety by improving/changing the reactor type/sequence and/or operating conditions				
Course code			**EST4304**				
Course title			**Material Science and Engineering**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites			Structural Mechanics, Applied Physics I and II				
Objectives of the course	**1**		Selection of MOC for a given application, maintenance and corrective measures for various engineering materials.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Material Science and Engineering	**1**		Engineering Materials: Classification, study of ferrous and non-ferrous materials				**2**
	2		Phase diagrams of steel, brass and the applications of phase diagrams				**3**
	3		Effect of structure on properties: subatomic to macroscopic level				**3**
	4		Modification and control of material properties				**4**
	5		Polymeric materials , Ceramic materials, Composite materials and Smart materials				**4**
	6		Corrosion Engineering: Electrochemical principles, different types of corrosion, Polarisation, mechanisms of corrosion control and prevention, preventive coatings. Corrosion behavior of important alloys such as stainless steels, brass etc.				**8**
	7		Theory of failure: Crystal defects, plastic deformation. Types of mechanical failure, fracture , fatigue and creep				**8**
	8		Criteria for selection of materials in chemical process industry				**4**
			Total				**36**
Suggested books							
Suggested books /reference books	**1**		The Essence of Materials for Engineers, Robert W. Messler, Jr.				
	2		Materials Science and Engineering, Raghavan V.				
	3		Materials Science and Engineering, Van Vlack L.H.				
	4		Engineering Materials and Applications, Flin R.A., Trojan P.K.				
Outcomes							
			Outcomes **Students will be able to**				
	CO1		Students will be able to draw simple Phase Diagram				
	CO2		Describe causes of mechanical failure				

	CO3		List types of corrosion and describe method to control them				
	CO4						
Course code			**CET4304**				
Course title			**Separation Processes**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Material & Energy Balance Calculations, Chemical Engineering Operations – I, Chem. Eng. Thermodynamics-I and II, Momentum Transfer, Applied Mathematics I and II				
Objectives of the course	**1**		This is a course further built up on and in continuation with Chem. Engg. operations. It forms the basis oc Chemical Engineering Principles and hence it is required in almost all the courses and throughout the professional career of a Chemical Engineer.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Separation Processes	**1**		Extraction and Leaching of ternary systems: Ternary diagrams, Hunter-Nash graphical method and Maloney–Schubert graphical equilibrium-stage method, Solvent Selection, Operating point, number of stages, maximum solvent to feed ratios, minimum reflux, minimum number of stages, Introduction to reactive extraction, aqueous two phase extraction, extraction of biomolecules, supercritical fluid extraction, Solid-liquid extraction: Solid - liquid equilibria, efficiency, performance evaluation, Equipment for extraction, leaching and their sizing, Design considerations				**15**
	2		Adsorption and Ion exchange: Liquid Adsorption, Ion-Exchange Equilibria, Equilibria in Chromatography, Breakthrough Curves, Kinetic and transport considerations, Convection-Dispersion Model, Separation Efficiency (Plate Height or Bandwidth), Correlations for Transport-Rate Coefficients, Equipment for sorption operations, Scale-Up and Process Alternatives, Adsorptive Membranes, simulated-moving-bed operation, modes of operation				**8**
	3		Crystallization: Theory of solubility and crystallization, phase diagram (temp/solubility relationship), Supersaturation, Nucleation, Crystal Growth, Population balance analysis, method of moments for rate expressions for, volume, area and length growth, CSD distribution, MSMPR operation, evaporative and cooling (rate expressions) , most dominant size, ideal classified bed, Precipitation, Melt crystallization, Process design of crystallizers and their operation				**8**
	4		Humidification and Cooling Towers: Method of changing humidity and equipment, Cooling tower process design, counter-current, concurrent and cross current, mass and heat balances in bulk and interfaces, Estimation of air quality, performance evaluation of cooling towers.				**9**
	5		Membrane Separations: Types of separations, reverse osmosis, ultrafiltration, gas separation, vapour permeation and pervaporation, dialysis, electrodialysis, nanofiltration, Transport Through Porous Membranes, Resistance Models, Liquid Diffusion Through Pores, Gas Diffusion Through				**8**

			Porous Membranes, Transport Through Nonporous Membranes, Solution-Diffusion for Liquid Mixtures, Gas Mixtures, Concentration Polarization and Fouling, Membrane modules, arrangement of modules in cascades, performance criteria and design considerations				
			Total				**48**
Suggested books /reference books	**1**		Richardson, J.F., Coulson, J.M., Harker, J.H., Backhurst, J.R., 2002. Chemical engineering: Particle technology and separation processes. Butterworth-Heinemann, Woburn, MA.				
	2		Seader, J.D., Henley, E.J., 2005. Separation Process Principles, 2 ed. Wiley, Hoboken, N.J.				
	3		McCabe, W., Smith, J., Harriott, P., 2004. Unit Operations of Chemical Engineering, 7 ed. McGrawHill Science/Engineering/Math, Boston.				
	4		Green, D., Perry, R., 2007. Perry's Chemical Engineers' Handbook, Eighth Edition, 8 ed. McGrawHill Professional, Edinburgh.				
	5		Dutta, B.K., 2007. Principles of Mass Transfer and Separation Process. Prentice-Hall of India Pvt. Ltd, New Delhi.				
Outcomes			**Students will be able to**				
	CO1		List situations where liquid–liquid extraction might be preferred to distillation, Make a preliminary selection of a solvent using group-interaction rules, Size simple extraction equipment				
	CO2		Differentiate between chemisorption and physical adsorption, List steps involved in adsorption of a solute, and which steps may control the rate of adsorption, Explain the concept of breakthrough in fixed-bed adsorption				
	CO3		Explain how crystals grow, Explain the importance of supersaturation in crystallization. Describe effects of mixing on supersaturation, mass transfer, growth, and scale-up of crystallization				
	CO4		Explain membrane processes in terms of the membrane, feed, sweep, retentate, permeate, and solutemembrane interactions. Distinguish among microfiltration, ultrafiltration, nanofiltration, virus filtration, sterile filtration, filter-aid filtration, and reverse osmosis in terms of average pore size.				
	CO5		Explain common idealized flow patterns in membrane modules.				
	CO6						
	CO7						

Course code			**CET4302**				
Course title			**Biochemical Engineering**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites			Chemical Reaction Engineering, Introduction to Biological Sciences and Bioengineering, Physical Chemistry, Material and Energy Balance Calculations, Chem Engg Thermodynamics I and II, Chem Engg Operations				
Objectives of the course	**1**		This course integrates Biological sciences and chemical engineering and a requisite for Biobased Industry				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Biochemical Engineering	**1**		Introduction to Biotechnology: Role of chemical engineers in biotechnology. Basic of Genetic				**4**

			Engineering and Tissue Culture : Recombinant DNA technology				
	2		Structure function relations of enzymes; Classification, Mechanism of Enzyme action, Enzyme kinetics, inhibition and regulation, Enzyme purification and characterization, Coenzymes, cofactors, Enzyme reactors, thermostabilization, immobilization of enzymes, Enzymes as industrial catalysts- Examples				**8**
	3		Bioprocess Development, Plant and animal cell cultures for the production of biochemicals, Immobilized cells, Kinetics of microbial growth, models and simulations, Batch and continuous culture, Mixed microbial culture, Biochemical process development and bioreactors using biological catalysts, Integration of downstream processing with bioprocessing				**12**
	4		Transport phenomena in bioreactions and bioreactors				**4**
	5		Fundamentals of fermentation-submerged fermentation, Fermenter design and basic biochemical engineering aspects of fermentation				**4**
	6		Reactor design for biochemical reactions and scale up, Process Design for bioproducts, Bioreactor design, Scale up of bioreactions/reactors,				**4**
	7						
			Total				**36**
Suggested books reference books	1		Biochemical Engineering Fundamentals, Bailey and Olis, Wiley				
	2		Biotransformations and Bioprocesses, Doble,Anilkumar and Gaikar, Marcel Dekker				
Outcomes			**Students will be able to**				
	CO1		calculate microbial/enzymatic kinetics parameters				
	CO2		Design enzyme reactors and scale up fermenters				
	CO3		calculate biomass production/substrate requirements				
	CO4		decide process parameters				
	CO5		estimate energy equipments/oxygen requirements				
	CO6		estimate bio-reactor size/time for a given microbial/enzymatic process.				

Course code			**CEP4301**				
Course title			**Chemical Engineering Laboratory-II**				
Scheme and Credits			**0 L: 0 T: 8 P 4 Credits**				
Pre-requisites			Heat Transfer, Mass Transfer				
Objectives of the course	**1**		Chemical Engineering lab provides students the first hand experience of verifying various theoretical concepts learnt in theory courses				
	2		It also exposes them to practical versions of typical chemical engineering equipments and servers as a bridge between theory and practice				
	3		This particular lab focuses on heat transfer and mass transfer				
Detailed contents				**L**	**T**	**P**	**Tot**
	1		Heat Transfer (6-7 experiments)			**50**	
	2		Mass Transfer (3-4 experiments)			**10**	
	3		Sedimentation (1-2 experiments			**10**	
	4		Thermodynamics (3-4 experiments)			**16**	

	5		Mass transfer (1-2 experiments)			**10**	
			Total	**0**	**0**	**96**	**96**
Outcomes							
			Students will be able to				
	CO1		Learn how to experimentally verify various theoretical principles				
	CO2		Visualize practical implementation of chemical engineering equipments				
	CO3		Capability to visualize and understand chemical engineering unit operations related to fluid and particle mechanics, and mass transfer				
	CO4		Able to clearly communicate the results of experimental work in oral and written formats.				

Course code			**CEP4311**				
Course title			**Process Simulation Lab-1**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			Chemical Engineering Thermodynamics, Separation process				
Objectives of the course	**1**		To learn write programs on Chemical Engineering processes and equipment				
	2		To learn the design aspects equipments through programming				
	3		To Learn the solving process of Chemical Engineering problems through computational techniques				
Detailed contents				**L**	**T**	**P**	**Tot**
	1		Programming of equation of state, fugacity calculation, excess Gibbs energy models				
	2		Computation of vapor-liquid equilibria and liquid-liquid equilibria				
	3		Bubble point and dew point calculation				
	4		Computation of absoption and stripping unit				
	5		Computation of distillation unit				
	6		Computation of multistage liquid-liquid extractor				
	7		Computation of cooling tower				
			Total	**0**	**0**	**48**	**48**
Outcomes							
			Students will be able to				
	CO1		Able to write algorithms of chemical engineering problems				
	CO2		Able to design chemical engineering problems and equipment				
	CO3		Able to perform qualitative and quantitative analysis of chemical engineering problems computationally				
	CO4		Able to clearly communicate the results of modelling work in oral and written formats.				

Study 6 (T10)										
				Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
39	S	ST	xxT4xxx	Special Elective-III	3	2	1	0	50	100
40	S	ST	xxT4xxx	Special Elective-IV	3	2	1	0	50	100
41	CE	CET	CET4403	Environmental Engineering and Process Safety	3	2	1	0	50	100
42	CE	CET	CET4405	Chemical Process Control	4	3	1	0	50	100
43	CE	CEE	CET4408	Industrial and Engineering Chemistry	4	3	1	0	50	100
44	CE	CEP	CEP4402	Chem. Eng. Laboratory-III	4	0	0	8	50	100
45	CE	CEP	CEP4412	Process Simulation Lab-II	2	0	0	4	50	100
46	S	SP	xxP4402	Special Lab-II	2	0	0	4	25	50
				TOTAL	**25**	**12**	**5**	**16**	**350**	**700**

Course code			**CET4405**				
Course title			**Chemical Process Control**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Material and Energy Balance Calculations, Applied Mathematics I and II, Mathematical Methods in Chem Engg., Momentum and Mass Transfer, Chemical Reaction Engineering, Heat Transfer, Chem Engg Operations, Separation Processes,				
Objectives of the course	**1**		Process control plays a very critical role in the context of actual operation of a chemical plant. Most of the core chemical engineering courses focus on the steady state operation. In the real life environment, process is continuously subjected to various disturbances which deviates the operation from the designed steady state. This course specifically prepares students to assess the impact of such disturbances and equip them with the tools available with the chemical engineer to tackle these situations.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Chemical Process Control	**1**		Introduction to process control: Motivation, importance, components of control system, control relevant process modeling	**2**	**1**		**3**
	2		Dynamics of first, second and higher order systems: Examples systems, characterizing parameters, features, etc.	**6**	**3**		**9**
	3		Feedback control: Motivation, elements of feedback control, servo problem, regulatory problem, effect of proportional, integral and derivative action, responses of P, PI and PID controllers	**3**	**1**		**4**
	4		Controller selection and design: Controller selection guidelines, controller design criteria, common control loops (level, pressure, flow, temperature), reactor control, distillation control	**3**	**1**		**4**
	5		Controller tuning: Open loop tuning, closed loop tuning, direct synthesis, commercial controller tuning packages	**3**	**1**		**4**
	6		Stability analysis: Laplace domain analysis, frequency domain analysis	**3**	**1**		**4**
	7		Introduction to Multivariable and advanced control: Cascade control, dynamic matrix control, internal model control, basics of ratio control, split range control, override control, adaptive control, inferential control, model predictive control, geometric control	**6**	**3**		**9**

	8		Digital control: Discrete time systems, basics of z-transforms, stability analysis	**3**	**1**		**4**
	9		Electronics for control systems: Distributed control system, Programmable Logic Controllers, SCADA, HMI	**3**	**1**		**4**
	10		Instrumentation: Basic measurement devices and working principles for level, flow, pressure and temperature, types of control valves, etc.	**2**	**1**		**3**
			Total	**34**	**14**	**0**	**48**
Suggested books /reference books			Stephanopoulos, G.Chemical Process Control: An Introduction to Theory and Practice.				
			Bequette, B.W.Process Control: Modeling, Design, and Simulation.				
			Seborg, D.E. and Mellichamp, D.A. and Edgar, T.F. and Doyle, F.J.Process Dynamics and Control.				
			Johnson, C.D.Process Control Instrumentation Technology.				
Course code & title			**Outcomes** **Students will be able to**				
	CO1		Understand the importance of process dynamics (unsteady state operation)				
	CO2		Design a control strategy for key unit operations (reactor, distillation column, etc)				
	CO3		Tune a controller to reject disturbances or manage operating point transitions				
	CO4		Understand working principles of basic instruments available for flow, pressure, level and temperature measurement				
	CO5		Describe modern industrial control system architecture				

Course code			**HUT4202**				
Course title			**Environmental Studies and Process Safety**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			Material & Energy Balance Calculations, Chemical Reaction Engineering, Chemical Engineering Operations, Momentum and Mass Transfer, Biochemical Engg., Chem Engg Thermodynamics I and II				
Objectives of the course	**1**		The course 'Environmental Engineering and Process Safety' is highly relevant in all fields of activities, and process industry in particular. The above clearly highlights the necessity and significance of the course. This course will certainly add value to our chemical engineering graduates.				
			A chemical engineer working in any function of process industry should have working knowledge of all the prevailing safety,environment, and health standards, and may be involved in / responsible for any or all of the following: - site process safety, environmental affairs - assisting the Health Safety Environment (HSE) team - employee safety observations and pre-job risk assessments - implementation of HSE policies and guidelines to help ensure that all employees, contractors, and visitors enjoy high levels of safety, health and environmental protection; this reduces company's liability exposure. - improvement of process safety performance and				

			reduction of risk by facilitating Process Hazard Analyses				
			and Layer of Protection Analyses - incident investigations for process safety and environmental incidents - recognising information that would be pertinent to process safety documentation and follow through with site personnel to ensure information is well documented - developing and updating site Policies and Procedures related to process safety and environmental. - capital and other project teams to identify and resolve regulatory issues, analyse process and property hazards, and establish protective measures to mitigate risks to a tolerable level. - assisting the plant with government interfaces and inspections. - training using internal and external resources; provides guidance to site management for implementation of programs or controls to comply with environmental requirements. - managing site environmental programs including but not limited to waste management, spill prevention & response, etc. - preparation and submission of reports to appropriate agencies to assure compliance with federal, state and local regulations. Responds to corporate requests in a timely manner. - obtaining new or revised environmental permits that provide operational flexibility within the schedule established for new projects. Ensure that the operating units can meet all provisions and provide tools to enable compliance. - providing environmental guidance; develop procedures and training, and HSE support as needed. - participate in site objectives in the areas of community relations.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Environmental Engineering and Process Safety	**1**		Introduction to all prevailing international standards of Health, Safety, and Environment (HSE); Environmental laws and regulations; Standards (air quality, noise, water), ISO 14000+	**3**	**1**		**4**
	2		Environmental impact assessment, Life cycle assessment (LCA)	**3**	**1**		**4**
	3		Pollution prevention in chemical manufacturing, effluent valorisation	**1**	**1**		**2**
	4		Air pollution; Air pollutants: sources (specific pollutants), effects, and dispersion modelling, air pollution, air quality, pollutants minimisation and control, fugitive emissions (source and control),	**3**	**1**		**4**
	5		Noise pollution	**3**	**1**		**4**
	6		Wastewater treatment; Groundwater and surface water pollution, removal of specific water contaminants; Solid waste; Hazardous waste	**4**	**2**		**6**
	7		Inherent safety; Major disasters (e.g. Flixborough, UK; Bhopal, India; Seveso, Italy; Pasadena, Texas; Texas City, Texas; Jacksonville, Florida; Port Wentworth, Georgia)	**1**	**0**		**1**
	8		Toxicology; Industrial hygiene	**3**	**1**		**4**
	9		Source models; Toxic release and dispersion models	**3**	**1**		**4**

	10		Fires and explosions; Concepts to prevent fires and explosions	**1**	**1**		**2**
	11		Chemical reactivity	**3**	**1**		**4**
	12		Reliefs and reliefs sizing; Hazard identification; Risk assessment	**3**	**1**		**4**
	13		Safety procedures and designs	**1**	**1**		**2**
	14		Some case histories	**2**	**1**		**3**
			Total	**34**	**14**	**0**	**48**
Suggested books							
	1		Chemical Process Safety: Fundamentals with Applications – Daniel A. CROWL and Joseph F. LOUVAR				
	2		Guidelines for Process Safety Management, Environment, Safety, Health, and Quality – Center for the Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)				
	3		Environmental Engineers' Handbook – Irene LIU (Editor)				
	4		Chemical Process Safety Learning from Case Histories – Roy E. SANDERS				
	5		Guidelines for Process Safety Documentation – Center for the Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)				
	6		Environmental and Health and Safety Management: A Guide to Compliance – Nicholas P. CHEREMISINOFF, Madelyn L. GRAFFA				
	7		Environmental Pollution Control Engineering – C. S. Rao				
	8		Environmental Engineering – H. S. Peavy				
Outcomes							
			Students will be able to				
	CO1		calculate BOD / COD for a given composition of effluent stream, Estimation of bio Kinetics				
	CO2		calculate adiabatic lapse rate and determine conditions for suitability of atmospheric dispersion, effective stack height, chimney design				
	CO3		calculate concentrative of pollutant at any point in the neighbourhood of emission given atmospheric conditions like wind, dispersion, environmental factors etc.				
	CO4		calculate size/time/power required for primary clarifier, secondary treatment, tertiary treatment, sizing of different types of Biological treatments etc.				
	CO5		identify hazards in a given process and assess the same and provide solutions for operating safely.				
	CO6		specify safety requirements for storage and handling of a given chemical.				
Course code			**CET4408**				
Course title			**Industrial and Engineering Chemistry**				
Scheme and Credits			**3 L: 1 T: 0 P 4 Credits**				
Pre-requisites			XIIth Standard Chemistry and Physics, Organic Chemistry I & II, Material & Energy Balance Calculations, Physical Chemistry				
Objectives of the course	**1**						
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Chemical Process Control	**1**		Overview of Indian chemical industry, raw material and energy sources, role of catalysis, inorganic products, organic intermediates and final products	**2**	**1**		**3**
	2		Petroleum refining and cracking operations	**4**	**2**		**6**

	3		Industrial processes for ammonia, syngas and hydrogen, methanol, chemicals from oxo-synthesis	**4**	**2**		**6**
	4		Organic chemicals based on methanol and ethanol (e.g., formaldehyde, acetaldehyde, acetic acid)	**4**	**2**		**6**
	5		Petrochemicals: e.g., ethylene oxide, α-olefins, vinyl acetate, phenol, aniline, LAB, phthalic anhydride, PTA	**4**	**2**		**6**
	6		Polymers (e.g., polyethylene / polypropylene)	**2**	**1**		**3**
	7		Manufacturing of inorganic acids (sulfuric and nitric acid)	**2**	**1**		**3**
	8		Chlor-alkali industry (chlorine, caustic soda, soda ash)	**1**	**1**		**2**
	9		Fertilizers (urea and phosphates)	**1**	**1**		**2**
	10		Industrial processes using bio-catalysts	**1**	**1**		**2**
	11		Production of industrial gases	**1**	**1**		**2**
	12		Coal: Classification, sampling, analysis, and selection; gasification,	**3**	**1**		**4**
	13		Combustion	**2**	**1**		**3**
			Total	**31**	**17**	**0**	**48**
Suggested books /reference books			Encyclopedia of Chemical Technology, Kirk-Othmer				
			Ulmann's Encyclopedia of Industrial Chemistry				
			Industrial Organic Chemistry, Weissermel & Arpe				
			Chemical Process Industries, Shreve B. Austin				
			Fuels Handbook, Johnson				
			Chemical Process Technology, Moulijn, M. and van Dippen				
Course code & title			**Outcomes** **Students will be able to**				
	CO1		Draw process flow diagrams/process block diagrams for the manufacture of various chemicals from process description				
	CO2		List out various alternatives for carrying out a particular process and provide recommendations for the best choice				
	CO3		List coal utilization technologies and advantages of clean coal technology				
	CO4		List Principles of combustion systems for solid, liquid and gaseous fuel				

Course code			**CEP4402**				
Course title			**Chemical Engineering Laboratory-III**				
Scheme and Credits			**0 L: 0 T: 8 P 4 Credits**				
Pre-requisites			Chemical reaction Engineering, Separation Process, Chemical Process Control				
Objectives of the course	**1**		Chemical Engineering lab provides students the first hand experience of verifying various theoretical concepts learnt in theory courses				
	2		It also exposes them to practical versions of typical chemical engineering equipments and servers as a bridge between theory and practice				
	3		This particular lab focuses on Chemical reaction Engineering, Separation Process, Chemical Process Control				
Detailed contents				**L**	**T**	**P**	**Tot**
	1		Mass Transfer Experiments (2-3 experiments)				
	2		Chemical Reaction Engineering (6-8 experiments)				
	3		Transport Phenomena (3-5 experiments)				
	4		Process Control (3-4 experiments)				

	5		Residence time distribution in CSTR				
			Total	**0**	**0**	**96**	**96**
Outcomes							
			Students will be able to				
	CO1		Learn how to experimentally verify various theoretical principles				
	CO2		Visualize practical implementation of chemical engineering equipments				
	CO3		Develop experimental skills				
	CO4		Able to clearly communicate the results of experimental work in oral and written formats.				

Course code			**CEP4412**	**L**	**T**	**P**	**Total**
Course title			**Process Simulation Lab-2**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			Transport phenomena, Chemical reaction Engineering, Separation process, Process Simulation Lab-1				
Objectives of the course	**1**		To learn write programs on Chemical Engineering processes and equipments				
	2		To learn the design aspects equipment through programming				
	3		To learn the solving process of Chemical Engineering problems through computational techniques				
Detailed contents				**L**	**T**	**P**	**Tot**
	1		Unsteady state heat and mass transfer				
	2		Fluid flow inside a pipe, heat transfer profile of flowing fluid				
	3		Terminal velocity, pump and friction factor				
	4		Computation of agitated vessel				
	5		Computation of heat exchanger				
	6		Computation of single-effect evaporator				
	7		Computation of dryer				
	8-12		Process simulation with Aspen Plus/other Process Simulation Software				
			Total	**0**	**0**	**48**	**48**
Outcomes							
			Students will be able to				
	CO1		Able to write algorithms of chemical engineering problems				
	CO2		Able to design chemical engineering problems and equipments				
	CO3		Able to perform qualitative and quantitative analysis of chemical engineering problems computationally				
	CO4		Able to clearly communicate the results of modelling work in oral and written formats.				

Study 7 (T12)										
			No.	Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
47	CE	CE	CET4409	Project Management and Economics in Chemical Industry	3	2	1	0	50	100
48	CE	CET	CET4406	Process Development and Engineering	3	2	1	0	50	100
49	CE	CEP3201	CEP4201	Mathematical Methods in Chemical Engineering/Optimization Chem. Eng. Proc.	4	2	0	2	50	100
50	ES	ESP	ESP4501	Equipment Design and Drawing	4	2	0	4	50	100
51	S	ST	xxT4xxx	Special Elective - V	3	2	1	0	50	100
52	CE	CEP	CEP4471	Seminar	3	0	0	6	50	100
				TOTAL	**20**	**10**	**3**	**12**	**300**	**600**

Course code			**HUT4401**				
Course title			**Project Management and Economics in Chemical Industry**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites			Material and Energy Balance Calculations, Equip Des and Dwg I, Energy Engineering, Ind Eng Chem.				
Objectives of the course	**1**		This course is required for the future professional career				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Project Management and Finance in Chemical Industry	**1**		Introduction to greenfield projects and global nature of projects; Impact of currency fluctuations on Project justification and cash flows andConcepts of "Quality by Design" including typical design deliverables andunderstanding constructability, operability and maintainability during all stages of project execution. Meaning of Project Engineering, various stages of project implementation				**4**
	2		Relationship between price of a product and project cost and cost of production, EVA analysis. Elements of cost of production, monitoring of the same in a plant, Meaning of Administrative expenses, sales expenses etc. Introduction to various components of project cost and their estimation. Introduction to concept of Inflation, location index and their use in estimating plant and machinery cost. Various cost indices, Relationship between cost and capacity.				**6**
	3		Project financing: debt: Equity ratio, Promoters' contribution, Shareholders' contribution, source of finance, time value of money. Concept of interest, time value of money, selection of various alternative equipment or system based on this concept. Indian norms, EMI calculations. Depreciation concept, Indian norms and their utility in estimate of working results of project. Working capital concept and its relevance to project.				**4**
	4		Estimate of working results of proposed project. Capacity utilization, Gross profit, operating profit, profit before tax, Corporate tax, dividend, Net cash accruals. Project evaluation: Cumulative cash flow analysis Break-Even analysis, incremental analysis, various ratios analysis, Discounted cash flow analysis				**5**
	5		Process Selection, Site Selection, Feasibility Report				**5**
	6		Project: Conception to Commissioning: milestones, Project execution as conglomeration of technical and non technical activities, contractual details. Contract: Meaning, contents, Types of contract. Lumpsum				**4**

			Turnkey (LSTK), Eng, Procurement and Construction (EPC), Eng, Procurement and Construction Management (EPCM). Mergers and Acquisitions				
	7		Reading of Balance Sheets and evaluation of Techno-commercial Project Reports.				**6**
	8		PERT, CPM, bar charts and network diagrams				**2**
			Total				**36**
Suggested books							
Suggested books /reference books	**1**		Chemical Project Economics, Mahajani V. V. and Mokashi S M.				
	2		Plant Design and Economics for Chemical Engineers, Peters M.S., Timmerhaus K.D.				
	3		Process Plant and Equipment Cost Estimation, Kharbanda O.P.				
Outcomes							
			Outcomes **Students will be able to**				
	CO1		Calculate working capital requirement for a given project				
	CO2		Calculate cost of equipment used in a plant total project cost				
	CO3		Calculate cash flow from a given project				
	CO4		Select a site for the project from given alternatives				
	CO5		List out various milestones related to project concept to commissioning				

Course code			**CET4407**				
Course title			**Multiphase Reaction Engineering**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites			Chemical Reaction Engineering , Momentum and Mass Transfer (CET 1101: Semester III), Heat Transfer, Chemical Reaction Engineering, Chemical Engineering Operations Separation Processes, Chem Engg Thermodynamics I and II				
Objectives of the course	**1**		Multiphase Reaction Engineering is concerned with the utilisation of chemical reactions on a commercial scale. This course is very relevant but not limited to the following industries: Inorganic chemicals, organic chemicals, petroleum & petrochemicals, Pulp & paper, Pigments & paints, rubber, plastics, synthetic fibres, Foods, Dyes and intermediates, Oils, oleochemicals, and surfactants, Minerals, cleansing agents, Polymers and textiles, Biochemicals and biotechnology, pharmaceuticals and drugs, Microelectronics, energy from conventional and non-conventional resources, Metals				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Multiphase Reaction Engineering	**1**		Classification of multiphase reactors, qualitative description, examples of industrial importance				**2**
	2		Hydrodynamics, scale-up, process design and performance of the following major classes of multiphase reactors, case studies and problems, w.r.t:				
	3		- Stirred tank reactors,				**6**
	4		- Bubble columns, packed bubble columns, sectionalised bubble columns,				**6**
	5		- Internal loop and external loop air-lift reactors, jet loop reactors,				**4**

	6		- Fluid-fluid reactors such as spray columns, packed columns, plate columns, static mixers, rotating disc contactors				**6**
	7		- Fixed bed reactors, trickle bed reactors,				**6**
	8		- Solid-liquid and gas-solid fluidised bed reactors, solid-gas transport reactors				**6**
			Total				**36**
Suggested books /reference books	**1**		Heterogeneous Reactions, Vol. I and II – L. K. Doraiswamy, M. M. Sharma				
	2		Fluid Mixing and Gas Dispersion in Stirred Reactors – G. B. Tatterson				
	3		Bubble Column Reactors – W. D. Deckwer				
	4		Fluidisation – D. Kunni and O. Levenspiel				
	5		Gas Liquid Reactions – P. V. Danckwerts				
	6		Fluidisation – J. F. Davidson and D. Harrison				
	7		Random Packings and Packed Tower Design – R. F. Strigel				
Outcomes			**Students will be able to**				
	CO1		calculate operating regime for a given reaction.				
	CO2		calculate intrinsic kinetics from the data on model contactors.				
	CO3		calculate conversion / selectivity / size / temperature / pressure / power required for conducting a given multiphase reaction equipment.				

Course code			**CET4406**				
Course title			**Process Development and Engineering**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites			All chemical Engineering subjects, Material Science and Engineering, Env Engg and Proc Safety				
Objectives of the course	**1**		This course integrates all the chemical engineering and allied subjects for appropriate design of process plants, in selection of processes and evaluating alternatives				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Process Development and Engineering	**1**		Development of a preliminary Process System: Modular approach				**2**
	2		Multiple process synthesis, selection of process, basic economic evaluation				**2**
	3		Sequencing of operations and integration in processes				**2**
	4		Process Engineering aspects of low and medium volume chemicals including process development. Batch vs continuous vs semi-batch processes-Scale up Scale up aspects; identification of controlling steps of process				**4**
	5		Concept of dedicated and multiproduct plant facilities, pilot plant, mini plants				**3**
	6		Development and evaluation of alternative flow sheets				**3**
	7		Green Engineering principles				**3**
	8		Utilisation of energy; cost of utilities, heat exchange networks				**3**
	9		Process intensification				**3**
	10		Preparation of Conceptual process and instrumentation diagrams.				**3**
	11		Preparation of process specifications for typical equipment.				**3**
	12		Safety and Risk of chemical processes				**3**
	13		Learn from mistakes				**2**

			Total				**36**
Suggested books /reference books	1		Industrial Chemical Process Design, D. L. Erwine				
	2		Laboratory Chemical Process Development, Anderson N.				
	3		Organic Unit Processes, Groggins				
	4		Chemical Process Engineering: Design and Economics, Silla H.				
	5		Handbook of Chemical Process Development, Chandalia S. B.				
	6		Conceptual Chemical Plant Design, Douglas J. M.				
Course code & title			**Outcomes** **Students will be able to**				
	CO1		to select a strategy for a process from amongst the alternatives				
	CO2		Determine strategy for carrying out a particular process				
	CO3		Prepare specifications for a particular equipment				
	CO4		Calculate utility requirements				

Course code			**ESP4501**				
Course title			**Equipment Design and Drawing**				
Scheme and Credits			**2 L: 0 T: 4 P 4 Credits**				
Pre-requisites			Equipment Design and Drawing-I, Structural Mechanics, Material Sci and Engg				
Objectives of the course	**1**		Chemical Engineers should have knowledge about Mechanical Design of Chemical Process Equipments such as Reaction Vessels, Heat Exchangers ,Distillation Columns etc . This will also be useful for using Design software which is widely used in chemical industries.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Equipment Design and Drawing	**1**		Mechanical Design of Reaction Vessels . a) Design of shells subjected to internal and external pressures. b) Types of Jackets /Coils used for heating and cooling in reaction vessels and their design. c) Type of agitators and their design. d) Design of agitator system components such as shafts,stuffing box etc.	**4**		**8**	**12**
	2		High Pressure Vessels. a) Construction and design.	**4**		**8**	**12**
	3		Mechanical Design of Heat Exchangers a) Types of heat exchangers such as double pipe, shell and tube type and special heat exchangers. Design of heads, flanges, nozzles, compensation for pressure vessels b) Components of shell and tube type heat exchangers. c) Design of various components of heat exchangers such as Fixed tube sheet type,U tube, Floating head etc. d) Various codes for heat exchangers.	**4**		**8**	**12**
	4		Mechanical design of distillation columns a) Types of columns such as tray and packed . Types of packings b) Various components of columns such as trays, packings, downcomers,bubble cap etc c) Design of shell for various stress conditions . d) Tray supports and their design	**3**		**6**	**9**

	5		Design of supports such as bracket, saddle and skirt for chemical process equipment	**2**		**4**	**6**
	6		Engineering flow sheets	**4**		**8**	**12**
	7		Piping and Instrumentation diagrams.	**3**		**6**	**9**
	8			**24**	**0**	**48**	**72**
			Total				
Suggested reference books	**1**						
	2						
	3						
	4						
	5						
Outcomes			**Students will be able to**				
	CO1		Students will be able to design (Mechanical) various parts such as shell, nozzles, for chemical process equipment.				
	CO2		Students will be able to prepare drawing for chemical process equipment.				

Study 8 (T14)										
				Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
53	CE	CET	CET4541	Advanced Transport Phenomena	3	2	1	0	50	100
54	CE	CET	CET4543	Advanced Mass Transfer	3	2	1	0	50	100
55	CE	CET	CET4543	Advanced Separation Processes	3	2	1	0	50	100
56	ES	EST	EST4501	LCA and Sustainability/ NPTEL/ Chemical Safety and Risk Management	3	2	1	0	50	100
57	S	ST	xxT4xxx	Advanced Special Elective - VI	3	2	1	0	50	100
58	HU	HUT	HUT4501	Research Methodology	4	3	1	0	50	100
59	CE	CEP	CEP4571	Design / Research Project - I	4	0	0	8	50	100
				TOTAL	**23**	**13**	**6**	**8**	**350**	**700**

Course code			**HUT4501**				
Course title			**Research Methodology/Design and Analysis of Experiments**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites			Applied Mathematics I				
Objectives of the course	**1**		Modern day manufacturing activities and R&D activites need decisions taken with a scientific rigour and should be wellsupported by 'statistics'. Chemical engineering graduates who will serve industry as well as postgraduate research students who will serve industry, R&D organisations, or academic research should have a reasonably good background of statistical decision making. This also involves extraction of meaningful data from well-designed minimal number of experiments at the lowest possible material costs. This course will also help the students in all domains of their life by imparting them a vision for critical appraisal and analysis of data.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Design and Analysis of Experiments	**1**		Overview of statistical analysis of data, statistical sampling, statistical inference, tests of significance, regression analysis.				**8**
	2		Analysis of variance.				**6**
	3		Statistical design of experiments, Factorial design, Response Surface Methodology (RSM).				**10**
	4		Box-Behnken and Plackett Burman methods, Central Composite Design (CCD)				**12**
			Total				**36**
Suggested books /reference books	**1**		Design of Experiments in Chemical Engineering: Živorad R. Lazić				
	2		Design and Analysis of Experiments: D. C. Montgomery				
	3		Introduction to Statistical Quality Control: D. C. Montgomery				
	4		Response Surface Methodology: Process and Product Optimization using Designed Experiments: R. H. Myers, D. C. Montgomery				
Course code & title			**Outcomes** **Students will be able to**				
	CO1		Realize importance of statistical analysis of data				
	CO2		Statistically correlate one set of data with another set, and identify whether the correlation is significant or not				

	CO3		List out set of experiments needed for a particular situation/process considering the interation between parameters/numbers of experiments needed				
	CO4		Apply the methods of experimental design to optimisation, and to identifying those parameters that are of highest importance				
Course code			**CET4541**				
Course title			**Advanced Transport Phenomena**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites							
Objectives of the course	**1**						
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		Turbulent flow: basics, Reynolds average Navier-Stokes equations, closure problem, Boussinesques hypothesis, Prandtl mixing length theory, turbulence models, energy spectrum, Turbulent boundary layer, universal velocity profile				**15**
	2		Gas-liquid and solid-liquid fluidised beds: Characteristics of particles, Principle of fluidisation and mapping of various regimes, Two phase theory of fluidisation, Bubbles in fluidised bed, Entrainment and Elutriation, Fast fluidised bed, Mixing, segregation and gas dispersion, Heat and mass transfer in fluidised bed, Solid-liquid fluidised bed and three phase fluidised bed, Design of fluidised bed reactors.				**12**
	3		Introduction to Computational Fluid Dynamics				**9**
			Total				**36**
Suggested books							
Suggested books /reference books	**1**		Transport Phenomena, R.B. Bird, W.E. Stewart, E.N. Lightfoot				
	2		Transport Phenomena, R.S. Brodkey				
	3		Momentum, Heat and Mass Transfer, Bennet and Myers				
	4		Fluid Mechanics, Pijush K. Kundu				
	5		Fluid Mechanics, K. Subramanya				
	6		Fluid Dynamics, G.K. Batchelor				
	7						
Outcomes							
			Outcomes **Students will be able to**				
	CO1		Calculate pressure drop in pipelines and equipment for different situations such as single- and two-phase flow, fixed and fluidized beds (K3)				
	CO2		Describe and discuss equation of motion for turbulent flows (K2)				
	CO3						
	CO4						
Course code			**CET4542**				
Course title			**Advanced Chemical Reaction Engineering**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites							
Objectives of the course	**1**						
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		• Theory of mass transfer with chemical reaction (regimes and examples), model contactors				**10**

	2		• Kinetics of solid-catalysed gas phase reactions: Diffusion with reaction in porous catalyst, Mechanism of catalytic reactions. Development of rate equations for solid catalysed fluid phase reactions; Estimation of kinetic parameters External/internal mass and heat transfer resistances in catalyst particles.				**10**
	3		• Design of fixed bed catalytic reactor - isothermal, adiabatic, non-isothermal programmed reactors: • Non-ideal flow in reactors; RTD, Estimation of dispersion/backmixing, dispersed plug flow and tanks in series model, design aspects of reactors with non ideal flow, micro and meso mixing in reactors				**10**
	4		• Reactor stability				**6**
			Total				**36**
Suggested books /reference books	1		Chemical Reaction Engineering, O. Levenspiel				
	2		Chemical Engineering Kinetics, J.M. Smith				
	3		Elements of Chemical Reaction Engineering, H. Scott Foggler				
	4		Chemical Reactor Analysis and Design, G.F. Froment, K.B. Bischoff				
	5		Chemical Reaction Analysis, E.E. Petersen				
	6		Heterogeneous Reactions vol. I and II, L.K. Doraiswamy, M.M. Sharma				
	7		Gas Liquid Reactions, P.V. Danckwerts				
	8		Mass Transfer with Chemical Reaction, G. Astarita				
Course code & title			**Outcomes** **Students will be able to**				
	CO1		Describe and discuss principles of various types of reactors (K2)				
	CO2		Calculate rates of reactions based on given reaction scheme (K3)				
	CO3		Design various components of reactors used in industrial practice (K5)				
	CO4		Compare various reactors and select an appropriate reactor for a given situation (K5)				

Course code			**2451**				
Course title			**Advanced Separation Processes**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites							
Objectives of the course	**1**						
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Advanced Separation Processes	**1**		Membrane Separations: Types of separations, reverse osmosis, ultrafiltration, gas separation, vapour permeation and pervaporation, dialysis, electrodialysis, nanofiltration	**9**	**3**		**12**
			Transport Through Porous Membranes, Resistance Models, Liquid Diffusion Through Pores				
			Gas Mixtures: Gas Diffusion Through Porous Membranes, Transport Through Nonporous Membranes, Solution-Diffusion for Liquid and gas mixtures				
			Concentration Polarization and Fouling, Membrane modules, arrangement of modules in cascades, performance criteria and design considerations				
	2		Methods for multicomponent separations: Fenske-Underwood-Gilliland Method, selection of two key	**6**	**2**		**8**

			components, minimum number of stages, minimum reflux and distribution of non key components, Kremser group method				
	3		Chromatographic Separations: Principles of chromatographic separation, criteria for effective separation, supports, and methodology and process design.	**4**	**2**		**6**
	4		Separation of Racemic Mixtures: Principles of racemic modification and their application in separation of racemic mixtures with specific examples.	**3**	**1**		**4**
	5		Dissociation Extraction, Reactive Extraction, Reactive distillation	**4**	**2**		**6**
			Total				**36**
Suggested books /reference books	**1**		Transport Processes and Separation Process Principles, C.J. Geankoplis				
	2		Separation Processes, C.J. King				
	3		Separation Process Principles, Authors: J.D. Seader, E.J. Henley				
	4		Principles of Mass Transfer and Separation Processes, B.K. Dutta				
	5		Mass Transfer Operations, R.E. Treybal				
	6		Green Separation Processes, C.A.M. Afonso, J.F. Crespo				
	7		Equilibrium Stage Separation Operations in Chemical Engineering, E.J. Henley, J.D. Seader Diffusion: Mass Transfer in Fluid Systems, E.L. Cussler				
	8		Chemical Engineering, Volume 2, J.M. Coulson, J.F. Richardson				
	9						
Outcomes			**Students will be able to**				
	CO1		Describe and discuss principles of various advanced separation processes based on membranes, chromatography, distillation, extractions (K2)				
	CO2		Design various components of equipment used in advanced separation processes (K5)				
	CO3		Compare various options and select an appropriate process for a particular separation (K5)				
Course Code			EST4501				
Course Title			LCA and Sustainability				
Credits			2L +1 T = 3 credits				
Course Outcomes			**(students will be able to…..)**				
		1	Understand the different types of environmental pollution problems, and their sustainable solutions				
		2	Able to work in the area of sustainability for research and education				
		3	Have a broader perspective in thinking for sustainable practices by utilising the engineering knowledge and principles gained from this course				
		4	?????????				
		5	Create a model research project				
		1	Understand the different types of environmental pollution problems, and their sustainable solutions				
List of Prerequisite Courses			Introductory knowledge of linear algebra, probability, chemistry, and economics is recommended.				

List of Courses where this course will be prerequisite			Design / Research Project – II (CEP-4552)				
Course Description			Today our world is confronted with sustainability challenges at an unprecedented scale. Human-induced climate change, the depletion of natural resources including water, and threats to food security threaten to adversely affect people's well-being at a time when many individuals also struggle to overcome poverty, inequity, and other affronts to human rights. The magnitude of these challenges and their wide-ranging adverse ramifications motivate proactive businesses and entrepreneurs to act, whether by participating in efforts to mitigate risk and negative externalities or by innovating to create positive change. This course is relevant as it the students will: Have an increased awareness amongst students on issues in areas of sustainability. Understand the role of engineering and technology within sustainable development. Know the methods, tools, and incentives for sustainable product-service system development. Establish a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, and economic problems.				
Course Contents							
		1	**Sustainability:** Need and concept; Challenges				
		2	Environment acts and protocols				
		3	Global, regional, and local environmental issues; Natural resources and their pollution				
		4	Carbon credits; Zero waste concept				
		5	Carbon credits				
		6	Zero waste concept				
		7	ISO 14000				
		8	**Life Cycle Analysis (LCA):** Environmental impact assessment studies				
		9	Sustainable habitat; Green buildings				
		10	Green materials; Conventional and renewable sources of materials				
		11	Conventional and renewable sources of energy				
		12	Technology and sustainable development				
		13	Sustainable urbanisation				
		14	Ecology				
		1	Allen D. T., Shonnard, D. R.; Sustainability Engineering: Concepts, Design, and Case Studies; Prentice-Hall.				
		2	Bradley, A. S., Adebayo, A. O., Maria, P.; Engineering Applications in Sustainable Design and Development; Cengage Learning				
		3	Environmental Impact Assessment Guidelines; Notification of Government of India, 2006				

		4	Mackenthun, K. M.; Basic Concepts in Environmental Management, Lewis Publication, London, 1998				
		5	ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications – GRIHA Rating System.				
		6	Ni Bin Chang; System Analysis for Sustainable Engineering: Theory and Applications; McGraw-Hill Professional.				
		7	Twidell, J. W., Weir, A. D.; Renewable Energy Resources, English Language Book Society (ELBS).				
		8	Purohit, S. S.; Green Technology – An Approach for Sustainable Environment; Agrobios Publication				

CET-4544: Chemical Safety and Risk Management (3 = 2+1+0; CT = 25; End-sem = 25; Total = 50)

Course code: CET-4544 **Course Title: Chemical Safety and Risk Management** **Credits = 3**

		L	**T**	**P**
Term: 8	**Total contact hours: 36???**	**2**	**1**	**0**

Course Outcomes (students will be able to…..)

1	List principles of safety, risk management, and material hazards	K1
2	Define safety principles, procedures, standards and regulations	K1
3	Describe safety aspects related to chemicals, fires, electricity, pathogens, etc.	K2
4	Apply SHE management principles in the industry	K3
5	Assess the risks and environmental impact of projects and processes	K4
6	Perform tasks such as hazard identification or plant layout, etc.	K3

List of Prerequisite Courses

1 Basic knowledge of chemical processes

List of Courses where this course will be prerequisite

1 Design / Research Project – II (CEP-4552)
2 This course will be useful for an advanced level course on chemical process safety.

Description of the relevance of this course in the *Integrated M. Tech.* Program

This course will provide key information on several safety-related aspects in the chemical industry and research laboratories.

Course Contents (Topics and subtopics) Hours

1 Introduction to Safety and Risk Management
   Major industrial disasters and evolution of safety and risk management
2 Material hazard - GHS MSD - physical hazard, toxic hazard and eco-toxicity
   MSDS (Material Safety Data Sheet), 16-point MSDS, uniformity in MSDS, details of MSDS, LD50 & LD10 dosage values; TLV, STEL, Flash, Vapour pressure; Globally Harmonized System (GHS), R&S phrases
3 PSM elements
   Why PSM; Overview of 14 elements
4 Hazard evaluation techniques – What-If, Checklist, HAZOP, FEMA etc.
   Overview of each of HAZOP & HAZAN Analysis; Cause and Consequence Analysis; FMEA; LOPA; Fault Tree Analysis; QRA
5 Hazard identification and assessment – 1.
   Basic Hazard identification, assessment & measures
6 Flammability and fire safety-extinguishers
   Fire types, Types of fire extinguishers, Agents for fire-fighting, Fire hydrant
7 SHE regulations in India- Factories Act, Water and Environment Act
   Statutory regulations in India; Codes and Standards; Scenario at present and vision for future; Factory Act.
8 Human elements in safety - behaviour safety

9 Laboratory safety
Basics and Dos & Do not.
10 Basic OSH
Occupational hygiene basics.
11 Compliance with statutory safety audits
Overview of safety audits based on ISO standards (14000)
12 Biosafety
Biohazards; Basic microbiology of pathogens; Pathogenic risks; Containment; Biosafety levels; Laboratory facilities for handling pathogens; Personal protective equipment; Disinfection and decontamination; Biohazard waste disposal; Emergency measures.
13 Plant layout based on process safety & fire safety-fire hydrant system design
Solvent yard, warehouse, and plant layout with the fire safety system design.
14 Management Practice in SHE in Plant Operation
Man-management, organization management, policy management; Fundamentals of safety management systems for occupational safety, job hazard analysis (confined space, height safety, hot jobs); Chemical and plant security; Cyber security as applicable to Chemical Projects; Management of change; Incident reporting and investigation; Human elements in safety, ergonomics and behavioural safety.
15 Hazard assessment – 2. Process safety, thermal safety, dust explosion etc.
Inherent safety concepts for processes and unit operations; Powder handling hazards - dust explosion.
16 Safety in utilities
Safety in electrical power generation units including nuclear, steam boilers, boiler feed water, thermic fluids, transformers.
17 Storage, handling and transportation of hazardous substances
Safety provisions during transport of petroleum products including LNG and other hazardous materials by ship, rail, air cargo and roads; transport emergency; isolated storage; warehouses; colour coding of pipelines; inventory management; packaging and labelling.
18 Environmental Impact Assessment
Environmental impact and risk assessment (EIRA), risks of projects, process-related risks, measurement and monitoring tools
19 Emergency response plan
Hazard identification and elements of emergency response plan; OHC categorization, control banding and precautions while handling substances; GMP principles

List of Textbooks / Reference Books

1 Elements of Industrial Hazards – Ratan Raj Tatiya, CRC Press
2 Environmental Life Cycle Analysis – Ciambrone, D. F., CRC Press
3 Handbook on Life Cycle Assessment: Operational Guide to ISO Standards, Kluwer Academic Pub.

CEP-4571: Design/Research Project – I (3 = 2+1+0; CT = 50; End-sem = 50; Total = 100)

Course code: CEP-4571	**Course Title: Design/Research Project – I**	**Credits = 4**		
		L	**T**	**P**
Term: 8	**Total contact hours: 4571**	**0**	**0**	**4**

The Design / Research Project – I is concerned with detailed and critical analysis of literature related to the research OR design topic allotted to the candidate. This will be supervised by two faculty members. The candidate is expected to submit a report as per the guidelines provided below. The report will be evaluated based on the presentation made by the candidate by both the supervisors and one external examiner from the Department OR Industry. A suitable combination of the marks for the report and presentation will be considered for the final evaluation.

Guidelines

1. Typically, the report should contain the following:
(a) Introduction: 2 pages maximum.
(b) Exhaustive review of the literature (**including** figures): 10 – 12 pages
(c) Critical analysis of the literature and comments critical analysis should also contain a quantitative comparison of observations, results, and conclusions amongst the various papers.

2. Two typed copies of the report on thesis size bond paper (297 mm x 210 mm) are to be submitted to the Coordinator on the date **to be decided by the coordinator. In addition, a soft copy of the report should be submitted to the coordinator.** The detailed timetable for the presentation would be communicated.

3. The report should be prepared using the Times Roman font (size 12) using 1.5-line spacing leaving a 1-inch margin on all sides. The report should be printed on one side of the paper and should **not** be bound in a hardcover binding. Figures and tables should be shown as a part of the running text. The figures must be sufficiently clear and hand-drawn figures will be acceptable. Particular care must be taken if a figure is photocopied from the source. Each figure must have a sequence number and caption below. Each table must have a sequence number and title at the top.

4. Name of the student, title of the problem and year of the examination must be indicated on the top cover of the report. THE NAME OF THE SUPERVISOR (**ONLY THE INITIALS**) MUST APPEAR ON THE BOTTOM RIGHT CORNER OF THE TOP COVER.

5. The report must be precise. All important aspects of the topic should be considered and reported. **The total number of pages, including tables, figures, and references should not exceed 30**. Chapters or subsections **need not be** started on new pages while getting the report typed.

6. Typographical errors in the report must be corrected by the student. The student will be discredited for any omission in the report. All the symbols used in the text should be arranged in alphabetical order and given separately after conclusions.

7. The list of REFERENCES should be arranged in **alphabetical order** of the **last names** of authors. In the text, the reference should be cited with the author's name and year. (author-date style). For example:

(i) The flow pattern in gas-liquid-solid fluidized beds has been reported in the published literature (Murooka et al., 1982).

OR

(ii) Murooka et al. (1982) have measured flow patterns in gas-liquid-solid fluidized beds. The title of the article should also be included. The references must be given in the following standard format.

(a) Format for listing references of articles from periodicals: Murooka S., Uchida K. And Kato Y., Recirculation Turbulent Flow of Liquid in Gas-Liquid-Solid Fluidised Bed", J. Chem. Engg. Japan, 15, 29-34 (1982).

(b) Format for listing references of Books:

Constant R.F., Crystallization, Academic Press, New York, pp. 89-90, 1968.

(c) Format for listing Thesis:

Niranjan K., "Hydrodynamic and Mass Transfer Characteristics of Packed Columns", PhD (Tech.) Thesis, University of Mumbai, 1983.

(d) Format for listing references of Patents in Chemical Abstracts:

Cananaush R.M., U.S. Patent 2,647,141, Cf. C.A. 48, 82636 (1954).

(e) Format for listing Handbooks, Tables, Symposia etc.:

Kumar R and Kuloor N.R., "Formation of Drops and Bubbles", in Advances in Chemical Engineering, Vol.8, T.B. Drew et.al. (Eds.) New York, Academic Press, pp.256-364 (1970).

(f) Format for listing Private Communications and other categories:

Sharma, M.M., Private Communication (1984).

8. Consistency of units should be maintained in the written report. SI systems should be used. [For SI system – Ref: Ind. Chem. Engr., 24, 32, 3 (1983)]. Units used in the literature (if not SI) should be correctly converted.

9. The time allotted for the oral presentation is 20 minutes: additional 10 minutes are provided for questions and answers.

10. INCOMPLETE AND CARELESSLY WRITTEN REPORT IS LIABLE TO BE REJECTED.

11. The last date for submission will NOT be extended on any grounds whatsoever.

12. There must not be any acknowledgement about the guidance by the faculty in the report.

13. The report will be evaluated based on (i) rational approach to the problem, ii) correctness and completeness of the written text and iii) performance in the oral presentation.

14. Word-to-word copying from the published article is not permitted.

Course Outcomes (students will be able to…..)

1	Collect literature related to an assigned area	K1
2	Understand the lacunae in the literature	K2
3	Analyse the literature and present suitable guidelines	K4
4	Write a neat report following the guidelines	K2, K4
5	Propose a defined plan for the design/research	K6
6	Start the execution of design/research project	K6

List of Prerequisite Courses

All courses taught till date.

List of Courses where this course will be prerequisite

1 CEP-4552 Design/Research Project – II

Description of the relevance of this course in the *Integrated M. Tech.* Program

This project is a continuation of the Design/Research Project-I. This course enables the students to analyse and utilise the information and data gathered in the Design/Research Project-I on a particular Design/Research topic, and come up with a suitable design AND/OR research conclusion. The student should submit and present a written and oral summary on that topic.

Study 9 (T15)										
				Subjects	Credits	Hrs/week				
						L	T	P	E. S.	Total
60	HU	HU	HUT4402	Perspectives of Society, Science and Technology	3	2	1	0	50	100
61	HU	HU	HU4501	Industrial Psychology and Management	3	2	1	0	50	100
62	CE	CET	CET4407	Advanced Chemical Reaction Engineering	3	2	1	0	50	100
63	CE	CEE	CET4xxx	Advanced Chemical Eng. Elective - I	3	2	1	0	50	100
64	S	ST	xxT4xxx	Advanced Special Elective - VII	3	2	1	0	50	100
65	CE	CEP	CEP4572	Design / Research Project - II	9	0	0	18	75	150
				TOTAL	**24**	**10**	**5**	**18**	**325**	**650**

Course code			**HUT4402**				
Course title			**Perspectives of Society Science and Technology**				
Scheme and Credits			2 L: 1 T: 0 P 3 Credits				
Pre-requisites			All the Science and Engineering Courses so far				
Objectives of the course	**1**		This course is relevant for future professional career of a Chemical Engineer.				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Perspectives of Society Science and Technology	**1**		History of Science and Technology and its relevance in the respective era				4
	2		Recent developments in technology (chemical, biotechnology energy, telecommunications, etc.) and their influence on society				4
	3		Economics and Sustainable Development				4
	4		Value system and Ethics in the profession of Technology, Science and Engineering.				2
	5		Problems before the World and India. Various approaches in solving them.				2
	6		Integrating Issue: Society and Science				4
	7		Industrial disasters and their effect on science and technology and society				2
	8		Environmental degradation, global warming and their effect on science and technology and society				2
	9		IPR issues and their relevance to science and technology and society				2
	10		Some aspects of future of Society, Technology, Science and Engineering.				2
	11		Interdependence of Theology and Science				2
	12		Impact of climate change on the nexus of water, energy and water				2
	13		Technology and World Peace Role of Innovation and R&D				2
	14		Industry-Academia Interaction to Enhance Standard of Living				2
			Total				36
Suggested books							
	1		Science, Technology and Society: An Encyclopedia by Sal Restivo, Oxford University Press 2005				
	2		Science, Technology and Society: A Sociological Appraoach by Wenda K. Bauchspies, Jennifer Croissant, Sal P. Restivo				
	3		Vision of STS: Counterpoints in Science Technology and Society Studies by Stephan H. Cutcliffe, Carl Mitcham, Sunny Press 2012				
	4						
Outcomes			**Students will be able to**				
	CO1		List some historical scientific developments				

	CO2		State importance and implications of patents and some of the relevant laws				
Course code			**HU4501**				
Course title			**Industrial Psychology and Management**				
Scheme and Credits			**3 L, 1 T, 0 P = 4 Credits**				
Pre-requisites							
Objectives of the course	**1**		This course equips students with human resource management skills to be able to function effectively in their professional career				
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
Equipment Design and Drawing	**1**		Introduction & Overview of the course	**2**	**1**		**3**
	2		Changes/Challenges in HRM	**2**	**1**		**3**
	3		Management Theories	**2**	**1**		**3**
	4		Research Methodology & Statistical Tools	**2**	**1**		**3**
	5		Management of Change	**2**	**1**		**3**
	6		Organizational Culture & Climate	**2**	**1**		**3**
	7		Knowledge Productivity	**2**	**1**		**3**
	8		New Leadership Motivation Theories	**2**	**1**		**3**
	9		Talent Management	**2**	**1**		**3**
	10		Training & Development	**1**	**1**		**2**
	11		Performance Management	**1**	**1**		**2**
	12		Selection and Recruitment	**1**	**1**		**2**
	13		Compensation, Unions and Entrepreneurship	**2**	**1**		**3**
			Total	**23**	**13**	**0**	**36**
Suggested reference books	**1**		Personality and Organization, Argyris C.				
	2		The Essence of Leadership, Locke, Edwin A				
	3		Organisational Behaviour, Robbins S				
	4		Managing Human Resources, Bach, S. 2005				
	5		Human Resource Management: A Contemporary Approach, Claydon, T and J. BeardwellFolger, R. and R.				
Outcomes			**Students will be able to**				
	CO1		Students should be able to explain the fundamental concepts of IPHRM.				
	CO2		Students should be able to analyze practical situations				
	CO3		Students will be able to provide applicable solutions				
Course code			**CET4543**				
Course title			**Advanced Mass Transfer**				
Scheme and Credits			**2 L: 1 T: 0 P 3 Credits**				
Pre-requisites							
Objectives of the course	**1**						
Course title			**Detailed contents**	**L**	**T**	**P**	**Tot**
	1		Thermodynamic, kinetic and hydrodynamic physical phenomena governing interfacial mass transfer and generation of interfacial transfer area.	**6**	**3**		**9**
	2		Shell balances to set up lumped parameter models and more sophisticated differential equation based models to describe mass transfer under various commonly encountered industrial situations.	**6**	**3**		**9**
	3		The Stefan-Maxwell Unified approach to mass transfer.	**2**	**1**		**3**
	4		Standard algorithms for multicomponent countercurrent mass transfer and their applicability.	**4**	**2**		**6**
	5		Mass Transfer equipment of Industrial significance and their quantitative characterization.	**6**	**3**		**9**
			Total	**24**	**12**		**36**
Suggested books							

Suggested books /reference books	**1**		Transport Phenomena, R.B. Bird, W.E. Stewart, E.N. Lightfoot				
	2		Transport Phenomena, R.S. Brodkey				
	3		Momentum, Heat and Mass Transfer, Bennet and Myers				
	4		Fluid Mechanics, Pijush K. Kundu				
	5		Fluid Mechanics, K. Subramanya				
	6		Fluid Dynamics, G.K. Batchelor				
	7						
Outcomes							
			Outcomes **Students will be able to**				
	CO1		Describe and discuss principles of various mass transfer operations (K2)				
	CO2		Calculate Mass transfer rates for given mass transfer operation (K3)				
	CO3		Design various components of equipment used in mass transfer operations (K5)				
	CO4		Compare various options of mass transfer operations and equipment and select an appropriate equipment / operation for a particular situation (K5)				

Minor Degree: Special Electives

Lipids

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1		SLT4302	Theory	Introduction to Lipid Technology
2		SLT4303	Theory	Chemistry of Lipids and their applications
3		SLT4403	Theory	Lipid Processing Technology I
4		SLT4404	Theory	Production and Applications of Soaps, Surfactants and Detergents
5		SLT4405	Theory	Lipid Processing Technology II
6		SLT4506	Theory	Essential Oils and Cosmetics
7		SLT4507	Theory	Technology of Oleochemicals
1		SFP4301	Laboratory	Lipids Laboratory-I
2		SLP4402	Laboratory	Lipids Laboratory-II

Course code			**SLT4302**				
Course title			**Introduction to Lipid Technology**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites							
Description of course			This course will give an overview of applications of technology and engineering principles in oil and lipid industry				
Objectives of the course	**1**		Understand the industrial chemistry of oils, fatty acids, surfactants and oleochemicals.				
	2		Understand the chemistry behind the oils, lipids, essential oils.				
	3		Understand and explain the mechanism, theory and practice of oil extraction, refining and modification.				
Syllabus	**1**		General introduction to oils, fats, waxes and essential oils; Important Minor/ Non-triglyceride Constituents of natural oils and fats; Separation and isolation of fatty acids; Chemical properties of fatty acids and their esters; Chemical analysis of oils	**4**	**2**		**6**
	2		Glyceride Synthesis, acylation procedures, Introduction and removal of protecting groups ; Advanced methods of analysis of oils	**4**	**2**		**6**
	3		Introduction to technology of oil and fat production and edible oil processing; Natural sources of oils and fats, domestic and world production, trade and marketing of oilseeds and oils; Newer sources of oils and fats; Oilseeds processing; Recovering and production of oils and fats from different sources like palm oil, rice bran oil, etc.	**8**	**4**		**12**
	4		Antinutritional constituents of oilseeds; Newer techniques of refining of oils and fats; Manufacture of butter, margarine and ghee, Vanaspati, bakery and confectionery fats and fatty foods; Protection against auto oxidation	**8**	**4**		**12**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses, Frank D. Gunstone, Blackwell Publishing Ltd, UK (2004)				

	2		Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 6: Industrial and Nonedible Products from Oils and Fats, Ed. Fereidoon Shahidi, Wiley Interscience Publication (2005).				
	3		Chemistry and technology of oils and fats by Prof. M. M. Chakrabarti, allied publishers (2003).				
Outcomes			On completion of the course, the students will be able to				
	CO1		Ability to understand and explain the constitution of Oils and Fats and their importance				
	CO2		Ability to conceptualize and develop the different modes of derivatizations from oils/ fatty acids.				
	CO3		Able to understand fundamental knowledge on basics of post harvest technology for oilseeds, chemistry involved in the oil /fat production and refining				
				L	**T**	**P**	**Total**
Course code			**SLT4303**				
Course title			**Chemistry of Lipids**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites							
Description of course			Students will be able to understand the industrial chemistry of oils and fatty acids. They will be trained with respect to basics of sources of oils, minor constituents, physical and chemical properties of oils and fatty acids, various derivatisation pathways and related analytical tools.				
Objectives of the course	**1**						
	2						
	3						
Syllabus	**1**		General introduction to oils, fats and waxes: Chemical structure, sources and composition. Classification of oils and fats by source type, fatty acid composition and drying properties. Statistics of Indian as well as world production of commercial oil seeds/ oil bearing materials, oils and fats, importance as feedstock for food and chemical industries.	**2**	**1**		**3**
	2		Physical characteristics of natural oils and fats: Oiliness and viscosity, density and expansibility, thermal properties, smoke, fire and flash points, solubility and miscibility, refractive index and molecular refraction, adsorption spectra, electrical properties, colour value.	**2**	**1**		**3**
	3		Fatty acids: Nomenclature and classification; saturated, monounsaturated, polyunsaturated fatty acid and essential fatty acids. Physical properties of fatty acids and their esters. Polymorphism and crystal structure, solubility, refractivity, optical activity, spectroscopic properties.	**2**	**1**		**3**
	4		Important minor/ non-triglyceride constituents of natural oils and fats: Phospholipids, galactolipids, sphingolipids, diacylglycerols, monoacylglycerols, sulfolipids, waxes, sterols, triterpene alcohols, and their esters, tocopherols/tocotrienols, lipid-soluble	**2**	**1**		**3**

			vitamins, hydrocarbons, pigments, phenolic compounds etc.				
	5		Separation and isolation of fatty acids: Distillation, crystallization and counter current distribution. Methods of structure determination.	**4**	**2**		**6**
	6		Hydrolysis and esterification: Acid-, base-catalyzed and enzymatic hydrolysis of oils/fats, Fat splitting process. Neutralization, saponification, formation of metallic soaps. Acylation, esterification, interesterification, transesterification.	**4**	**2**		**6**
	7		Chemical reactions of oils/fats and fatty acids: Estolide synthesis. Hydrogenation, halogenation, epoxidation, hydroxylation, ozonolysis, metathesis. Thermal and oxidative polymerization, Diels-Alder reaction, Stereomutation, double bond migration and cyclization.	**4**	**2**		**6**
	8		Glyceride Synthesis, acylation procedures, introduction and removal of protecting groups, 1-monoglycerides, 2-monoglycerides, 1,2-diglycerides, 1,3-diglycerides, Trans fatty acids	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Treatise on fats, fatty acids and oleochemicals by O. P. Narula, Vol I & II, Industrial Consultants (India), (1994)				
	2		Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 6: Industrial and Nonedible Products from Oils and Fats, Ed. Fereidoon Shahidi, Wiley Interscience Publication (2005).				
	3		Chemistry and technology of oils and fats by Prof. M. M. Chakrabarti, allied publishers (2003).				
Outcomes			On completion of the course, the students will be able to				
	CO1		Able to understand fundamental knowledge on basics of post harvest technology for oilseeds, chemistry involved in the oil /fat production and refining				
	CO2		Able to describe the plant and processes for oil/ fat extraction				
	CO3		Able to understand and explain the meal composition, upgradation of meal/ cake and antinutritional factors and detoxification				
	CO4		Able to explain the fat storage, auto oxidation and spoilage				
				L	**T**	**P**	**Total**
Course code			**SLT4403**				
Course title			**Lipid Processing Technology I**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites							
Description of course			This course will give an overview of applications of technology and engineering principles in oil and lipid industry				
Objectives of the course	**1**		Students will understand the mechanism, theory and practice of oil extraction.				
	2		They will be able to explain refining of oils/fats, fat modification processes.				

	3		Understand and explain the mechanism, theory and practice of oil extraction, refining and modification.				
Syllabus	**1**		Storage, sampling, grading, cleaning, crushing, and heat treatment of oilseeds	**2**	**1**		**3**
	2		Mechanical expression, solvent extraction, rendering and other methods of recovering oils and fats. Economic aspects of these processes.	**4**	**2**		**6**
	3		Specific methods for the production of palm oil, palm kernel oil and rice bran oil.	**2**	**1**		**3**
	4		Technical refining of oils for industrial uses, detoxification and technical products from oil cakes, edible products from oil meals, synthetic fatty material.	**4**	**2**		**6**
	5		Antinutritional constituents of oilseeds. General methods of upgrading and utilization of oils, oil cakes and other products, Protein concentrates and isolates from oil meal	**4**	**2**		**6**
	6		Processes and equipment employed for refining, bleaching, deodorization, hydrogenation and winterization of oils or edible purposes	**4**	**2**		**6**
	7		Newer techniques of refining of oils and fats	**2**	**1**		**3**
	8		Composition and properties of these spoilage during storage of fats, and fat products, protection against auto oxidation	**2**	**1**		**3**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses, Frank D. Gunstone, Blackwell Publishing Ltd, UK (2004).				
	2		Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 6: Industrial and Nonedible Products from Oils and Fats, Ed. Fereidoon Shahidi, Wiley Interscience Publication (2005).				
	3		Chemistry and technology of oils and fats by Prof. M. M. Chakrabarti, allied publishers (2003).				
	4		Fatty Acids in Industry, R. W. Johnson, and E. Fritz, eds., Marcel Dekker, Inc., New York, (1989)				
	5		Oils and Fats Manual, Eds. A. Karleskind and J.-P. Wolff, Vols. I and II, Intercept Ltd., Andover, U.K. (1996).				
	6		Fatty Acid and Lipid Chemistry, F. D. Gunstone, Blackie Academic and Professional, London, U.K. (1996).				
Outcomes			On completion of the course, the students will be able to				
	CO1		Understand and explain the constitution of oils and fats and their importance as feedstock for food and chemical industries. (K2)				
	CO2		Analyze and illustrate the physical, chemical and stability characteristics of oils and fats/ fatty acids. (K4)				
	CO3		Understand the technical importance of the minor constituents of natural oils and fats.(K2)				
	CO4		Implement different modes of derivatizations of oils/ fatty acids. (K3)				
	CO5		Identify and interpret the tools for chemical analysis of oils and fats. (K3)				

				L	**T**	**P**	**Total**
Course code			**SLT4404**				

Course title			**Production and Applications of Soaps, Surfactants and Detergents**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites							
Description of course							
Objectives of the course	**1**		Students will understand the mechanism,theory and practice of Surfactant production.				
	2		They will be able to explain types of soaps,detergents and their formulations				
Syllabus	**1**		Raw materials for the soap industry, classification and selection of raw materials, properties of soaps and soap solution. Testing and evaluation, Indian Standard Institution methods, essential oils and other ingredients for soaps.	**2**	**1**		**3**
	2		Phases in soap boiling, processes employed in the manufacture of soap, various types of soaps and cleaning preparations	**2**	**1**		**3**
	3		Detergents, their classification, raw materials, processes, and plants for the manufactures of detergents for domestic and industrial consumption, product evaluation, Indian Standard Institution Methods, essential oils and other ingredients for detergents.	**6**	**3**		**9**
	4		Plant & processes for the production of important anionic, non-ionic, cationic and amphoteric surfactants.	**4**	**2**		**6**
	5		Fluorinated surfactants, new generation surfactants such as Gemini surfactants, silicon surfactants and sugar based surfactants.	**4**	**2**		**6**
	6		Fluorinated surfactants, new generation surfactants such as Gemini surfactants, silicon surfactants and sugar based surfactants.	**2**	**1**		**3**
	7		Application of soaps, surfactants and detergents in food, pharmaceuticals, textile, leather, surface coating, adhesives and other industries	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Soaps by Prof. J. G. Kane				
	2		Treatise on fats, fatty acids and oleochemicals by O. P. Narula, Industrial Consultants (India), Vo. I & II (1994)				
	3		Fats, Oleochemicals and surfactants challenges in 21 st Century by V. V. S. Mani and A. D. Shitole, Oxford and IBH Publishing Co. Pvt. Ltd. (1997)				
	4		Manufacture of soaps, other detergents and glycerin by E. Woollatt, John Wiley and Sons (1985)				
Outcomes			On completion of the course, the students will be able to				
	CO1		Able to describe the plant and processes for soaps, surfactants and detergents extraction				
	CO2		Able to understand and raw materials and formulations of common types of surfactants, soaps and detergents				

	CO3		Able to explain new generation of surfactants and quality standards of soaps, surfactants and detergents				
	CO4		Able to explain the industrial applications of soaps and surfactants				
				L	**T**	**P**	**Total**
Course code			**SLT4405**				
Course title			**Lipid Processing Technology II**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites							
Description of course							
Objectives of the course	**1**						
	2						
Syllabus	**1**		Fat splitting: Hydrolysis of oils and fats; composition of partially split fats, Technology of fat splitting, Effect of temperature, pressure, catalyst and ratio of reactants in hydrolysis of fats; degree of splitting;	**7**	**2**		**9**
	2		Fatty acid fractionation: distillation, crystallization, high purity fatty acid products blends, etc	**4**	**2**		**6**
	3		Hydrogenation of oils: Significane of hydrogenation, Catalysts for hydrogenation, kinetics of reaction, effect of operating parameters on kinetics, selectivity and isomer formation, trans fat replacement solutions and technology, worldwide trends & regulations.	**7**	**2**		**9**
	4		Production of fatty alcohols	**4**	**2**		**6**
	5		Production of bio diesel and green diesel	**4**	**2**		**6**
				26	**10**	**0**	**36**
Suggested books/ reference	**1**		M.M Chakrabarty. Chemistry and Technology of Oils and Fats. Allied Publishers Pvt. Ltd. New Delhi				
	2		Treatise on fats, fatty acids and oleochemicals by O. P. Narula, Industrial Consultants (India), Vo. I & II (1994)				
	3		Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 6: Industrial and Nonedible Products from Oils and Fats, Ed. Fereidoon Shahidi, Wiley Interscience Publication (2005).				
	4		Hydrogenation of Oil & Fat Edited by H.B.W. Patterson Applied Science publishers (1983)				
	5		Gupta, M. K., Practical guide to vegetable oil processing. AOCS Press, 2008 Urbana, Illinois.				
	6		Fats and oils, Formulating and Processing for Applications, 3rd Edition,2009, Richard D.O. Brien.				
	7		Fats and Oils Handbook, Michael Bockisch, 1st Edition, 1998, AOCS Press				
Outcomes							
	CO1						
	CO2						
	CO3						
	CO4						

				L	T	P	Total
Course code			**SLT4506**				
Course title			**Essential Oils and Cosmetics**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites							
Description of course							
Objectives of the course	**1**						
	2		Students will understand the chemistry of cosmetics products, raw materials and other ingredients required and their significance in cosmetics formulations.				
Syllabus	**1**		Essential oils: extraction from different sources, separation and purification. Enflurage, Maceration, solvent extraction, supercritical extraction, water distillation, water steam distillation and steam distillation. Analysis of essential oils for RI, optical rotation, density, solubility, boiling point, melting point.	**6**	**2**		**8**
	2		Characteristics and composition of Indian essential oils like sandal wood oil, pine oil, cedar wood oil, palmrosa oil, patchouli, mint, clove, cardamom, cinnamon leaf oils, coriendor oil, ajwan, cumene, vetivert, eucalyptus, rosha oil, citrus oils, orange oils, rose, jasmine juichameli oils etc. Role of essential oil in aroma therapy. Stability studies of essential oil. Evaluation and testing of essential oils by sensory hedonic and substantively and GC tests.	**6**	**2**		**8**
	3		Common ingredients used in cosmetics, surfactants, additives, antioxidants, preservatives. Equipments, plants and machinery used for manufacture.	**4**	**2**		**6**
	4		Formulations of different cosmetic creams such as hair care products, skin creams, Shaving products, after shave products, Aerosol cosmetics, perfumes and aromatic products	**4**	**2**		**6**
	5		Evaluation and Efficacy of cosmetics products. Stability tests and product specifications	**3**	**1**		**4**
	6		Concept of product design, labeling, claiming and claim support understanding of current needs, translation of current needs to products	**3**	**1**		**4**
				26	**10**	**0**	**36**
Suggested books/ reference	**1**		Essential oils (Vol. I to VI) by Guenther E.				
	2		Modern Cosmetics by Thomssen, Universal Publishing Corporation (1951)				
	3		Formulations and functions of cosmetics by Jellinek, Wiley Interscience 1970)				
	4		Hand book of Cosmetic Science and Technology, Third Edition, André O. Barel, Marc Paye, Howard I. Maibach				
	5		Cosmetics, Science and Technology, Edward Sagarin 1957				

	6		Perfume and flavour materials of natural origin by Arctander S.				
Outcomes							
	CO1		Discuss novel process of extraction of essential oils from various natural sources and different types of Essential Oils. (K5)				
	CO2		Select the various ingredients and manufacturing processes for various cosmetics.(K4)				
	CO3		Develop formulations of different cosmetics products (K3)				
	CO4		Summarize stability analysis of cosmetic formulations . (K3)				
				L	**T**	**P**	**Total**
Course code			**SLT4507**				
Course title			**Technology of Oleochemicals**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites							
Description of course			Students will understand the chemistry and technology of Oleochemicals involved while processing and manufacturing various Oleochemicals. They will be able to explain its synthesis, applications in various processes, evaluation techniques and schemes according to the chemistry involved.				
Objectives of the course	**1**						
	2						
Syllabus	**1**		Glycerine: Processes for treatment of sweet water and spent soap lye, Manufacture of glycerine from natural sources. Synthetic glycerin, grades of glycerin, properties and utilization of glycerine	**4**	**2**		**6**
	2		Products obtained by interesterification, hydrogenation, oxidation and pyrolysis. Metallic soaps.	**4**	**2**		**6**
	3		Technology of drying oils and resins	**4**	**2**		**6**
	4		Alkyd resins: Fatty acid route, mono glyceride route, solvent process, fusion process, classification of alkyd resins according to oil length (short/ medium/ long oil), choice of polybasic acid, etc.	**4**	**2**		**6**
	5		Miscellaneous fat-based produced: Manufacture and utilization of nitrogen, phosphorous and sulfate containing products	**4**	**2**		**6**
	6		Applications of oleochemicals in food, pharmaceutical, textile, plastic, leather and other industries	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Glycerin, Key cosmetic ingredient by Eric Jugermann, Marcel Dekker Inc., (1991)				
	2		Treatise on fats, fatty acids and oleochemicals by O. P. Narula, Industrial Consultants (India), Vo. I & II (1994)				

	3		Recent advances in chemistry and technology of fats and oils by R. J. Hamilton, Elsevier Applied Science (1987)				
	4		Natural fatty acids and their sources by E. H. Pryde				
	5		Fatty Acids by Markley K. S. Vol. I to IV, Robert E. Krieger publishing Co. (1973)				
	6		Fatty acids in industry by R. W. Johnson, Marcel Dekker Inc. (1989)				
	7		Fats, Oleochemicals and surfactants challenges in 21st Century by V. V. S. Mani and A. D. Shitole, Oxford and IBH Publishing Co. Pvt. Ltd. (1997)				
	8		Manufacture of soaps, other detergents and glycerin by E. Woollatt, John Wiley and Sons (1985)				
Outcomes							
	CO1		Able to understand the basic process of manufacture of different oleochemicals (K2)				
	CO2		Select appropriate process for the manufacture of oleochemicals (K4)				
	CO3		Summarise about advance method of analysis of oleochemicals. (K3)				
	CO4		Select Specific method for the identification of particular oleochemical and understand its properties. (K4)				

				L	**T**	**P**	**Total**
Course code			SLP4401				
Course title			Lipids Laboratory-I				
Scheme and Credits			0L:0T: 4P 2 credits	**0**	**0**	**4**	**2**
Pre-requisites							
Description of the Course			This course will introduce the student to analytical techniques used for lipid characterization, common lipid transformations, soaps, detergent synthesis, etc.				
Objectives of the course	**1**		1. Students will understand and interpret the analytical numbers in testing of oils and fatty acids adulteration of oils				
			2. Apply and infer the physical and chemical testing of oils, fatty acids and oleochemicals				
Syllabus	**1**		Analysis of Oils and Fats: Acid value, Iodine value, Saponification value, Hydroxyl value, Peroxide value, anisideine value, Soap stock analysis/unsap matter, Ash content			**24**	**24**
	2		Determination of physical and chemical characteristics of Vanaspati, margarine, ghee and waxes			**12**	**12**
	3		To detect castor oil and soyabean oil mixture using TLC, Detection of adulteration oils/ Identification of Oils in mixture			**12**	**12**
	4		Acid Oil analysis: FAME-GC analysis				
	5		Analysis of Butter: Salt content, TFM, MP				
				0	**0**	**48**	**48**
Suggested books/ reference	**1**		Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 1:Edible Oil and Fat Products:Chemistry, Properties, and Health Effects, Ed. Fereidoon Shahidi, John Wiley & Sons, Inc., Wiley Interscien				
	2		Fatty Acids by Robert Johnson				
	3		Fats and Oils Handbook by Bockisch Michael				

	4		The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses – Frank D. Gunstone, Blackwell Publishing Ltd,				
	5		Manual of methods of analysis of foods (oils & fats) - FSSAI Handbook (2015)				
Outcomes			On completion of the course, the students will be able to				
	CO1		Analyze and evaluate physical characteristics of oils like specific gravity, refractive index, color, viscosity etc. (K4)				
	CO2		Evaluate properties of oils, fatty acids and oleochemicals like acid value, sap value, iodine value, oxidation, crystallization, oxirane value, amine value etc. (K5)				
	CO3		Interpret the analytical numbers in testing of oils and fatty acids, adulteration of oils				
				L	**T**	**P**	**Total**
Course code			SLP4402				
Course title			Lipids Laboratory II				
Scheme and Credits			0L:0T: 4P 2 credits	**0**	**0**	**4**	**2**
Pre-requisites			Lipid Lab 1, Lipid Processing Technology I, Production and Applications of Soaps, Surfactants and Detergents				
Description of the Course							
Objectives of the course	**1**						
	2						
	3						
	4						
Syllabus	**1**		Solvent Extraction: oil extraction from oil seeds				**0**
	2		Aqueous Extraction: oil extraction from oil seeds				
	3		Hydraulic Expelling: oil extraction from oil seeds				
	4		Refining Of Crude Edible Oil: physical/chemical refining of oils				
	5		Double Solvent Extraction: oil extraction from oil seeds				
	6		Wax processing and analysis: Crystallization process, oil content				
	7		Splitting of Purified Wax				
	8		Analysis of Detergents: Foaming, wetting test, surface tension, active matter				
	9		Analysis of Soap: TFM, Glycerol Content				
	10		Splitting of vegetable oils to get MAG, DAG FA and the analysis using HPLC				
				0	**0**	**0**	**0**
Suggested books/ reference	**1**		Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 1:Edible Oil and Fat Products:Chemistry, Properties, and Health Effects, Ed. Fereidoon Shahidi, John Wiley & Sons, Inc., Wiley Interscien				
	2		Fatty Acids by Robert Johnson				
	3		Fats and Oils Handbook by Bockisch Michael				

	4		The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses – Frank D. Gunstone, Blackwell Publishing Ltd,				
	5		Manual of methods of analysis of foods (oils & fats) - FSSAI Handbook (2015)				
Outcomes							
	CO1						
	CO2						
	CO3						

Foods

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SFT3202	SFT4202	Theory	Introduction to Food Technology
2	SFT3301	SFT4301	Theory	Biochemistry/Microbiology
3	SFT3403	SFT4403	Theory	Food Chemistry
4	SFT3404	SFT4404	Theory	Food Processing and Technology I
5	SFT3405	SFT4405	Theory	Food Ingredients and Additives
6	SFT3506	SFT4506	Theory	Food Processing and Technology II
7	SFT3507	SFT4507	Theory	Food Packaging Science and Technology
1	SFP3302	SFP4302	Laboratory	Food Analysis Laboratory
2	SFP3402	SFP4402	Laboratory	Food Processing Laboratory

Course code			**SFT4302**				
Course title			**Introduction to Food Technology**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Introduction to Biological Sciences and Bioengineering (BST 4202), Biochemistry & Microbiology (SFT 4201)				
Objectives of the course	**1**		Understand the significance food science, technology and processing				
	2		Understand reasons for food spoilage and methods of food preservation used for various food systems especially for perishable foods such as dairy, fruit vegetable, poultry etc.				
	3		Understand chemistry of food constituents, additives, functional properties and importance of product attributes in sensory evaluation of foods				
Syllabus	**1**		Introduction to basic concepts of physical and microbial food spoilage. Principles of food preservation, strategies to preserve food by thermal (blanching, canning, pasteurization, sterilization), chemical preservation, water activity reduction.	**6**	**3**		**9**
	2		Food preservation by irradiation, fermentation, Hurdle technology: principle, methods and equipments used. Examples from perishable foods - fruits vegetables, meat -poultry etc.	**4**	**2**		**6**
	3		Chemistry of food constituents such as carbohydrates, proteins, lipids. Other food additives such as gums, emulsifiers to impart desired texture and functional properties to processed food. Basic information on sensory evaluation of food.	**6**	**3**		**9**
	4		Some important methods of food processing and other unit operations such as size reduction, retorting, extrusion, baking, frying, membrane concentration. Some examples from Indian traditional foods will be illustrated from various commodity eg. Shrikhand, Chapati, pickles, bhujiya and mithai.	**8**	**4**		**12**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Food Processing Technology by P. Fellows				
	2		Food Science by N. Potter				
	3		Food chemistry by Meyer				

	4		Handbook of Food Engineering by R.P. Singh and Heldman				
Outcomes			On completion of the course, the students will be able to				
	CO1		Gain the ability to perform the root cause analysis of any food spoilage				
	CO2		Ability to develop the strategies to preserve the food products				
	CO3		Understand the constituents of food and their functional role in quality of the food product.				
	CO4		Extrapolate the knowledge gained about unit operations in developing the processing operations for various food products.				

				L	**T**	**P**	**Total**
Course code			**SFT 4201**				
Course title			**Biochemistry/Microbiology**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Introduction to Biological Sciences and Bioengineering (BST 4202)				
Objectives of the course	**1**		Understand the significance of Biochemistry and Microbiology in Food technology, pharmaceutical sciences and lipids				
	2		Able to connect biological pathways to digestion and drug action.				
	3		Understand and apply the principles of enzymes to human system.				
	4		Know and explain morphology, diversity, cultivation methods, physiology and metabolism of microorganisms				
	5		Apply microscopy and staining techniques to study and differentiate different microorganisms				
Syllabus	**1**		Prelude: Introduction to basic concepts of biochemistry and microbiology	**2**	**1**		**3**
	2		Human digestion and absorption- metabolic pathways and energy yield for breakdown of carbohydrates; electron transport chain and coupled oxidative phosphorylation; Pathways for breakdown and synthesis of fatty acids and lipids; Metabolism of proteins and amino acids; Inborn errors in metabolism; Metabolism of drugs; Types of hormones and their role	**8**	**4**		**12**
	3		Enzymes- definition, structure, function, nomenclature, classification. mechanism of action, specificity; Enzyme kinetics with focus on human digestive enzymes; Enzymatic spoilage of foods and oils (case studies). Enzyme activity regulation (competitive, non competitive inhibition); regulation of enzyme synthesis (repression, induction); enzyme activity assay	**6**	**3**		**9**
	4		Microorganisms- Major groups of microorganisms; pathogenic/ toxigenic and spoilage organisms, beneficial organisms used in industrial fermentations and food fermentations; The human gut microbiota and Prebiotics, Probotics; Growth curve; Physical and chemical factors affecting growth and destruction of microbes; Cultivation of microbes in lab, types of media, enumeration techniques and identification	**8**	**4**		**12**

			techniques; classical and rapid microbiological analysis methods				
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Prescott's Microbiology 11th Edition, Joanne Willey, Kathleen Sandman, Dorothy Wood; McGraw-Hill Education (2019)				
	2		Microbiology, Pelczar, McGraw-Hill Education				
	3		Biochemistry, Jeremy M. Berg , Lubert Stryer , John Tymoczko , Gregory Gatto; WH Freeman; 9th ed. 2019 edition				
	4		Principles of Biochemistry, Albert L. Lehninger, David L. Nelson, and Michael M. Cox, Wley				
Outcomes			On completion of the course, the students will be able to				
	CO1		Understand and elucidate structural as well as metabolic role of different macromolecules in the cell				
	CO2		Evaluate and elucidate impact of different catalytic reactions involved in metabolic pathway				
	CO3		Evaluate and explain influence and interactions of different metabolic pathway on each other				
	CO4		Know the cultivation/control methods for diversity of microorganisms, their physiology and metabolism				

				L	**T**	**P**	**Total**
Course code			**SFT 4303**				
Course title			**Food Chemistry**				
Scheme and Credits			**2 L: 1T : 0P 3 credit**				**0**
Pre-requisites			Basics of organic and inorganic Chemistry, Physical chemistry, Analytical chemistry				
Objectives of the course	**1**		To understand basic physico-chemical properties and chemical structures of food components				
	2		To understand the importance and mechanisms of the reactions of food components taking place during food processing				
	3		To understand the significance and mechanisms of the reactions of food components taking place storage and spoilage				
	4		To think critically on the role of water and its various forms in food preservation				
	5		To understand the role of food constituents responsible for nutritional/anti-nutritional, and aesthetic quality of foods (such as texture, flavor, and color)				
	6		To apply course concepts in solving problems related to food constituents				
Syllabus	**1**		Introduction to the constituents of foods: Water in food systems: Chemistry, properties and food significance	**2**	**1**		**3**
	2		Carbohydrates: Classification, Physicochemical and functional properties of carbohydrates	**6**	**3**		**9**
	3		Proteins: Classification, Physicochemical and functional properties	**4**	**2**		**6**
	4		Lipids: Classification, Physicochemical and functional properties	**3**	**2**		
	5		Minerals: Classification, Physicochemical and functional properties	**3**	**1**		**4**

	6		Vitamins: Classification, Physicochemical and functional properties	**3**	**1**		**4**
	7		Contaminants, Toxicants, and anti-nutritional compounds in food systems	**3**	**2**		**5**
				24	**12**	**0**	**36**
Suggested Reference Books	**1**		Food Chemistry – Belitz H.D, Grosch W, and Schieberle. P.3rd Edn. Springer Berlin / Heidelberg				
	2		Food Chemistry- Fennema O.R 2nd Edn., Marcel Dekker, New york. (1985)				
	3		Food Chemistry- Aurand L.W and Woods A.E, Avi Publishing Company, Inc, Westport, CT (1973).				
	4		Sugar Chemistry- Shallenberger, R. S. and Birch, G. G. AVI Publishing Co., Inc.				
	5		Food Chemistry. Meyer. Cbs Publisher. (2004)				
Outcomes							
	CO1		Describe the various constituents present in foods and their roles therein				
	CO2		Describe the mechanisms and significance of physicochemical reactions involved in food processing and subsequent storage				
	CO3		Describe the mechanisms and significance of physicochemical reactions involved in spoilage of foods				
	CO4		Explain the significance of water in food quality, preservation and storage				
	CO5		Describe and demonstrate the role of food constituents on nutritional/anti-nutritional and aesthetic quality of raw and processed foods				
	CO6		Extrapolate the knowledge gained on food composition to practical problems in food quality				

				L	**T**	**P**	**Total**
Course code			**SFT4405**				
Course title			**Food Processing and Technology I**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Introduction to Food Technology				
Objectives of the course	**1**		To understand principles of food processing and preservation				
	2		To acquaint post-harvest technology of fruits and vegetables				
	3		To analyse various processing methods involved in plantation crops				
	4		To understand post-slaughter processing of meat and poultry products				
	5		To learn different commercial processing techniques for value addition				
Syllabus	**1**		Principles of food processing and preservation; unit operations in food processing (mechanical separation processes, food conversion operations, material handling etc.)	**4**	**2**		**6**
	2		Technology of fruits and vegetables processing: Current scenario of production of fruits and vegetables; post-harvest technology; minimal processing; commercial canning of fruits and vegetables; processing and preservation of fruit beverages; processing of fruit preserves; commercial processing technology for value addition.	**8**	**4**		**12**

	3		Technology of plantation crops, herbs and spices processing: Processing of minor and major spices; extraction of spice oil and oleoresins; post-harvest processing of plantation crops; processing of medicinal and tuber crops; by-products of plantation crops and spices.	**6**	**3**		**9**
	4		Technology of meat, fish, poultry and egg processing: Meat processing operations; egg processing and preservation; processing of fish and marine products; by-products of meat, poultry and egg and their waste utilization.	**6**	**3**		**9**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Post-Harvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management by Verma LR and Joshi VK				
	2		Introduction to Spices, Planation Crops, Medicinal and Aromatic Plants by N. Kumar and Abdul Khader				
	3		Meat, Egg and Poultry Science and Technology by Vikas Nanda				
Outcomes			On completion of the course, the students will be able to				
	CO1		Understand the basic knowledge of food processing and value addition				
	CO2		Asses various aspects of post-harvesting operations				
	CO3		Asses various aspects of post-slaughtering operations				
	CO4		Gather knowledge of spice processing equipment's				
	CO5		Understand importance of by-product processing and waste utilization				

				L	**T**	**P**	**Total**
Course code			**SFT4506**				
Course title			**Food Processing and Technology II**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Food Processing and Technology I				
Objectives of the course	**1**		To understand the basics of various unit operations in food processing				
	2		To memorize processing and milling of cereals				
	3		To explore newer techniques used for extraction of oleoresins				
	4		To differentiate various dairy products and the equipment's used for its processing				
	5		To learn different commercial processing techniques for value addition				
Syllabus	**1**		Recent advances in product and process development; important aspects of process and equipment design for food processing; food plant layout; CGMP/HACCP; process control; waste management in food processing	**6**	**3**		**9**
	2		Technology of cereal processing: Grain storage principles; grain storage structures; wheat milling; paddy processing; parboiling and ageing of rice; barley malting; sorghum, ragi and oat processing; processing of cereals and millets for food uses.	**6**	**3**		**9**

	3		Technology of legume and oilseed processing: Types of legumes and pulses; nutritional changes during soaking and sprouting of pulses; methods used for removal of anti-nutritional compounds; oilseed processing; newer techniques in extraction of oleoresins.	**6**	**3**		**9**
	4		Technology of milk and dairy processing: Dairy developments in India; sampling and quality testing of milk; processing technology of dairy products; dairy plant cleaning and sanitization operational details.	**6**	**3**	**0**	**9**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Fundamentals of Food Process Engineering, Toledo RT, 2000, Chapman and Hall.				
	2		Chemistry and Technology of Cereals as Food and Feed by Matz				
	3		Postharvest Technology of Cereals, Pulses and Oilseeds by M Chakraverthy				
	4		Outlines of Dairy Technology by Sukumar Dey				
Outcomes			On completion of the course, the students will be able to				
	CO1		Understand the basic knowledge of food processing and value addition				
	CO2		Develop an overall understanding of cereal processing aspect				
	CO3		Asses various aspects of oilseed processing operations				
	CO4		Gather knowledge of dairy processing equipment's				
	CO5		Understand importance of by-product processing and waste utilization				

				L	**T**	**P**	**Total**
Course code			**SFT4405**				
Course title			**Food Ingredients and Additives**				
Scheme and Credits			**L:2 T:1 P:0 3 credits**	**0**	**0**	**4**	**2**
Pre-requisites			Introduction to Food Technology, Food Chemistry				
Description of the Course			Course emphasis on the gaining knowlege on different ingredients and food aditives which are used in processing, preservation and storage of food products for improved quality. Course also give insight on the the mechanism of actions of different food additives, effect of processing conditions on additives as well as about the legal standards and regulations for safe use of food additives.				
Objectives of the course	**1**		To understand the classification of food additives and ingredient				
	2		To understand the significance of different food additives and ingredients in food quality, preservation and storage				
	3		To understand the safety of use of food additives and ingredients				
	4		To understand the effect of different process conditions on stability of food additives and ingredients				

Syllabus	**1**		Ingredients used in food production and their technology of production and application	**6**	**3**		**9**
	2		Additives used in food preservation such as preservatives, antioxidants, humectants etc. with respect to chemistry and food uses. Food colors and dyes (Natural and synthetic) their importance in processing, Food flavours and taste enhancers in food processing.	**8**	**4**		**12**
	3		Additives used as aids in food processing such as sequesterants, emulsifier, hydrocolloids, stabilizers, anticaking and firming agents, flour bleaching and maturing agents, sweeteners, acidulants etc, and their functions in food processing and storage.	**8**	**4**		**12**
	4		Safety aspects of Food Additives: Tolerance levels & Toxic levels in Foods, Legal safeguard, Risks of food additives.	**2**	**1**		**3**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Food Additives: Characteristics, Detection and Estimation by S.N. Mahindru in 2008 Aph Publishing Corporation, New Delhi. S.S.				
	2		Handbook of Food Toxicology by S. S. Deshpande in 2002. Marcel and Dekker AG, Basel, Switzerland.				
	3		Food Additives 2nd Edition By A L Brannen, P M Davidson, S Salminen, J H Thorngate III in 2002(eds). Marce lDekker Inc, New York.				
	4		Handbook of Food Additivies, 2ndedn, T E Furia in 1972, (ed) CRC Press, Cleveland, Ohio				
Outcomes			On completion of the course, the students will be able to				
	CO1		Describe the various additives and ingredients used in food industries				
	CO2		Understand the importance and mechanisms of action of different food additives in processing, preservation and storage of food.				
	CO3		Understaning the safety of use of food additives and ingredients				
	CO4		Extrapolate the knowledge gained on food additives and ingredients in food industries				

				L	**T**	**P**	**Total**
Course code			**SFT4507**				
Course title			**Food Packaging Science and Technology**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Introduction to Food Technology				
Objectives of the course	**1**		To understand the role of food packaging in food preservation				
	2		To understand the nature of different materials used in food packaging				
	3		To understand the various food packaging applications with respect to various food commodities				
	4		To understand different types of package testing methods employed to evaluate quality, performance and safety of food packaging materials				
	5		To understand various food-package interactions and environmental issues related to packaging				

	6		To understand newer food packaging application technologies				
Syllabus	**1**		Introduction to food packaging; causes of food spoilage; factors affecting food spoilage; packaging as a method for preservation of foods; functions of food packaging	**8**	**4**		**12**
	2		Different materials used in food packaging such as paper, glass, metal containers, plastics, laminates/composites	**6**	**3**		**9**
	3		Testing of various packaging materials and packages for evaluation of qualit	**2**	**1**		**3**
	4		Food and Packaging material interactions including migration, scalping off-flavour; biodegradable packaging	**2**	**1**		**3**
	5		Newer packaging technologies-VP/CAP/MAP; aseptic processing and packaging; active and intelligentpackaging	**6**	**3**		
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Packaging Media by Paine F.A. Publisher: Blackie and son Ltd., Bishop Briggs (1977)				
	2		Food Packaging and Preservation: theory and practice by Mathlouthi. M. Publisher Elsevier applied science publishers. London(1966)				
Outcomes			On completion of the course, the students will be able to				
	CO1		justify the role of food packaging in food preservation				
	CO2		describe different food packaging materials and their properties				
	CO3		describe packaging of various food commodities				
	CO4		comprehend food and packaging material interactions				
	CO5		describe newer food packaging technologies				

				L	**T**	**P**	**Total**
Course code			**SFP4301**				
Course title			**Food Analysis Laboratory**				
Scheme and Credits			**0L:0T: 4P 2 credits**	**0**	**0**	**4**	**2**
Pre-requisites			Introduction to Food Technology				
Objectives of the course	**1**		To give students hands on training on chemical analysis of specific food products				
	2		To analyse and quantify chemically the quality attributes of food				
	3		To identify adulterants and quality analysis of food				
	4		To train the students on different biochemical assay for food products				
Syllabus	**1**		Proximate composition in food			**4**	**4**
	2		Analysis of milk and dairy products			**4**	**4**
	3		Analysis of wheat flour			**4**	**4**
	4		Analysis of tea and coffee			**4**	**4**
	5		Estimation of phytochemicals			**8**	**8**
	6		Analysis of Food adulteration			**4**	**4**
	7		Discriminative and Descriptive Sensory analysis of Foods			**8**	**8**
	8		Demo of colorimeter, texture analyzer, DSC, etc.			**4**	**4**

	9		Demo of HPLC, GC-MS, etc.			**4**	**4**
	10		Demo of spray drier, extruder, SCFE, Tray drier etc.				
	11		Microbial assay				
	12		Enzyme assay			**4**	**4**
				0	**0**	**48**	**48**
Suggested books/ reference	**1**		AOAC International. 2003. Official methods of analysis of AOAC International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities				
	2		Leo ML.2004. Handbook of Food Analysis. 2nd Edition. Vol 1,2 and 3, Marcel Dekker				
Outcomes			On completion of the course, the students will be able to				
	CO1		Demonstrate the knowledge of redox chemical reactions to develop a protocol for analysing specific food attributes				
	CO2		Interpret different chemical and biochemical analysis specific to food				
	CO3		Compare protocols on different types of chemical and sensory analysis in foods				
	CO4		Apply and infer about the principles of different enzyme and vitamin assays				

				L	**T**	**P**	**Total**
Course code							
Course title			**Food Processing Laboratory**				
Scheme and Credits			**L:0 T:0 P:4** 2 credits	**0**	**0**	**4**	**4**
Pre-requisites			Introduction to Food Technology, Food Processing I and II				
Description of the Course			Course will help to student to improve their hands on handling different food processing equipments. Also develop understanding about food product and process formulation in food industry.				
Objectives of the course	**1**		To analyze the integration of processing in food formulations				
	2		To design and develop the process flow chart for any product development				
	3		To design the product and process formulations in food industry				
	4		To evaluate the processing cost of any developed product				
Syllabus	**1**		Preparation of tomatoes products (minimum three types)	**0**	**0**	**8**	**8**
	2		Preparation of fruit preserves from selected fruits (minimum three types)	**0**	**0**	**8**	**8**
	3		Preparation of selected bakery products (minimum three types)	**0**	**0**	**8**	**8**
	4		Preparation of fermented food products (minimum three types)	**0**	**0**	**4**	**4**
	5		Preparation of value added poultry/meat/ egg products (minimum three types)	**0**	**0**	**8**	**8**
	6		Preparation of fried products (minimum three types)	**0**	**0**	**4**	**4**
	7		Preparation of milk based food products (minimum three types)	**0**	**0**	**4**	**4**

	8		Preparation of sugar based sweets/traditional Indian confection products (minimum three types)	**0**	**0**	**4**	**4**
	9		Preparation of extrudate snack products (minimum three types)	**0**	**0**	**48**	**48**
	10		Preparation of non-alcoholic beverages (minimu three types)				
	11		Preparation of soy based food products (minimum three types)				
	12		Demostration and preparation of dehydrated food product using spray, cabinet or vaccum dryer				
Suggested books/ reference	**1**		Handbook of Food Products Manufacturing: Principles, Bakery, Beverages, Cereals, Cheese, Confectionary, Fats, Fruits, and Functional Foods by Y.H. Hui. 2007. John Wiley & Sons, Inc., Hoboken, New Jersey, USA				
	2		Meat and Meat Products Technology Including Poultry Products Technology by B.D. Sharma in 1999. Jaypee Brothers Medical Publishers Pvt. Ltd, New Delhi.				
	3		New Food Product Development: From Concept to Market place by Fuller,G.W. in 2011. 3rd ed, CRCPress,UK				
	4		Preservation of Fruits and Vegetables by GiridhariLal, G.S. Siddappa,G.L.Tandon in 1998, ICAR,NewDelhi.				
Outcomes			**Course Outcomes (students will be able to…..)**				
	CO1		Apply the knowledge of material balance specific to different food processing operations (K1)				
	CO2		Explain the major processing steps applied for food preparations (K2)				
	CO3		Use different food processing equipment specific to the product (K3)				
	CO4		Develop protocol for different types of food preparations (K4)				
	CO5		Apply the engineering principles to design novel food product and process(K4).				

Special Subject 1

Biochemistry and Microbiology

Course code	**SFT3201**
Course title	**Biochemistry and Microbiology**
Scheme and Credits	**2 L: 1 T: 0 P** **3 Credits**
Objectives of the course	This course aims to provide information on basics of biochemistry, structure and function of DNA and RNA, details about microorganism, cell culture and cell cloning.

Course title		Detailed contents	Total contact h
Biochemistry and Microbiology	1	Water and biomolecules. Introduction to biochemistry. Carbohydrates: Fundamentals of chemistry of carbohydrates. Monosaccharides, oligosaccharides and polysaccharides. Qualitative tests and color reactions. Quantitative analysis. Biosynthesis. Lipids: Fatty acids, waxes, phospholipids, sphingolipids, sterols and terpenoids. Function and comparative distribution of lipids. Biosynthesis. Hydrogenation. Sap value, Iodine value, Acid value. Biochemical tests. Lipoproteins and lipopolysaccharides. Amino acids: pK, pI, structure and chemistry Protein: Structure and function. Globular and fibrous proteins. Enzymes and activity assay. Qualitative and quantitative tests for amino acids, proteins. Precipitation of proteins. Solid phase peptide synthesis. Protein sequencing. Protein metabolism. Transmutation, SGOT/SGPT, deamination and decarboxylation. Vitamins and Co-enzymes: Structure and function. Qualitative and quantitative analysis. DNA and RNA: Structure and function. DNA - RNA - Protein. Sequencing. Fluorescence tagging. Recombination and repair. Gene and control of gene expression. Operon.	10
	2	History of microbiology (focus on microscopy). Types of microscopes. Application of microbiology. Introduction to cell and cell classification as prokaryotes and eukaryotes. Parts of the cell. Tissue and its property.	2
	3	Microorganisms: types, structure and properties. Habitat, nutrition and cultivation. Motility. Different types of staining techniques (with reference to bacteria): Monochromatic staining, Gram staining, Acid fast staining, Capsule – flagella – spore – cell wall staining, Negative staining. Virus: Types and structure. Reproduction and cultivation. Oncogenic and HIV viruses.	8
	4	Cell culture: Isolation and identification of pure culture. Culture media and their types. Introduction to biosafety. Sterilization methods. Aseptic technique. Biocontainment. Disinfection and disinfectants.	6
	5	Mutation: Types and mechanisms. Mutagenic agents. Evolution.	2
	6	Cell cloning: PCR and DNA amplification, restriction enzymes, DNA digestion, DNA ligation, transformation. Gibson assembly. Recombinant cells and selection markers. Vectors and plasmids. Competent cells. Reverse transcription. cDNA. Transfection. CRISPR technique. Cell preservation.	8
		Total	36

Suggested text/reference books

1. Microbiology Concepts and Applications: M. J. Pelczar Jr., E. C. S. Chan and N. R. Krieg
2. Lehninger: Principles of Biochemistry: David Nelson, Michael Cox
3. Outlines of Biochemistry: Eric Conn and Paul K Stumf

4. Harpers Biochemistry: Robert Murray, Daryl Granner

Special Subject 2:

Introduction to Food Technology

Course code		**SFT3302**	
Course title		**Introduction to Food Technology**	
Scheme and Credits		**2 L: 1 T: 0 P** **3 Credits**	
Objectives of the course		This course aims to understand the fundamental concepts in food technology. The course will briefly explain the various thermal and non-thermal processes adopted in food industries to preserve the food during storage and packaging.	
Course title		**Detailed contents**	**Total contact h**
Introduction to Food Technology	1	Introduction to food processing of various foods including dairy, bakery, agri commodities and newer developments such as fabricated foods, functional foods, designer food, nutraceuticals, probiotics and prebiotics. Concept of personalized nutrition and special food for infants, women etc.	8
	2	Thermal processing principles; Inactivation Kinetics; Process time calculation; Retort processing; UHT; Advances in food processing techniques both thermal and nonthermal. Extrusion	8
	3	Ohmic heating, pulsed electric field, high-intensity light pulses, radio-frequency heating, microwave, thermo-sonication, modified atmosphere, enzymic processing and hurdle technology etc.	6
	4	High hydrostatic processing of foods. Effect on enzymes, microorganisms in various food systems Equipment for batch and continuous processing. Other applications of HPP including thawing	8
	5	Recent developments in Food Processing with focus on Indian Industry, Advanced Membrane Technology for water and liquid foods and effluent treatment., dehydration. Freezing, VCRS, freezing time, Freeze drying	6
		Total	36
Suggested text/reference books	1. Advances in food and nutrition research by Steve L. Taylor, 2009 2. Handbook of food and bioprocess modeling by Sablani S., Rahman M, 2007 3. Food processing and technology: Principle and practice by P Fellows, Taylor and Francis, 2009		

Special Subject 3:

Nutrition and Nutraceuticals

Course code		**SFT3403**	
Course title		**Nutrition and Nutraceuticals**	
Scheme and Credits		**2 L: 1 T: 0 P** **3 Credits**	
Objectives of the course		This course aims to provide advance knowledge on various biomolecules showing health benefits and to make aware on various sources and characterization of biomolecules showing health benefits. Also, to gain knowledge about the nutraceutical constituents present in various food products and understand the extraction techniques of plant-based nutraceuticals.	
Course title		**Detailed contents**	**Total contact h**
Nutrition and Nutraceuticals	1	Classification of food components based on nutritional value, nutritional assessment of carbohydrates, proteins and fats, recommended dietary intake, acceptable dietary intake, nitrogen balance, protein efficiency ratio, net protein utilization. Basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI) and Standard Dynamic Action (SDA) with special reference to nutraceutical industry.	6

	2	Defining nutraceuticals. Nature, type and scope of nutraceuticals compounds and their classification based on chemical and biochemical nature with suitable and relevant descriptions.	6
	3	Disease and Nutrition: Functions of dietary fiber (soluble and insoluble) in control of certain disease conditions like diabetes, cancer, heart diseases etc. Effect of drugs on ingestion, digestive absorption & metabolism of nutrients, Effect of food nutrients & nutritional status in drug dosage & efficacy.	6
	4	Functional Foods and their applications: Role of Isoprenoids, Isoflavones, Flavonoids, carotenoids, Tocotrienols, polyunsaturated fatty acids, sphingolipids, lecithin, choline. Terpenoids, whey and soy protein. Vegetables, seeds, cereals, sea foods, milk, and dairy products as Functional foods. Probiotics and prebiotics. Role of nutraceuticals with special reference to diabetes mellitus, hypertension, hypercholesterolemia, cancer, glands in the prevention and treatment.	9
	5	Nutraceutical evaluation and testing: Biological testing and bioassays, preclinical testing, and clinical trials. Quality control and quality assurance of nutraceuticals. Marketing of nutraceuticals.	4
	6	Nutritional genomics: Plants as bioreactors as a tool for production of Nutraceuticals. 'Tailor-made' carbohydrates and lipids of plant and non-plant origin. Transgenic plants for the large-scale production of proteins for pharmaceutical and industrial uses. Commercial transgenic crops like herbicide resistant soybean, maize, vegetables, fruit crops, golden rice.	5
		Total	36

Suggested text/ reference books

- Brigelius-Flohé, J & Joost HG. Nutritional Genomics: Impact on Health and Disease.Wiley VCH. 2006.
- Cupp J & Tracy TS. 2003. Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press.
- Gibson GR &William CM. Functional Foods - Concept to Product. 2000.
- Losso JN. Angi-angiogenic Functional and Medicinal Foods. CRC Press. 2007.
- Robert E.C. Wildman Handbook of Nutraceuticals and Functional Foods, CRC, 2006.
- L. Rapport and B. Lockwood Nutraceuticals, 2nd Edition, Pharmaceutical Press (2002).

Special subject 4

Food Chemistry

Course code	**SFT3404**
Course title	**Food Chemistry**
Scheme and Credits	**2 L: 1 T: 0 P** **3 Credits**
Objectives of the course	This course will be helpful to learn fundamentals of food chemistry and understand the standards of identity based on authentic chemical composition. Also, to understand the interactions of different constituents within the food systems, the various contaminants and toxicants present in the food systems. To apply knowledge to judge the quality and authenticity of the food.

Course title		Detailed contents	Total contact h
Food Chemistry	1	Food chemistry and its role in food processing. Water: Importance of water in foods, Structure of water & ice, Concept of bound and free water and their implications.	6
	2	Browning reactions: Enzymatic and non-enzymatic browning, advantages and disadvantages, factors affecting their reaction and control.	6

	3	Plant pigment: Importance, structure and properties of plant pigments, chemical changes of in pigments during food processing. Flavour and aroma of foods: Importance, structure and properties of flavouring and aromatic components of foods.	6
	4	Food additives- definitions, classification, and functions, need for food additives, food preservatives, classifications, antimicrobial agents (types, mode of action and their application). Nutrient supplements & thickeners, polysaccharides, bulking agents, antifoaming agents, synergists, antagonists.	6
	5	Antioxidants (synthetic and natural, mechanism of oxidation inhibition), chelating agents: types, uses and mode of action.	6
	6	Coloring agents: color retention agents, applications and levels of use, natural colorants, sources of natural color (plant, microbial, animal and insects), misbranded colors, color extraction techniques, color stabilization. Flavoring agents: flavors (natural and synthetic flavors), flavor enhancers, flavor stabilization, flavor encapsulation. Flour improvers: leavening agents, humectants, and sequestrants, hydrocolloids, acidulants, pH control agents buffering salts, anticaking agents. Sweeteners: natural and artificial sweeteners, nutritive and non-nutritive sweeteners, properties and uses of various sweeteners in food products.	6
		Total	36

Suggested text/ reference books

- Owen Fennema, Food chemistry, CRC Press
- Peter, Schieberle, Grosch, Belitz, Werner, Food Chemistry, Springer
- Meyer, Food chemistry, Indian
- Harish Kumar Chopra, Parmjit Singh Panesar, Food Chemistry, Indian
- Food Additives, 2nd and, AL Brannen, PM Davidson, S Salminen, JH Thorngate III, 2002 (eds). Marcel Dekker Inc, New York, pp. 1-9
- Handbook of Food Additives, 2nd edn, TE Furia, 1972, (ed) CRC Press, Cleveland, Ohio.
- Madhavi, Deshpande and Salunkhe, Food Antioxidants: Technological, Toxicological and Health Perspective, CRC Press.

Special subject 5

Food Processing and Technology

Course code	**SFT3405**
Course title	**Food Processing and Technology**
Scheme and Credits	**2 L: 1 T: 0 P** **3 Credits**
Objectives of the course	This course will be useful to acquaint with principles of different techniques used in processing and preservation of foods and to learn various heat transfer related unit operations in food processing.

Course title		Detailed contents	Total contact h
Food Processing and Technology	1	Material and energy balance in food processing operations, Heat Transfer Theory and Applications. Conduction, convection and radiation heat transfer.	4
	2	Thermal processing, sterilization, pasteurization, blanching, thermal death time, F values, equivalent killing power at other temperatures. In-can processing, thermal process calculations for canned foods, retorts. Types of heat exchangers.	5

	3	Evaporation Theory: Boiling point elevation, Raoult's law, Duhring's rule, Duhring plot, latent heats of vaporization. Evaporation of heat-sensitive materials, heat transfer in evaporators, vacuum evaporation and evaporation equipment.	5
	4	Drying theory, drying characteristics, selection of dryers, different types of dryers and their working principles, food freezing theory and equipment, chilling.	5
	5	Contact equilibrium process, extraction process, rate of extraction, stage-equilibrium extraction, solvent extraction, supercritical fluid extraction, extraction equipment. Crystallization, crystallization equipment.	5
	6	Size reduction: Grinding, Cutting, Emulsification, homogenization, energy concept in size reduction, Kick's law, Rittinger's law, Bond's law. Grinding and milling equipment.	5
	7	Mechanical separations: Sedimentation and filtration, membrane separations, Sieving / Screening, Sieve analysis.	4
	8	Parboiling, Extrusion, Frying, Baking, Roasting, Puffing, Agitation and mixing, Irradiation and non-thermal processing operations.	3
		Total	36
Suggested text/ reference books	- R. L. Earle, Unit Operations in Food Processing, NZIFST (Inc.) - R. T. Toledo, Fundamentals of Food Process Engineering, Springer - J. G. Brennan, Food Processing Handbook, WILEY-VCH Verlag GmbH & Co. KgaA - A.S. Mujumdar, Handbook of Industrial Drying, Taylor and Francis - Zeki Berk, Food Process Engineering and Technology, ELSEVIER		

Special subject 6

Packaging and Recycle Technology

Course code	**SFT3506**
Course title	**Packaging and Recycle Technology**
Scheme and Credits	**2 L: 1 T: 0 P** **3 Credits**
Objectives of the course	This course aims to understand the food packaging development, packaging systems and analyze complex systems of food packaging. Role of packaging in safety and stability of food materials and to understand environmental concerns and life cycle assessment.

Course title		Detailed contents	Total contact h
Packaging and Recycle Technology	1	Function of packaging, marketing consideration for a package and types of packaging. Barrier properties of packaging material, Packaging materials for foods. Selection criteria of packaging materials for raw and processed food products.	7
	2	Machinery for Packaging. Package labelling: functions, nutrition labelling, ingredient characterization handling instruction, and regulations Packaging logistics.	7
	3	Testing of various packaging materials and packages for evaluation of quality, for identification, for evaluation of performance (barrier and strength properties) for transport worthiness, for biodegradability, for migration etc; Package design; Cushioning materials; shelf-life testing of packaged foods.	8
	4	Packaging materials for newer techniques like radiation processing, microwave and radiowave processing, high pressure processing, CAP/ MAP and thermal processing as retortable pouches, aseptic packaging; biodegradable packaging; active packaging; intelligent packaging; migration; flavor scalping.	7

		Application of nanotechnology in food packaging, environmental concerns and life cycle assessment.	
	5	Introduction of Plastics Waste, Plastics Waste Management, Recycling of Rubber, Post Recycling Operations, Green plastics for food packaging, Faults and Remedies in Plastics Recycling process, Processing of Thermo plastic Recyclate, Testing consumer responses to new packaging concepts, Safety and legislative aspects.	7
		Total	36
Suggested text/ reference books	-	Food packaging and preservation by M. Malthlouthi, 1994	
	-	Food and Packaging Interactions by Risch. S. H. 1991	
	-	Handbook of Food Packaging by F.A. Paine and H.Y. Paine 1983	
	-	Food Packaging Technology (Vol.1 & 2) by G. Bureau and J. L. Multon, 1996	
	-	Handbook of Package Engineering by Hanlon Kelsey & Forcinio	

Special subject 7

Recent Advances in Regulatory Affairs

Course code	**SFT3507**
Course title	**Recent Advances in Regulatory Affairs**
Scheme and Credits	**2 L: 1 T: 0 P** **3 Credits**
Objectives of the course	This course helps to explain the functional role and safety issues of food contaminants and adulteration. To describe the hygiene and sanitation in processing plant, equipment, storage and handling. Also, to identify and analyze the critical quality control point in different stages of production of food and thereby designing the HACCP system.

Course title		Detailed contents	Total contact h
Recent Advances in Regulatory Affairs	1	Indian Standards: AGMARK act and rules- Certification procedure, laboratory approvals and actions on non-compliance, appeals, BIS- scope, definition, power and functions of BIS, Licensing procedure, export and import laws and regulations, Export (Quality and inspection) act 1963; APEDA (Agricultural and Processed Food Products Export Development Authority) & MPEDA (Marine Products Export Development Authority introduction, act and rules, functions and products monitored. (Cover them briefly)	6
	2	FSSAI 2006, Food Safety and Standards (Licensing and Registration of Food Businesses, Food Products Standards and Food Additives, Prohibition and Restriction of Sales, Packaging and Labelling, Contaminants, Toxins and Residues, Laboratory and Sampling Analysis) Regulation, 2011 Food Safety and Standards (Health Supplements, Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose, Functional Food and Novel Food) Regulations, 2016 Food Safety and Standards (Food Recall Procedure, import, Approval for Non-Specific Food and Food Ingredients, Organic Food, Import) Regulation, 2017	6
	3	Food Safety and Standards (Alcoholic Beverages, Fortification of Food, Food Safety Auditing) Regulation, 2018 Food Safety and Standards (Recovery and Distribution of Surplus food) Regulation, 2019 Food Safety and Standards (Safe food and balanced diets for children in school, Labelling and Display) Regulations, 2020	6

	4	Introduction to Food Regulatory Affairs in global perspective: India (FSSAI), USA (USFDA guideline and document, Rules and Regulation- 21 CFR), Canada, Europe, United Kindom, Australia & New Zealand, South Africa, UAE (GCC). International Food Laws: Codex: Implications on trade in light of SPS and TBT, Alimentarius: Role of CAC and its committees, Introduction to OIE and IPPC, Other International Food Standards (e.g. European Commission, USFDA etc). WTO: Introduction to WTO Agreements: SPS and TBT Agreement.	6
	5	Quality management and quality assurance: Total quality management, good manufacturing practices, good agricultural practices, good laboratory practices; Quality management systems, QSS; Quality circles, SQC; ISO system, Six Sigma. ISO: ISO 22000, 9001: 2008, PDCA cycle, Introduction, Salient features, Certification & Auditing. FSMS Food Safety Management System – 22000:2005, Introduction to the family of ISO 22000 standards, Comparison of ISO 9001:2008 vs. ISO 22000:2005. HACCP: Principles, implementation; Plan documentation, types of records; Auditing: Surveillance, audit, mock audit, third party quality certifying audit, auditors and lead auditors; Certification, certification procedures, certifying bodies, accrediting bodies, international bodies.	6
	6	Regulatory Compliance GMP-GHP requirements. Food Industry IPR, Patents, Copyrights and Trademarks Food Licensing & Registration, Packaging & Labelling in India. Food Product Marketing, Import and Export regulations.	6
		Total	36

Suggested text/ reference books

- Food safety by Laura K Egendorf, 2000
- International standards of food safety by Naomi Rees, David Watson, 2000
- Codex alimentarius by FAO & WHO, 2007
- C. A. Roberts, “The Food Safety Information Handbook”, 2nd edition, Oryx Press, 2001
- R. H. Schmidt and G. E. Rodrick, “Food Safety Handbook”, 3rd edition, John Wiley & Sons, 2005.
- N. Rees and D. Watson, “International standards for food safety”, 1st edition, Aspen publishers, Gaithersburg, Maryland. 2000.
- P. L. Knechtges, “Food safety: Theory and Practice”, 1st edition, Jones and Bartlett learning, UK, 2012.
- Lawley, R., Curtis L. and Davis, J. The Food Safety Hazard Guidebook, RSC publishing, 2004.
- Guide to US Food Laws and Regulations, 2nd Edition Patricia A. Curtis (Editor) ISBN: 978-1-118-22778-7. Year 2013.

Special Lab 1

1 To determine the moisture content of food products using different methods

2 To determine the water activity of food products using different methods

3 Quality analysis of food products using colorimeter

4 To determine protein content of food products

5 To determine fat content of food products

Special Lab 2

1 To study the quality degradation kinetics of food products using different methods of heating

2 To study the color degradation kinetics of food products during different methods blanching

3 To study the textural properties of food products treated with different heating methods

4 To study the drying characteristics of food products using different methods of drying

5 To study the moisture sorption isotherm characteristics of food products

Pharma

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SRT3302	SRT4302	Theory	Introduction to Pharmaceutical Technology
2	SFT3201	SFT4201	Theory	Biochemistry and Microbiology
3	SRT3403	SRT4403	Theory	Pharmaceutical Chemistry
4	SRT3507	SRT4507	Theory	Formulation Technology and Drug Delivery
5	SRT3506	SRT4506	Theory	Pharmaceutical Technology and Drug Design
6	SRT3404	SRT4404	Theory	Process Development for Fine Chemicals and API
7	SRT3405	SRT4405	Theory	Natural Product based Pharmaceuticals
1	SRP3401	SRP4401	Laboratory	Pharmaceutical Analysis Laboratory
2	SRP3403	SRP4403	Laboratory	Pharmaceutical Chemistry and Formulation Technology Laboratory

				L	T	P	Total
Course code			**SRT4301**				
Course title			**Introduction to Pharmaceutical Technology**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Biochemistry/Microbiology (SFT 4201)				
Description of course			This course will give an overview of applications of technology and engineering principles in Pharmaceutical Industry				
Objectives of the course	**1**		Know the different drug categories				
	2		Understand basics of monophasics, biphasics, topical formulation, aerosols, stability testing				
Syllabus	**1**		General pharmacology (ADME, routes of administration, MOA) with different organ systems; Chemotherapy: Sulphonamides, Diaminopyridines, Quinolones, β-lactam antibiotics, Tetracyclines, Nitrobenzene derivatives, Aminoglycosides, Anti-malarial, Anti-fungal, Anti-tubercular, Anti-cancer agents, etc.	**12**	**6**		**18**
	2		Solubilization techniques; Monophasics (Oral and Topicals) (solution, syrups, elixirs, linctus, glycerites, nasal drops, ear drops, etc.) , Biphasic, Ointments, Creams, Gels, Suppositories, Aerosols - Suspensions and Emulsions: Pre-formulation, Principles and Stabilization techniques, Formulation Development, Evaluation, Large scale manufacture and packaging with focus on equipment, Layout design and unit operations; Stability Testing	**8**	**4**		**12**
	3		Overview of Pharmaceutical Industry; Classification of pharmaceutical dosage forms and routes of drug administration; Origin & development of the pharmacopoeia – IP/BP/USP, Introduction to monograph and Biopharmaceutics	**4**	**1**		**5**
				24	**11**		**35**

Suggested books/ reference	**1**		Remington-The Science And Practice Of Pharmacy (Vol.1& 2), David B.Troy, 21st edition,2006, Lippincott Williams &Wilkins				
	2		Pharmacology H. P. Rang, M. M. Dale, J. M. Ritter 5				
	3		J. McMurry, Brooks/Cole, Organic Chemistry				
Outcomes			On completion of the course, the students will be able to				
	CO1		Understand general principles of Pharmacology including pharmacokinetics and Pharmacodynamics.				
	CO2		Know the different drug categories				
	CO3		Conceptualize and develop monophasic, biphasic and other products				
	CO4		Explain stability evaluation and stabilization of products				

				L	**T**	**P**	**Total**
Course code			**SRT4403**				
Course title			**Pharmaceutical Chemistry**				
Scheme and Credits			**2L: 1T: 0P 3 credits**				
Pre-requisites			Introduction to Pharmaceutical Technology,Biochemistry/Microbiology				
Objectives of the course	**1**		To acquaint students with nomenclature, classification, molecular mechanism of action, synthesis and SAR of (a) Anti-infective agent (b) Anti-histaminic agent (c) Anti-inflammatory agents (d) Drugs acting on the cardiovascular system (e) Drugs acting on the hormonal system (f) Drugs acting on the central nervous system	**2**	**1**	**0**	**3**
	2		To train the students with the basics of Medicinal Natural Products and Phytochemistry				
Syllabus	**1**		Classification of Drugs; Molecular targets; Strategies in hit/lead discovery; Lead optimization; SAR, QSAR; Drug design	**6**	**3**		**9**
	2		Overview of Antibacterial agents; Anitparasitic agents; Antifungal agents; Antimycobacterial agents; Anticancer agents; Antiviral agents; Drugs Affecting the Central Nervous System; Cholinergic Drugs; Adrenergic Drugs; Analgesics	**8**	**4**		**12**
	3		Introduction to Anti inflammatory drugs; Cardiovascular Drugs; Drugs acting on hormonal systems; Other miscelleneous Classes of drugs	**6**	**3**		**9**
	4		Molecular targets, Enzymes as drug targets, Receptors as drug targets, Target identification methods	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Foye's Principles Of Medicinal Chemistry W. O. Foye, Lippincott Williams & Wilkins, 6th edition, 2008.				

	2		Burger's Medicinal Chemistry & Drug Discovery(Vol. 1-6) A. Burger And M.E. Wolff; John Wiley & Sons-New Jersey, 6th edition,2003				
	3		Textbook Of Medicinal And Pharmaceutical Chemistry Wilson And Gisvold, Lippincott Williams & Wilkins, Philadelphia, 11				
	4		The Practice of Medicinal Chemistry, C.G. Wermuth, Academic Press, 3 edition, 2008				
	5		Pharmaceutical Substances: Synthesis, Patents, Applications (N-Z) Kleemann Georg ThiemeVerlag-Stuttgart. Thieme, 4th edition, 2001				
	6		Dewick P.M., Medicinal Natural Products- A Biosynthetic Approach,2 edition/2002, John Wiley & Sons Ltd				
	7		Quality Standards of Indian Medicinal Plants, all volumes, ICMR				
Outcomes			On completion of the course, the students will be able to				
	CO1		Classify drugs based on different methods				
	CO2		Explain SAR and MOA of drugs at the molecular level of understanding				
	CO3		Apply principles of drug discovery from hit to lead to preclinical molecules				
	CO4		Theoretically predict absorption distribution, metabolism and excretion of drugs and related concept of prodrugs				

				L	**T**	**P**	**Total**
Course code			**SRT4507**				
Course title			**Formulation Technology and Drug Delivery**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Introduction to Pharmaceutical Technology				
Objectives of the course	**1**		To train the students with respect to basics and application of Technology of Solid dosage forms and introduce novel drug delivery systems				
	2		To train the students with respect to basics of validations and regulatory requirements of pharmaceuticals				
	3		To train the students with respect to basics and application of Technology of sterile pharmaceuticals				
Syllabus	**1**		Introduction to tablets, Preformulation considerations for tablet dosage form, Granulation techniques, Direct compression; Excipients in tablets; Tablets Formulation: Unit operations, tablet punching: physics of tablet punching, single punch and rotary tablet press, tablet tooling ; Tablet coating	**6**	**3**		**9**

	2		Introduction to capsules; Preformulation considerations for capsule dosage form; Hard and soft gelatin capsules: formulation considerations, capsule manufacture equipments, quality control tests, packaging, Large scale manufacture,layout design; Microencapsulation; Oral sustained release and controlled release formulations	**4**	**2**		**6**
	3		Facility design for parenteral manufacture with focus on air systems HEPA filters, environmental classes for manufacture of parenterals; Methods of sterilization; Water for Injection: Monograph IP, methods of preparation, quality control tests, storage; Containers and Closures for Parenteral Formulations; Small and Large volume parenterals: Formulation (discuss various dosage forms like solutions, suspensions, emulsions, dry powders), Quality control, Large scale manufacture and packaging with focus on equipment, Layout design and Unit operations	**6**	**3**		**9**
	4		Introduction to novel drug delivery systems like Transdermal and Transmucosal(buccal, sublingual, nasal, vaginal, rectal); Introduction to cosmetics	**4**	**2**		**6**
	5		Introduction to Quality by Design, Validation, Documentation and Regulatory bodies for pharmaceuticals.	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Remington-The Science And Practice Of Pharmacy (Vol.1& 2), David B.Troy, 21st edition,2006, Lippincott Williams &Wilkins				
	2		Pharmaceutics: The Science Of Dosage FormDesign, Michael E. Aulton, 1998, Churchill-Livingstone Dermatological Formulations, B. W. Barry, 198, New York, Marcel Dekker				
	3		ICH Guidelines				
	4		Coated Pharmaceutical Dosage Forms, K. H. Bauer, CRC Press, Boca Raton. Med Pharm.				
	5		Pharmaceutical Dosage Forms Vol. I & II, Liebermann, New York, Marcel Dekker, 1996.				
	6		Pharmacuetical Production Facilities: Design and Applciations G. C. Co				
	7		Pharmaceutics: The Science of Dosage Form Design. Michael E.Aulton, Churchill-Livingstone, 1998				
	8		Beotra's Law of Drugs Medicins and Cosmetics K. K. Singh, L. R. Bugga for the Law Book Co.Pvt. Ltd. Allahabad				
	9		Indian Pharmacopoiea, British Pharmacopoiea, United States Pharmacopoiea.				
Outcomes			On completion of the course, the students will be able to				
	CO1		Describe preformulation, formulation, unit operation, large scale manufacturing, layout design of tablets				

	CO2		Explain the coating polymers, technology and equipments used for coating of tablets and describe microencapsulation techniques				
	CO3		Describe formulations for hard and soft gelatin capsules, machinery used for filling hard gelatin capsules, process for soft gelatin capsules				
	CO4		Describe preformulation, formulation, evaluation, packaging, large scale manufacturing and facility design of parenteral products				
	CO5		Explain basics of novel drug delivery systems				
	CO6		Describe product and process validation and documentation required for the pharmaceuticals				

				L	**T**	**P**	**Total**
Course code			**SRT4506**				
Course title			**Pharmaceutical Technology and Drug Design**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Pharmaceutical Chemistry				
Objectives of the course	**1**		Learn how physicochemical properties / QSAR/ other computational techniques play role to design and optimize the structure of leads				
Syllabus	**1**		Introduction to Historical and Modern Drug Discovery-Sources of drugs/leads,Serendipity, random screening, natural sources, analogue based design, Rational drug design, Techniques and tools in modern drug discovery, Introduction to QSAR, SBDD and LBDD • Concepts of privileged structures and chemical diversity	**4**	**2**		**6**
	2		Physicochemical and Biopharmaceutical Properties of Drug Substances: Lipinski rule of 5, Concept of toxicophores, Insilico calculation of log P, Modification of leads to incorporate suitable ADMET properties	**2**	**1**		**3**
	3		2-D QSAR: History and development of 2-D QSAR, Parameters – lipophilicity and related parameters, electronic parameters, steric parameters, other parameters, Quantitative models – Hansch approach, Free Wilson analysis, the mixed approach, Statistical methods – regression analysis, partial least square and other multivariate statistical methods Design of test series in QSAR-Some examples of Hansch and other methods	**4**	**2**		**6**
	4		Molecular Mechanics and Energy Minimization: General features of force fields, cross terms, force field parameterization, Energy minimization – non-derivative and derivative methods, applications of energy minimization Techniques of searching the conformational space: systematic search, Monte Carlo, Molecular dynamics and distance geometry	**4**	**2**		**6**
	5		Docking by different techniques	**2**	**1**		**3**

	6		Pharmacophore Modelling: Difficulties in deriving a 3D-pharmacophore Techniques – constrained systematic search, ensemble distance geometry, ensemble molecular dynamics and genetic algorithms Incorporating additional geometric features into a 3D pharmacophore 3D database searches using pharmacophores.	**4**	**2**		**6**
	7		De Novo and fragment based ligand design and 3-D QSAR approaches CoMFA and CoMSIA, brief discussion on other methods like MSA, RSA and HASL methods, Limitations of QSAR	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Burger's Medicinal Chemistry, Drug Discovery and Development. 7th Edition Volume 1-9. By Donald J. Abraham, David P. Rotella. August 2010				
	2		Practical Application of Computer-Aided Drug Design, Paul S Charifson, Ed., Marcel Dekker, Inc., 1997				
	3		Textbook of Drug Design and Discovery, PovlKrogsgaard-Larsen, Ulf Madsen, Kristian Stromgaard, 5th Ed., 2016. Taylor and Francis.				
	4		3D QSAR in Drug Design: Theory, Methods and Applications, Kubinyi H Ed., Leiden ESCOM, 1993.				
	5		Drug Development, Hamner C. E., Ed., 2nd Ed., CRC Press, Boca Raton, 1990				
	6		Advanced Drug Design And Development: A Medicinal Chemistry Approach, P N Kourounakis, E. Rekka, 1st ed., Taylor & Francis, Year: 1994				
Outcomes							
	CO1		Understand basics of QSAR, for applications in drug design				
	CO2		Understand basics of physicochemical properties of drugs and their implications				
	CO3		Design new potential therapeutic molecules using structure based drug desig				
	CO4		Design new potential therapeutic molecules using ligand based drug design				

				L	**T**	**P**	**Total**
Course code			**SRT4404**				
Course title			**Process Development for Fine Chemicals and API**				
Scheme and Credits			**2L: 1T: 0P 3 credits**				
Pre-requisites			Introduction to Pharmaceutical Technology, Pharmaceutical Chemistry				
Objectives of the course	**1**		To understand the principles of chemical process development for API and fine chemical				
	2		Acquire the knowledge of Green Chemistry, Process Safety and Hazards				

Syllabus	**1**		Principles of Process Development for API'S: Background information, Literature search methodologies for the development of API's and Intermediates, Selection of best route for the synthesis/manufacture of API (Green processes), Process safety, MSDS, Safety laboratory data	**8**	**4**		**12**
	2		Status of pharmaceutical industry: Status of bulk drugs, natural products and formulations in India vis-a-vis industrialized nations	**2**	**1**		**3**
	3		Chemical Technology of Selected APIs: Case studies with emphasis on rationale for selection of routes, raw materials, process control methods, pollution control procedures, polymorphs, safety, etc.	**4**	**2**		**6**
	4		Chemistry and Technology of Fine Chemicals: Introduction, Role of Catalysis, Atom Economy, Alternative Reagents and Catalysts, Multiproduct and Multipurpose Plants (MMPs), Reactors for fine chemicals, Safety Aspects of Fine Chemicals	**4**	**2**		**6**
	5		Selected Fine Chemical Technologies with examples: Alkylation, Halogenation, Oxidation, Reduction, Esterification, Nitration, and Hydrogenation	**4**	**2**		**6**
	6		Impurity Considerations: Introduction, Steps to optimizing reactions, Minimizing impurity formation by indentifying impurities first, Method development for separation, Synthesis and Isolation of impurities and their characterization	**2**	**1**		**3**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Levenspiel, O. Chemical Reaction Engineering; 3rd ed.; John Wiley & Sons, New York (1999)				
	2		Gadamasetti, K., Process Chemistry in Pharmaceutical Industry; 1st ed.; CRC Press, London (1999)				
	3		Anderson, N. G.; Practical Process Research & Development: A Guide for Organic Chemists; 2nd ed.; Academic Press, London (2012)				
	4		Harrington, P. J.; Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up; Wiley, London (2011)				
	5		A. Cybulski M.M. Sharma R.A. Sheldon J.A. Moulijn;Fine Chemicals Manufacture: Technology and Engineering, Elsevier Science & Technology Books, (2001)				
Outcomes			On completion of the course, the students will be able to				
	CO1		Understand the principles of process design along with selection of different routes.				
	CO2		Get insights of underlying technologies in the manufacturing of various APIs				
	CO3		Differentiate between the bulk drugs and fine chemicals and state their various applications in industry and daily life				

	CO4		Explore the process of manufacture of variety of fine chemicals				

				L	**T**	**P**	**Total**
Course code			**SRT4405**				
Course title			**Natural Product based Pharmaceuticals**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Pharmaceutical Chemistry, Process Development for Fine Chemicals and API				
Objectives of the course	**1**		To make students familiar with natural products, its important and total synthesis strategies				
	2		To make students familiar with ayurvedic product, its formulations and regulatory guidelines as well as government policies for the development				
Syllabus	**1**		Role of Natural Products in New Drug Discovery**:** few selected NPs, with different pharmacophore, its source, purification and its drug target interactions, Case studies of taxol, artemisinin, etc	**2**	**1**		**3**
	2		Potential uese of natural products: Plant-derived molecules for perfumery, cosmetic, agrochemicals, dyes and pigments	**2**	**1**		**3**
	3		Overview of total synthesis and biomimetic synthesis of natural products with importance in drug discovery, Selected examples of retrosynthetic pathways of Natural products such as calanolide, colchicine, camptothecin	**4**	**2**		**6**
	4		Introduction to Ayurveda: History of Ayurveda and herbal drugs, Global Ayurvedic Medicine Market: Size, share, trend and forecast including organic herbs & extracts (NOP, USDA etc.)	**4**	**2**		**6**
	5		Ayurvedic/Polyherbal Formulations (PHF): Types of Ayurvedic formulations, single herb vs polyherbal formulations, Advantages and challenges associated with PHF, Preparation and detoxification methods for Ayurvedic formulations, CCRAS Guidelines for Ayurvedic Formulation	**6**	**3**		**9**
	6		Amendments in Drugs and Cosmetic Act for quality control of Ayurvedic medicines	**2**	**1**		**3**
	7		Government policies and initiatives for development of Ayurveda: Introduction to Ministry of AYUSH and its Allied Organizations like Pharmacopoeia Commission for Indian Medicine & Homoeopathy, Central Council for Research in Ayurvedic Sciences (CCRAS), National Medicinal plant board (NMPB). FSSAI Sustainability of Indian medicinal plants- CITES and Indian Govt. initiatives	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Lead Generation Approaches in Drug Discovery, Chapter 7: Role of Natural Products in Drug Discovery, Hugo Lachance, Stefan Wetzel, Herbert Waldmann, 2010, Wiley online library				

	2		Phytochemistry of Medicinal Plants, Vol. 29, J.T. Arnason, R. Mata, J. T. Romeo, 1995, Springer Science, Business Media New York				
	3		Total Synthesis of Natural Products, Jie Jack Li and E. J. Corey, 2012, Springer				
	4		Classics in Total Synthesis: Targets, Strategies, Methods, K.C. Nicolaou and E. J. Sorenson, 1996, Wiley-VCH				
	5		Biomimetic Organic Synthesis, Erwan Poupon and Bastien Nay, 2011, Wiley-VCH.				
	6		An introduction to Ayurveda, M.S. Valiathan, 2013, Orient Blackswan Private Limited - New Delhi				
	7		Handbook of Ayurvedic Medicines with Formulation, Eiri Board, 2009, Engineers India Research Institute				
	8		Regulatory and Pharmacological Basis of Ayurvedic Formulations, Kindle edition, Amritpal Singh, 2016, CRC Press				
	9		General guidelines for Drug development of Ayurvedic formulations, Guidelines Series-I, Central Council For Research In Ayurvedic Sciences, Ministry Of Ayush, Government of India, New Delhi, http://ayush.gov.in/				
Outcomes			On completion of the course, the students will be able to				
	CO1		Rationalize the contribution of natural products in new drug discovery				
	CO2		Plan various approaches for efficient natural product synthesis including biomimetic synthesis, semi-synthesis and total synthesis				
	CO3		Express the global demand of Ayurvedic medicines				
	CO4		Execute the preparation of polyherbal formulations as per the standard Ayurvedic texts				
	CO5		Appreciate the importance of the regulatory guidelines of Government authorities related to Ayurvedic medicines				

				L	**T**	**P**	**Total**
Course code			**SRP4401**				
Course title			**Pharmaceutical Analysis Laboratory**				
Scheme and Credits			**0L:0T: 4P 2 credits**	**0**	**0**	**4**	**4**
Pre-requisites			Chemistry Lab-I				
Objectives of the course	**1**		On performing the experiments, learner should be able to operate the instruments, understand its instrumentation, prepare solutions with accurate concentrations, measure the readings, calculate and interpret the results obtained				
	2		To familiarize the learner with the important aspects of accelerated stability testing and shelf life calculations				

Syllabus	**1**		UV spectrophotometric estimation of two components formulation by simultaneous equation method and by absorbance ratio method, Eg Caffeine and Sodium benzoate injection			**4**	**4**
	2		UV spectrophotometric estimation of formulation by Difference spectroscopy: Eg: Phenylephrine HCl ophthalmic solution			**4**	**4**
	3		Assay of finished products by UV spectroscopy (any two), using A (1%, 1 cm) eg. Paracetamol tablets, Propranolol tablets/Atenolol tablets/Hydrochlorothiazide tablets/Frusemide tablets/Albendazole tablet/Rifampicin capsules (two examples)			**4**	**4**
	4		Solubility determination of any drug/formulation by using UV spectroscopy			**4**	**4**
	5		Separation and identification of drug/Intermediate by TLC/Column chromatography			**8**	**8**
	6		Experiments based on HPLC eg. quantification of impurities in APIs			**4**	**4**
	7		Gas Chromatography (GC) handling and analyses of API intermediates			**4**	**4**
	8		Detection of residual solvent in the formulation by using Gas Chromatography			**4**	**4**
	9		Working of FTIR and Interpretation of IR spectra of any one drug.			**4**	**4**
	10		Polarimetry: Different concentrations of sugar, determination of unknown concentration and specific rotation			**4**	**4**
	11		Assay of streptomycin injection/Salicylic acid by using Colorimetry ((Construction of calibration curve using linear regression analysis))			**4**	**4**
	12		Accelerated stability testing of any suitable drug/ formulation, Problems based on Arrhenius equation for shelf life calculations			**4**	**4**
				0	**0**	**48**	**48**
Suggested books/ reference	**1**		Current editions of IP, BP and USP				
	2		G. D. Christian, Analytical Chemistry, John Wiley & Sons, Singapore, reprint by Wiley India Pvt. Ltd				
	3		**A. H. Beckett and J. B. Stenlake, Practical Pharmaceutical Chemistry, Part I and II, CBS Publishers and Distributors, India**				
	4		J. Mendham, R. C. Denney, J. D. Barnes, M. J. K. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, Pearson Education Ltd.				
	5		D. G. Watson, Pharmaceutical Analysis –A textbook for pharmacy students and pharmaceutical chemists, Churchill Livingstone Elsevier				
	6		R. M. Silverstein, F. X. Webster and D. J. Kiemle, Spectrometric identification of organic compounds, John Wiley & Sons, Inc. (Indian edition), New Delhi				
Outcomes							

	CO1		Record the absorbance and calculate concentration of analyte in formulation or as an API by use of A(1%, 1cm) by UV spectrophotometer				
	CO2		Develop and optimize mobile phase composition for qualitative analysis by TLC and interpret qualitative analysis data by TLC				
	CO3		Outline working and application of HPLC				
	CO4		Outline working and application of GC				
	CO5		Understand the sample preparation technique for FTIR spectroscopy, interpret the IR spectra to identify the functional groups				

				L	**T**	**P**	**Total**
Course code			**SRP4403**				
Course title			**Pharmaceutical Chemistry and Formulation Technology Laboratory**				
Scheme and Credits			**0L:0T: 4P 2 credits**	**0**	**0**	**4**	**4**
Pre-requisites			Pharmaceutical Chemistry, Formulation Technology and Drug Delivery				
Description of the Course			To train the students with respect to practical aspects of Green Chemistry while preparing the commonly used organic compounds as a drugs and also train the students on advanced formulation development technology				
Objectives of the course	**1**		To train the learner in preparation of typical monophasic liquid and semisolid formulations and carry out their Q.C. tests, and acquaint them with some biological preparations available in market				
	2		To introduce the learner to various hands-on experimental organic synthetic techniques including column chromatography and thin layer chromatography				
Syllabus	**1**		Evaluation of excipients: Bulking agents for Flow properties, Bulk density, Tapped density, Carr's index, Hausner's ratio and particle size and Disintegrating agents for Swelling index			**4**	**4**
	2		Preparation and evaluation of Transdermal/ophthalmic gels			**4**	**4**
	3		Preparation of Eye drops/ and Eye ointments			**4**	**4**
	4		Preparation of Creams (cold / vanishing cream)			**4**	**4**
	5		Preparation of Paracetamol paediatric elixir			**4**	**4**
	6		Representative examples of microencapsulation (Preparation and evaluation)			**4**	**4**
	7		Solubilisation of drugs by at least two novel techniques			**8**	**8**
	8		Evaluation of Glass containers (as per IP)			**4**	**4**
	9		Synthesis of two molecules/drug intermediates which may include three or more steps to isolate, purify (chemical methods and through chromatography) and characterize the product from each step			**12**	**12**
				0	**0**	**48**	**48**

Suggested books/ reference	**1**		Pharmaceutical Dosage Forms Vol. I & II, Liebermann, New York, Marcel Dekker (1996)				
	2		Latest Indian Pharmacopoeia, British Pharmacopoeia, United States Pharmacopoeia				
	3		Pharmaceutical Production Facilities: Design and Applications G. C. Cole, New York Ellis Horwood (1990)				
	4		Husa's Pharmaceutical Dispensing Martin E. W. Easton Mack Pub. Co. (1971)				
	5		Transdermal Delivery of Drug A. Kydonieus Florida, CRC Press (1987)				
Outcomes							
	CO1		Prepare transdermal and ophthalmic formulations.				
	CO2		Prepare and evaluate the semisolid dosage form				
	CO3		Prepare and evaluate the monophasic/biphasic liquid dosage form				
	CO4		plan and develop organic synthetic routes for small organic compounds				
	CO5		develop a set of separation and purification and structural characterization skills				

Special Subject 1- Biochemistry and Microbiology

Course code	**SRT3201**
Course title	**Biochemistry and Microbiology**
Prerequisite	**Introduction to biological science and bioengineering**
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**

Course title		Detailed contents	Total contact h
Biochemistry and Microbiology	1	Water and biomolecules. Introduction to biochemistry. Carbohydrates: Fundamentals of chemistry of carbohydrates. Monosaccharides, oligosaccharides and polysaccharides. Qualitative tests and color reactions. Quantitative analysis. Biosynthesis. Lipids: Fatty acids, waxes, phospholipids, sphingolipids, sterols and terpenoids. Function and comparative distribution of lipids. Biosynthesis. Hydrogenation. Sap value, Iodine value, Acid value. Biochemical tests. Lipoproteins and lipopolysaccharides. Amino acids: pK, pI, structure and chemistry Protein: Structure and function. Globular and fibrous proteins. Enzymes and activity assay. Qualitative and quantitative tests for amino acids, proteins. Precipitation of proteins. Solid phase peptide synthesis. Protein sequencing. Protein metabolism. Transmutation, SGOT/SGPT, deamination and decarboxylation. Vitamins and Co-enzymes: Structure and function. Qualitative and quantitative analysis. DNA and RNA: Structure and function. DNA → RNA → Protein. Sequencing. Fluorescence tagging. Recombination and repair. Gene and control of gene expression. Operon.	10
	2	History of microbiology (focus on microscopy). Types of microscopy (dark, fluorescence, atomic force, scanning, confocal etc.). Applications of microbiology.	2
	3	Microorganisms: Major groups of microorganisms- bacteria, yeast, algae etc., their structure and properties. Cell mobility and motility. Different types of staining techniques (with reference to bacteria): Monochromatic staining, Gram staining, Acid fast staining, Capsule – flagella – spore – cell wall staining, Negative staining. Virus: Types and structure. Reproduction and cultivation.	6
	4	Cell culture: Isolation and identification of pure culture, cell preservation. Culture media, their composition, and their types. Growth studies, microbial cell growth phases Introduction to biosafety. Sterilization methods. Aseptic technique. Biocontainment. Methods of Sterilization, disinfection, sanitation, and asepsis	8
	5	Mutation: Types and mechanisms. Mutagenic agents. Evolution.	2
	6	Cell cloning: PCR and DNA amplification, restriction enzymes, DNA digestion, DNA ligation, transformation. Gibson assembly. Recombinant cells and selection markers. Vectors and plasmids. Competent cells. Reverse transcription. cDNA. Transfection. CRISPR technique.	8
		Total	36

Suggested text/reference books

5. Microbiology Concepts and Applications: M. J. Pelczar Jr., E. C. S. Chan And N. R. Krieg
6. Microbiology: An Introduction: Gerard J. Tortora, Berdell R. Funke and Christine L. Case
7. Lehninger: Principles of Biochemistry: David Nelson, Michael Cox

8. Outlines of Biochemistry: Eric Conn and Paul K Stumf
9. Harpers Biochemistry: Robert Murray, Daryl Granner

Special Subject 2- Introduction to Pharmaceutical Technology

Course code	**SRT3302**
Course title	**Introduction to Pharmaceutical Technology**
Prerequisite	**Introduction to biological science and bioengineering, Biochemistry and Microbiology**
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**

Course title		Detailed contents	Total contact h
Introduction to Pharmaceutical Technology	1	General Aspects: Definition of a drug. Various drug categories such as Prescription and OTC drugs Drug nomenclature: Chemical name, Generic name, Prototype A brief history of Pharma industry (From Dyes to Small Molecules to Biologicals) Introduction about core subjects of Pharmacy: Pharmaceutics (including Biopharmaceutics and Pharmacokinetics), Pharmacology, Pharmaceutical, and analytical chemistry, Pharmacognosy Laws governing the drugs and various compendia (official and non-official)	6
	2	**Medicinal Chemistry and Process Chemistry:** Discovery of Hits and Leads, Lead optimization, Introduction to Process chemistry industry and its brief overview	6
	3	**Pharmacology:** Brief overview of Pharmacokinetic principles A brief overview of the mechanism of action of drugs A brief overview of Adverse Drug Reactions	4
	4	**Drug administration:** Brief overview of following routes of administration with their advantage and disadvantage Enteral: Oral, Sublingual, and Rectal Parenteral: Injections, Inhalation, Transdermal Topical routes: Ophthalmic, Nasal, Auditory	2
	5	**Dosage forms of the drugs:** Various definitions such as Formulation, Dosage form, API, Excipient, Vehicles Brief overview of following dosage forms- Solid, Liquid dosage forms for internal and external use, Inhalations, Aerosols, and suppositories Targeted Drug Delivery systems	6
	6	**Overview of drug development:** Various aspects of preclinical studies in brief, Clinical trials, and its phases in brief	2
	7	**Introduction to various commonly used analytical techniques and operations in Pharma industry:** Spectroscopic techniques, Chromatographic techniques, Extraction, and isolation techniques An overview of pharmaceutical engineering and various unit operations	4
	8	**Introduction to biological therapeutics:** Peptides and proteins as drugs and their synthesis in brief Introduction of rDNA technology Monoclonal antibodies	6
		Total	36

Suggested text/reference books

- Principles of Pharmacology, HL Sharma, KK Sharma, Paras Medical Publisher
- An introduction to pharmaceutical sciences: Production, chemistry, techniques, and technology, Jiben Roy, Woodhead Publishing Series in Biomedicine
- Real World Drug Discovery: A Chemist's Guide to Biotech and Pharmaceutical Research, Robert M. Rydzewski, Elsevier Science (2008)

Special Subject 3- Nutrition and Nutraceuticals

Course code	**SRT3403**
Course title	**Nutrition and Nutraceuticals**
Prerequisite	**Introduction to biological science and bioengineering, Biochemistry and Microbiology**
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**

Course title		Detailed contents	Total contact h
Nutrition and Nutraceuticals	1	Classification of food components based on nutritional value, nutritional assessment of carbohydrates, proteins, and fats, recommended dietary intake, acceptable dietary intake, nitrogen balance, protein efficiency ratio, net protein utilization.	6

		Basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI), and Standard Dynamic Action (SDA) with special reference to the nutraceutical industry.	
	2	Defining nutraceuticals. Nature, type, and scope of nutraceuticals compounds and their classification based on chemical and biochemical nature with suitable and relevant descriptions.	6
	3	Disease and Nutrition: Functions of dietary fiber (soluble and insoluble) in control of certain disease conditions like diabetes, cancer, heart diseases etc. Effect of drugs on ingestion, digestive absorption & metabolism of nutrients, Effect of food nutrients & nutritional status in drug dosage & efficacy.	6
	4	Functional Foods and their applications: Role of Isoprenoids, Isoflavones, Flavonoids, carotenoids, Tocotrienols, polyunsaturated fatty acids, sphingolipids, lecithin, choline. Terpenoids, whey, and soy protein. Vegetables, seeds, cereals, seafood, milk, and dairy products as functional foods. Probiotics and prebiotics. Role of nutraceuticals with special reference to diabetes mellitus, hypertension, hypercholesterolemia, cancer, glands in the prevention and treatment.	9
	5	Nutraceutical evaluation and testing: Biological testing and bioassays, preclinical testing, and clinical trials. Quality control and quality assurance of nutraceuticals. Marketing of nutraceuticals.	4
	6	Nutritional genomics: Plants as bioreactors as a tool for the production of Nutraceuticals. 'Tailor-made' carbohydrates and lipids of plant and non-plant origin. Transgenic plants for the large-scale production of proteins for pharmaceutical and industrial uses. Commercial transgenic crops like herbicide-resistant soybean, maize, vegetables, fruit crops, golden rice.	5
		Total	36

Suggested text/reference books

10. Brigelius-Flohé, J & Joost HG. Nutritional Genomics: Impact on Health and Disease. Wiley VCH. 2006.
11. Cupp J & Tracy TS. 2003. Dietary Supplements: Toxicology and Clinical Pharmacology. Humana Press.
12. Gibson GR & William CM. Functional Foods - Concept to Product. 2000.
13. Losso JN. Angi-angiogenic Functional and Medicinal Foods. CRC Press. 2007.
14. Robert E.C. Wildman Handbook of Nutraceuticals and Functional Foods, CRC, 2006.
15. L. Rapport and B. Lockwood Nutraceuticals, 2nd Edition, Pharmaceutical Press (2002).

Special Subject 4- Pharmaceutics and Pharmacology

Course code **SRT3404**

Course title **Pharmaceutics and Pharmacology**

Prerequisite **Introduction to biological science and bioengineering, Introduction to Pharmaceutical Technology**

Scheme and Credits **2 L: 1 T: 0 P** **3 Credits**

Course title		Detailed contents	Total contact h
Pharmaceutics and Pharmacology	1	History of Pharmacy Origin & Development of the pharmacopoeia – IP/BP/USP Introduction to the monograph, parts of the monograph	3
	2	Introduction to pre-formulation and formulation studies Quality control and Quality assurance, Introduction to GMP and cGMP, quality by design (QbD), and quality by test (QbT)	4

	3	Introduction to unit operations involved in pharmaceutics: Size reduction, size separation, mixing and homogenization, filtration, extraction, sterilization, and solubilization	4
	4	Formulation and scale-up considerations in the development of the following dosage forms: Solutions, syrups, elixirs, and tinctures Suspensions and emulsions Ointments, creams, lotions, and gels Tablets, capsules (soft and hard gelatin) Medical gases and aerosols Injectables and eye drops Pessaries and suppositories	8
	5	Stability Studies: Introduction to ICH climate zones and ICH guidelines for stability testing [Q1A, Q1B, and Q1C], Stabilization of dosage forms	3
	6	Introduction to the human body, organization of the human body Different systems of the human body Blood and lymphatic system, structure and function of the kidney, respiratory system, digestive system, endocrine system, nervous system (Neurotransmission, adrenergic and cholinergic system, CNS, ANS, and PNS), and cardiovascular system	4
	7	General pharmacology (ADME, routes of administration, and MOA)	2
	8	Hematinic, thrombolytics, coagulants/anticoagulants Antidiabetic drugs Drugs acting on the nervous system Drugs used in hypertension, vasodilator Analgesics and narcotics Anesthetics	6
	9	Anticancer drugs Antimicrobials and anti-infectives	2
	10	Gene therapy	1
		Total	36

Suggested text/reference books

16. Pharmaceutical Dosage Form And Drug Delivery Systems, Howard C. Ansel, Nicholas G. Popovich, Lord V. Alien, 6th edition, 1995, B.I.Waverly Pvt. Ltd., New Delhi
17. Remington-The Science And Practice Of Pharmacy (Vol.1& 2), David B.Troy, 21st edition,2006, Lippincott Williams &Wilkins
18. Tutorial Pharmacy J.W. Cooper, Colin Gunn, 4th edition,1950, Sir Isaac Pitman & Sons Ltd., London Pharmaceutics: The Science Of Dosage Form Design, Michael E. Aulton, 1998, Churchill-Livingstone Dermatological Formulations, B. W. Barry, 198, New York, Marcel Dekker
19. ICH Guidelines
20. Tortora's Principles of Anatomy and Physiology, Gerard J. Tortora
21. Arthur C. Guyton and John E. Hall, Textbook of Medical Physiology, 13thedition, W. B. Saunders Company, 2016
22. Essentials of Medical Pharmacology, K. D. Tripathi

Special Subject 5- Pharmaceutical Analysis

Course code	**SRT3405**
Course title	**Pharmaceutical Analysis**
Prerequisite	**Introduction to Pharmaceutical Technology, Pharmaceutics and Pharmacology**
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**

Course title		Detailed contents	Total contact h
Pharmaceutical Analysis	1	Introduction: Difference between qualitative and quantitative analysis. Pharmacopoeial monograph, literature collection, data handling, and expression of analytical results – documentation and record-keeping	3
	2	The theoretical basis of quantitative analysis Equivalent weight, Standard volumetric solutions. Normality, molarity, molality, formality, characteristics of a primary standard; Secondary standard,	3
	3	Analytical method validation (as per USP and ICH guidelines):	3

	Accuracy, Precision, Limit of detection, Limit of quantification, Linearity, Range, Robustness, Ruggedness, causes of errors	
4	Refractometry and Polarimetry: theory, instrumentation, and application	1
5	UV Visible Spectroscopy: Introduction to the interaction between electromagnetic radiation and matter, absorption of radiation by molecules, a chromophore	
	Definition - auxochromes, bathochromic shift, hypsochromic shift; Hyperchromism and hypochromism, Effect of solvent on absorption spectra	4
	Beer and Lambert's law, limitation of Beer's law, application of Beer's law to single component analysis and multi-component systems	
	Instrumentation of UV visible spectrophotometer, single beam UV visible spectrophotometer, and double beam spectrophotometer	
6	Infrared spectroscopy: Molecular structure and infrared spectra, vibrational transition frequency-structure correlations.	
	Instrumentation-discussions of light sources, frequency selector, Intensity control detectors, samples, preparation,	3
	Near IR spectroscopy – Different applications in the pharmaceutical industry, sampling techniques; Difference between FTIR and Dispersive IR	
7	Fluorescence spectroscopy: Theory of fluorescence phenomenon-origin of fluorescence and phosphorescence.	
	Molecular structure and fluorescence; Quantitative fluorescence analysis; Practical fluorescence analysis: Application of fluorescence analysis to drug: Instrumentation	2
8	Chromatography: Terminologies-mobile phase, stationary phase, normal phase, reverse phase, isocratic elution, gradient elution, retention time, theoretical plate, HETP, resolution	
	Types of chromatographic techniques: Adsorption, ion-exchange, affinity, size exclusion	5
	Instrumentation: pumps, injector, detector	
	Gas chromatography and HPLC	
9	Nuclear magnetic resonance spectroscopy: principle, ^{1}H NMR, chemical shift, and brief instrumentation	2
10	Mass spectrometry (MS): principle, methods of ionization, types of Mass spectrophotometer, application	3
	MS analysis of biologics: MALDI	
11	Thermal Analysis: TGA, DSC Their principle and application	2
12	Analysis of Biologics: DNA sequencing, Protein sequencing	
	Enzyme assay	3
	ELISA, southern blotting, and northern blotting techniques	
6	High throughput screening, flow cytometry	2
	Total	36

Suggested text/reference books

23. Practical pharmaceutical chemistry, 4thEdn. (Part II)-Beckett, A.H & Stenlake, J.B.
24. Pharmaceutical analysis-Lee, David&Webb, Michael
25. Vogel's textbook of quantitative chemical analysis, 6th edn - Mendham, J
26. Vogel's qualitative inorganic analysis – Svehla G
27. Introduction to Spectroscopy – Pavia
28. Pharmaceutical Analysis by Skoog and West
29. Analytical chemistry, 6th edn. - Christian, Gary
30. Organic Spectroscopy by William Kemp
31. Indian Pharmacopoeia
32. United States pharmacopoeia

Special Subject 6- Pharmaceutical Additives and Excipients

Course code	**SRT3506**
Course title	**Pharmaceutical Additives and Excipients**
Prerequisite	**Introduction to Pharmaceutical Technology, Pharmaceutics and Pharmacology, Pharmaceutical Analysis**
Scheme and Credits	**2 L: 1 T: 0 P** **3 Credits**

Course title		Detailed contents	Total contact h
Pharmaceutical Additives and Excipients	1	Pharmaceutical additives/excipients, their purposes, properties of additives, different classes of excipients Pharmaceutical processing aid	4
	2	Functions, features, scale-up considerations, and examples of the following: Fillers, Binders, Disintegrants, Coating agents, Sorbents, Glidants, Lubricants, Preservatives, Sweeteners, Flavoring agents, Coloring agents, Chelating agents, Cosolvents, Buffering agents, Humectant, Surfactants, Propellent	12
	3	Drug-excipient compatibility	4
	4	Package-excipient interactions	4
	5	Functional excipients affecting drug release profile with examples	4
	6	Excipient stability	4
	7	Regulatory requirements: FDA, IPEC, and pharmacopoeial	4
		Total	36

Suggested text/reference books

33. Remington-The Science And Practice Of Pharmacy (Vol.1& 2), David B.Troy, 21st edition,2006, Lippincott Williams & Wilkins
34. Tutorial Pharmacy J.W. Cooper, Colin Gunn, 4th edition,1950, Sir Isaac Pitman & Sons Ltd., London Pharmaceutics: The Science Of Dosage Form Design, Michael E. Aulton, 1998, Churchill-Livingstone Dermatological Formulations, B. W. Barry, 198, New York, Marcel Dekker
35. IPEC Guidelines
36. Indian Pharmacopoeia
37. United States pharmacopoeia

Special Subject 7- Medicinal Chemistry and Natural Products

Course code	**SRT3507**
Course title	**Medicinal Chemistry and Natural Products**
Prerequisite	**Introduction to biological science and bioengineering and Pharma minor courses**
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**

Course title		Detailed contents	Total contact h
Medicinal Chemistry and Natural Products	1	Introduction to Medicinal Chemistry: Definitions and explanation of terms used in Medicinal Chemistry (hits, lead, lead development, molecular libraries, toxicity studies, high throughput screening, ADME etc.), the nomenclature of drugs	1
	2	Introduction to modern drug discovery- rational design, molecular modeling, genetics, and DNA technology	2
	3	Drug targets: concepts of drug binding, affinity, selectivity. Discuss the following with examples. Enzymes as drug targets: concept of enzyme, apoenzyme, holoenzyme, coenzyme, cofactor Targeting human enzymes, targeting enzymes selective to pathogens Receptors as drug targets: types and properties of receptors Ligand-receptor interaction, types of bonds in the interactions, role of structure and conformation Types of inhibitions (competitive, non-competitive, uncompetitive Allosteric interaction	6
	4	Target identification methods: Brief overview of target identification, biopharmaceutical therapy, identification of druggable targets by proteome investigation, cellular screening, intracellular receptors and enzymes, a brief overview of drug metabolism and toxicity	3
	5	Strategies in hit/lead discovery a) natural product-based b) biology-oriented synthesis	2

		c) in silico screening d) fragment-based drug design	
	6	Lead optimization: lead likeness and drug-likeness, determination of compound, biological, biochemical properties, metabolic information using the internet, homologs,	3
	7	SAR, QSAR: the concept of SAR, effects of substituents and functional groups, methodology of QSAR, practical applications like compound library design, profiling, acquisition, screening. Drug design: Ligand-based (pharmacophore modeling) and receptor-based drug design (protein crystallography, molecular docking)	4
	8	Medicinal natural products: Scope of the subject, Source of the drug of natural origin, Organized and unorganized drugs	1
	9	Preparation of drugs for commerce and quality control Extraction and isolation of plant drugs: conventional and modern techniques used in extraction and separation of phytoconstituents.	3
	10	Phytochemistry: Chemical constituents in the production of plants (carbohydrates, protein enzymes, lipids, alkaloids, glycosides, steroids, tannins, terpenoids, flavonoids, plant pigments, etc.). Discuss at least 1 example from each of the above classes	6
	11	Biosynthesis approach: Building blocks and metabolic pathways for the formation of secondary metabolites.	2
	12	Extraction and isolation of plant drugs: conventional and modern techniques used in extraction and separation of phytoconstituents.	2
	13	Recent advances in phytopharmaceuticals (a topic of current interest)	1
		Total	36

Suggested text/reference books

38. Foye's Principles Of Medicinal Chemistry W. O. Foye, Lippincott Williams & Wilkins, 6th edition, 2008.
39. Textbook of Medicinal And Pharmaceutical Chemistry Wilson And Gisvold, Lippincott Williams & Wilkins, Philadelphia,11
40. The Organic Chemistry of Drug Design and Drug Action. R. B. Silverman Elsevier Publication
41. Dewick P.M., Medicinal Natural Products- A Biosynthetic Approach,2 edition/2002, John Wiley & Sons Ltd
42. Trease & Evans, Textbook of Pharmacognosy, 15
43. The Merck Index, Merck Research Laboratories, 13
44. Quality Standards of Indian Medicinal Plants, all volumes, ICMR
45. Indian Medicinal Plants, Kiritikar and Basu

Special Lab 1

1. API Synthesis
2. API purification and FT-IR, melting point analysis
3. Co-crystallization of API, analysis using XRD
4. Analysis of API and cosolvent (used in co-crystallization) by UV-VIS spectroscopy
5. Study of effect of co-crystallization on solubility
6. Natural product extraction using Soxhlet assembly
7. Enzymatic process for API intermediate synthesis and kinetic study using HPLC
8. Aseptic operation and sterilization

Special Lab 2

1. Antibiotic susceptibility testing using disc diffusion assay
2. Fermentative protein synthesis and protein purification using affinity chromatography
3. Granulation using granulator and hot melt extruder
4. Solid dosage form preparations
5. Semisolid and powder preparations
6. Quality control testing of various dosage forms

Energy

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SET3302	SET4302	Theory	Conventional Energy and Utilization
2	SET3303	SET4303	Theory	Renewable Energy Systems
3	SET3403	SET4403	Theory	Combustion and Chemistry of Fuels
4	SET3404	SET4404	Theory	Energy Conversion and Storage
5	SET3405	SET4405	Theory	Advanced Thermodynamics of Energy Systems
6	SET3506	SET4506	Theory	Materials for Energy Applications
7	SET3507	SET4507	Theory	Energy Management
1	SEP3301	SEP4301	Laboratory	Energy Lab-I
2	SEP3402	SEP4402	Laboratory	Energy Lab-II

				L	T	P	Total
Course code			**SET4302**				
Course title			**Conventional Energy and Utilization**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Material and Energy Balance Calculations, Chemical Engineering Thermodynamics II, Physics II and Chemistry II				
Objectives of the course	**1**		To present an overview of energy generation, distribution and control systems				
	2		To impart understanding of sources of energy and its significance				
Syllabus	**1**		Basics of energy: Different forms of energy, energy conversion process, indirect and direct energy conversion; Different energy sources; Conventional energy systems: engines, power plants, various methods of power generation;	**2**	**1**		**3**
	2		Energy Distribution: Power systems: Load and load duration curves, selection of generating units, Introduction to power generation, transmission and distribution, power systems losses and compensation, High voltage AC (HVAC) and High voltage DC (HVDC) transmission; Interconnected grid system	**4**	**2**		**6**
	3		Basics of fuels: Modern concepts of fuel, Solid, liquid and gaseous fuels, composition, basic understanding of various properties of solid fuels - heating value, ultimate analysis, proximate analysis, ash deformation points; liquid fuels - heating value, density, specific gravity, viscosity, flash point, ignition point (self, forced), pour point, ash composition and gaseous fuels	**4**	**2**		**6**
	4		Coal as a source of energy: Coal reserves – World and India, Coal liquefaction process, various types of coal and their properties, Origin of coal, composition of coal, analysis and properties of coal	**4**	**2**		**6**
	5		Petroleum as a source of energy and chemicals: Origin, composition, classification of petroleum, grading of petroleum; Processing of petroleum: Distillation of crude petroleum, petroleum products, purification of petroleum products – thermal processes, catalytic processes, specifications and characteristics of petroleum products. Natural Gas	**6**	**3**		**9**
	6		Nuclear Energy	**4**	**2**		**6**
				24	**12**	**0**	**36**

Suggested books/ reference	**1**		Nag P. K. (2014); Basic and Applied Thermodynamics, McGraw Hill.				
	2		Theraja B. L. and Theraja A. K. (1998); A Text Book in Electrical Technology, S. Chand and Co.				
	3		Sarkar S. (2010); Fuels and Combustion, Third Edition, CRC Press				
	4		Jaccard M. (2006); Sustainable Fossil Fuels, Cambridge University Press				
Outcomes			On completion of the course, the students will be able to				
	CO1		List forms of energy, conversion processes				
	CO2		Categorize renewable and non renewable energy sources				
	CO3		Estimate calorific value from fuel analyses				
	CO4		Explain energy generation and distribution systems				

				L	**T**	**P**	**Total**
Course code			**SET4303**				
Course title			**Renewable Energy Systems**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Material and Energy Balance Calculations, Chemical Engineering Thermodynamics II, Physics II and Chemistry II				
Description of the Course			This course aims to develop understanding of renewable energy sources				
Objectives of the course	**1**		To examine the principles of sustainability and renewable energy				
	2		To create an understanding of solar energy conversion including photovoltaic (PV) and solar thermal conversion systems.				
	3		To examine the tradeoffs with use of biomass based energy				
Syllabus	**1**		Bioenergy: World and India's bioenergy scenario, production of biomass, photosynthesis, assessment of biomass resources, Biomass composition and energy content; Biofuels, types of biofuels and production technologies; Advanced bio-systems and biofuel production	**2**	**1**		**3**
	2		Biochemical conversion: Bio-methanation: biogas production mechanism and technology, Design of biogas plants, biogas slurry utilization and management, biogas applications; Cost benefit analysis of biogas for cooking, lighting, power generation applications, Case studies	**4**	**2**		**6**
	3		Thermochemical conversion: Pyrolysis, Carbonization, Charcoal production, Biomass gasification, Liquefaction; Torrefaction and pyrolytic oil, typical composition Biomass Gasifiers: types of gasifiers and mechanisms of operation, gasifier product gas analysis, gasifier stoves, heat and mass balance of gasification system; Gasification based power generation, IGCC, cost benefit analysis, case studies	**4**	**2**		**6**
	4		Solar Radiation, Solar angles, Sun path diagram; Shadow determination, Solar spectrum, Effect of earth atmosphere on solar radiation, Measurement and estimation of solar radiation on horizontal and tilted surfaces, Solar radiation measurement devices, Solar radiation data analysis	**4**	**2**		**6**
	5		Photovoltaic: Principle of photovoltaic conversion; Solar cell basics and materials; Different solar cell technologies:	**4**	**2**		**6**

			Crystalline silicon solar cell, Thin Film solar cell, Tandem solar cell; Photovoltaic system: Component and configurations; off grid and grid connected PV systems, PV system design and economics				
	6		Solar thermal conversion: Theory and Basics. Introduction to different solar thermal energy systems: Solar flat plate collector, Concentrating collector, Solar cooker, Solar pond, Solar passive heating and cooling system; Design and components and flat plat collector; Development of solar thermal collectors; Solar cooling and refrigeration; Concentrating solar collector: optical design of concentrators, solar water heaters, solar dryers; Solar thermal power generation and economics;	**2**	**1**		**3**
	7		Wind energy conversion, tidal energy conversion Resource assessment, power, and energy calculations, aerodynamic analysis, development of the Betz limit, design limitations and optimization, and environmental impact of wind energy conversion devices.	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Sorensen B. (2010); Renewable Energy, Fourth Edition, Academic press				
	2		Mukunda H. S. (2011); Understanding Clean Energy and Fuels from Biomass, Wiley India				
	3		***Wind Energy Handbook***, Second Edition, by Tony Burton. 2011				
	4		***Wind Energy Explained, Theory Design and Application***, Second Edition, by James Manwell. 2009.				
	5		Solar Energy Conversion Systems (Elsevier, Academic Press), 2013 by J. R. S. Brownson				
Outcomes			On completion of the course, the students will be able to				
	CO1		Apply principles of mathematics, science and engineering to the analysis of solar, wind and biomass power				
	CO2		Design systems for harnessing biomass, solar, wind and hydrokinetic energy				
	CO3		Integrate the considerations of economic, environmental, sustainability, health and safety, social, and political factors for analysis of renewable energy systems				

				L	**T**	**P**	**Total**
Course code			**SET4403**				
Course title			**Combustion and Chemistry of Fuels**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Momentum Transfer, Mass Transfer, Chemical Engineering Thermodynamics II				
Description of the Course							
Objectives of the course	**1**		Provide fundamental knowledge of the chemistry, composition and upgrading of fuels				
	2		Fundamental understanding of combustion from thermodynamic, kinetic and transport perspectives				
Syllabus	**1**		Nature and properties of fossil and other fuels, including aerospace, in relation to use; preparation of fuels; by-products; fuel analysis.	**4**	**2**		**6**
	2		Coal: Action of heat on coal, caking and coking properties of coal; Processing of coal: Coal preparations, briquetting,	**4**	**2**		**6**

			carbonization, gasification and liquefaction of coal, Coal derived chemicals.				
	3		Combustion thermodynamics Combustion mechanism, elementary steps, chain reaction Adiabatic Flame Temperature, Equilibrium constant and free energy	**4**	**2**		**6**
	4		Combustion Kinetics Elementary, consecutive and parallel reactions Transition state theory, collision theory of reaction rates Steady state approximation, concept and applications Rate determining step, concept and applications	**4**	**2**		**6**
	5		Contribution of Transport Phenomena to Combustion Combustion chamber modelling, laminar premixed flames, laminar diffusion in flames, turbulent flames basics, coupled heat and mass transfer, ignition and heterogeneous combustion	**4**	**2**		**6**
	6		Emissions Thermodynamic, kinetic analysis of emissions and control of CO, NOx, SOx, biochar emissions, coal pyrolysis	**4**	**2**		**6**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		"An Introduction to Combustion: Concepts and Applications," Third Edition, by Stephen R. Turns, McGraw-Hill (2012)				
	2		Principles of Combustion , Kenneth Kuan-yun Kuo				
Outcomes			On completion of the course, the students will be able to				
	CO1		Apply knowledge to estimate heating value, and other characteristics of coal based fuels				
	CO2		Develop or validate model for combustion based on available data				
	CO3		Optimize process to minimize emissions				

				L	**T**	**P**	**Total**
Course code			**SET4404**				
Course title			**Energy Conversion and Storage**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Chemical Engineering Thermodynamics II, Conventional Energy Technology				
Description of the Course							
Objectives of the course	**1**		To expose students to energy storage chemistry particularly for storage of electricty.				
	2		Provide fundamental knowledge of the energy storage devices and systems				
	3		To review conversion of energy in form of fuels				
Syllabus	**1**		Different types of energy storage; Mechanical, Chemical, Electrical, Electrochemical, Biological, Magnetic, Electromagnetic, Thermal; Comparison of energy storage technologies.	**3**	**1**		**4**
	2		Thermal energy storage: principles and applications, Sensible and Latent heat, Phase change materials; solar energy and thermal energy storage, case studies.	**2**	**1**		**3**
	3		Flywheel and compressed air storage; Pumped hydro storage; Hydrogen energy storage	**2**			**2**
	4		Capacitor and super capacitor, Electrochemical Double Layer Capacitor: Principles, performance and applications.	**3**	**1**		**4**

	5		Electrochemical energy storage: Battery – fundamentals and technologies, characteristics and performance comparison: Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries.	**6**	**3**		**9**
	6		Hydrogen as energy carrier and storage; Hydrogen resources and production; Basic principle of direct energy conversion using fuel cells	**4**	**2**		**6**
	7		Fuel cell types: AFC, PEMFC, MCFC, SOFC, Microbial Fuel cell; Fuel cell performance, characterization and modeling; Fuel cell system design and technology, applications for power and transportation.	**4**	**2**		**6**
	8		Application of Energy Storage: Food preservation, Waste heat recovery, Solar energy storage	**2**	**0**		**2**
				26	**10**	**0**	**36**
Suggested books/ reference	**1**		Dincer I., and Rosen M. A. (2011); Thermal Energy Storage: Systems and Applications, Wiley				
	2		Huggins R. A. (2015); Energy Storage: Fundamentals, Materials and Applications. Springer				
Outcomes			On completion of the course, the students will be able to				
	CO1		Describe criteria used to determine performance, advantages, and disadvantages				
	CO2		Perform efficiency analysis of energy storage systems				
	CO3		Recommend optimal (appropriateness, cost and sustainability) solutions to any potential energy storage application				

				L	**T**	**P**	**Total**
Course code			**SET4405**				
Course title			**Advanced Thermodynamics of Energy Systems**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Chemical Engineering Thermodynamics II, Energy conversion and storage				
Description of the Course							
Objectives of the course	**1**		To impart understanding of fundamentals of energy conversion, reversibility and irreversibility				
	2		To study energy conversion and storage from molecular perspective				
Syllabus	**1**		Macroscopic and microscopic analysis of direct and indirect energy conversion in thermochemical, electrochemical, thermomechanical and other processes	**6**	**3**		**9**
	2		Kinetic theory and transport phenomena in energy systems	**6**	**3**		**9**
	3		Exergy analysis for energy conversion systems	**6**	**3**		**9**
	4		Case studies: fossil fuels, electrochemical cells, fuel cells, photovoltaics, supercritical and combined power generation cycles	**6**	**3**		**9**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Renaud Gicquel, Energy Systems: A New Approach to Engineering Thermodynamics, 2012, CRC Press, ISBN 9780415685009				
			Chandler, David (1987). Introduction to Modern Statistical Mechanics. Oxford University Press. ISBN 0-19-504277-8.				

	2		Ibrahim Dincer and Marc A. Rosen, Exergy, 2013, 2nd edition, Elsevier, ISBN: 978-0-08-097089-9				
Outcomes			On completion of the course, the students will be able to				
	CO1		Evaluate feasibility of a particular energy conversion process or strorage				
	CO2		Assess a process for energy efficiency using exergy analysis and recommend improvements				
	CO3		Design efficient energy systems for recovery of waste heat, electrochemical storage, etc.				

				L	**T**	**P**	**Total**
Course code			**SET4506**				
Course title			**Materials for Energy Applications**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Renewable Energy Systems, Combustion and Chemistry of Fuels				
Description of the Course							
Objectives of the course	**1**		To understanding the concepts of energy materials and their characterizations and applications in energy devices				
	2		To analyze the material design and relate to photovoltaic device, fuel cell systems and energy storage devices				
	3		To develop an attitude of innovation/creativity towards material design for various energy harvesting devices				
Syllabus	**1**		Device fabrication technologies: diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), plasma enhanced CVD (PECVD), hot wire CVD (HWCVD)	**6**	**2**		**8**
	2		High efficiency solar cells, PERL Si solar cell, III-V high efficiency solar cells, GaAs solar cells, tandem and multi-junction solar cells, solar PV concentrator cells and systems, III-V, II-VI thin-film solar cells; Amorphous silicon thin-film (and/or flexible) technologies, multijunction (tandem) solar cells, organic/flexible solar cells, polymer composites for solar cells, Spectral response of solar cells, quantum efficiency analysis, dark conductivity, I-V characterization	**12**	**4**		**16**
	3		Introduction to material characterization: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), X-ray diffraction (XRD), Raman spectroscopy, Atomic force microscopy (AFM); device fabrication and characterization;	**4**	**2**		**6**
	4		Materials and devices for energy storage; Batteries, Carbon Nano-Tubes (CNT), fabrication of CNTs, CNTs for hydrogen storage, CNT-polymer composites, ultra-capacitor; Polymer membranes for fuel cells, PEM fuel cell, Acid/alkaline fuel cells	**4**	**2**		**6**
				26	**10**	**0**	**36**
Suggested books/ reference	**1**		Duncan W. B., Dermot O., and Richard I. W. (2011). Energy Materials, 1st Edition, Wiley				
	2		Fahrenbruch A. L. and Bube R. H. (1983); Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press				
	3		Christoph B. Ullrich S. and Vladimir D. (2014). Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technologies, 2nd Edition, Wiley-VCH				
	4		San P. J. and Pei K. S. (2013). Nanostructured and Advanced Materials for Fuel Cells, 1st Edition, CRC Press				

Outcomes			On completion of the course, the students will be able to				
	CO1		Students will be able to understand and apply principles in solid state chemistry/physics, material science and engineering, adsorption, surface science, and catalysis in analyzing materials for energy applications.				
	CO2		Introductory information will be followed by case studies, state of the art review of current materials, and research needs for development.				
				L	**T**	**P**	**Total**
Course code			**SET4507**				
Course title			**Energy Management**				
Scheme and Credits			**2L: 1T: 0P 3 credits**	**2**	**1**	**0**	**3**
Pre-requisites			Chemical Engineering Thermodynamics II, Energy conversion and storage				
Description of the Course							
Objectives of the course	**1**		To understand the energy management, conservation processes, principles of energy auditing, energy flow diagram, economics of energy conservation opportunities.				
	2		To understand the energy management information systems, various key features of Energy Conservation Act and ECBC				
	3		To impart knowledge on fundamentals of economic principles and their applications in the broad field of supply and demand of energy				
	4		To arouse interest in the students about the problems of energy economics and arousing their interest on practical problem solving skills.				
Syllabus	**1**		Concept of energy management programme, basic components of an energy audit, types of energy audit, energy audit flow chart; Understanding energy use patterns and costs, Fuel and energy substitution; concepts of energy conservation and energy efficiency	**2**	**1**		**3**
	2		Energy audit tools; financial analysis techniques and options, Energy service companies, Project planning techniques; case studies; Energy conservation act and its features, Duties and responsibilities of energy managers and auditors	**4**	**2**		**6**
	3		Energy management systems, energy conservation policy and performance assessment, baseline and benchmarking, Action planning, monitoring and targeting, Energy management information systems, CUSUM techniques	**4**	**2**		**6**
	4		Case studies Energy conservation in buildings, building heating and cooling load management, Buildings code, solar passive and green building concepts	**2**	**1**		**3**
	5		Energy accounting framework; Economic theory of demand, production and cost market structure; National energy map of India, Energy subsidy – National and international perspectives	**4**	**2**		**6**
	6		Concepts of economic attributes involving renewable energy, Calculation of unit cost of power generation from different sources with examples, different models and methods	**2**	**1**		**3**
	7		Application of econometrics; input and output optimization; energy planning and forecasting - different methods	**2**	**1**		**3**
	8		Concepts of economic attributes involving renewable energy, Calculation of unit cost of power generation from	**2**	**1**		**3**

			different sources with examples, different models and methods				
	9		Evaluation of National and Regional energy policies; oil import, energy conservation, rural energy economics, integrated energy planning	**2**	**1**		**3**
				24	**12**	**0**	**36**
Suggested books/ reference	**1**		Bhattacharyya S. C. (2011); Energy Economics, Springer				
	2		Ferdinand E. B. (2000); Energy Economics: A Modern Introduction, First Edition, Kluwer				
	3		Doty S. and Turner W. C. (2012); Energy Management Handbook, Eighth Edition, Fairmont Press				
	4		Kreith F. and West R. E. (1996); Handbook of Energy Efficiency, First Edition, CRC Press				
Outcomes			On completion of the course, the students will be able to				
	CO1		Perform energy audit of given process, project, etc.				
	CO2		Establish benchline performance and design policy for energy efficiency in process				
	CO3		Design systems for minimum energy expenditure, minimizing life cycle costs through a combination of disparate energy sources, storage and conversion systems.				

Course code			**SEP4301**	**L**	**T**	**P**	**Total**
Course title			**Energy Laboratory-1**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			Conventional Energy and Utilization, Separation Process				
Objectives of the course	**1**		To learn to characterization techniques of conventional energy sources				
	2		To learn to collect, collate and interpret analytical results				
	3		To Learn quality and quantitative determination of sample				
Detailed contents				**0**	**0**	**48**	
	1		Determination of vaporization characteristics of given petroleum product by ASTM distillation.				
	2		Determination of flash point and fire point.				
	3		Determination of diesel index of given petroleum sample.				
	4		Determination of carbon residue of given petroleum fraction.				
	5		Determination of drop point of given sample.				
	6		Determination of viscosity of given petroleum sample.				
	7		Determination of cloud point and pour point.				
	8		Determination of the smoke point.				
	9		Determination of calorific value of fuel by Bomb calorimeter.				
			Total	**0**	**0**	**48**	**48**
Outcomes							
			Students will be able to				
	CO1		Describe the basic principles of different petroleum characterization techniques.				
	CO2		Suggest possible characterization techniques for given petroleum sample.				
	CO3		Strengthen the theoretical knowledge of petroleum products.				

	CO4		Able to clearly communicate the results of experimental work in oral and written formats.				
	CO3		Simulate and optimize processes for energy management				

Course code			**SEP4402**	**L**	**T**	**P**	**Total**
Course title			**Energy Laboratory-2**				
Scheme and Credits			**0 L: 0 T: 4 P 2 Credits**				
Pre-requisites			Renewable Energy Technology				
Objectives of the course	**1**		To learn to characterization techniques of renewable energy sources				
	2		To learn to collect, collate and interpret analytical results				
	3		To Learn quality and quantitative determination of sample				
Detailed contents				**0**	**0**	**48**	
	1		Solar cell effectiveness				
	2		Solar Thermal Heater				
	3		Performance analysis of Solar PV Electricity Generator				
	4		Biogas production from wate (biomass/wastewater)				
	5		Biohydrogen from waste (biomass/wastewater)				
	6		Production of biofuel				
	7		Characterization of biofuel				
			Total	**0**	**0**	**48**	**48**
Outcomes							
			Students will be able to				
	CO1		Describe the basic principles of different renewable energy sources characterization techniques.				
	CO2		Suggest possible characterization techniques for given renewable energy source.				
	CO3		Strengthen the theoretical knowledge of renewable energy source.				
	CO4		Able to clearly communicate the results of experimental work in oral and written formats.				

Course code		**SET3201**	
Course title		**Conventional Energy and Utilization**	
Scheme and Credits		**2 L: 1 T: 0 P 3 Credits**	
Pre-requisites		Thermodynamics, Heat transfer, Mass and Energy balance	
Objectives of the course		This part of the course deals with the production of energy from different non-renewable energy sources through conventional routes. It is intended to help the young minds to keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of conventional energy resources for cleaner energy production.	
Course title	**Detailed contents**		**Total contact h**
Renewable and Non-Renewable Energy	1	Introduction to the Topic; Classification of various energy sources; Key differences between them; Energy scenario in India; Global usage statistics	2
	2	Natural gas – Formation, Unconventional sources, composition and combustion properties, Natural gas production, transport and storage, applications.	4
	3	LNG production, transport and storage	2
	4	Coal – Origin, structure and classification; Coal mining	4
	5	Usage of coal in electricity generation, iron and cement industry	4
	4	Petroleum – Consumption of oil, sources and production of oil, crude oil characterization	4
	5	Refining of crude oil	4
	6	Nuclear Energy – Fission and Fusion cycle, Resources, fuel cycles, Electricity generation,	4
	7	Nuclear reactors – Types, Generations; Nuclear waste management	4
	8	Cleaner routes of energy production from conventional sources	2
	9	Hubbert Peak theory, Peak production forecast for conventional energy sources	2
	Total		36
Suggested text/reference books	1. Tushar K. Ghosh, Mark A. Prelas (eds.) - Energy Resources and Systems_ Volume 1_ Fundamentals and Non-Renewable Resources (2009, Springer Netherlands) 2. Kyle Forinash - Physics and the Environment – IOP Science, 2017 3. Vikram Janardhan, Bob Fesmire - Energy Explained, Volume 1_ Conventional Energy (2010, Rowman & Littlefield Publishers)		

Course code		**SET3302**	
Course title		**Special Subject 2: Renewable Energy and Utilization**	
Scheme and Credits		**2 L: 1 T: 0 P 3 Credits**	
Pre-requisites		Thermodynamics, Heat transfer, Conventional energy	
Objectives of the course		This part of the course deals with the production of energy from different renewable energy sources through different routes. It is intended to help the young minds to keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of unconventional energy resources for cleaner energy production.	
Course title	**Detailed contents**		**Total contact h**
Renewable and Non-Renewable Energy	1	Classification of various renewable energy sources; Principles of renewable energy, Renewable Energy scenario in India; Global usage statistics	1
	2	Solar Energy: • Energy Transfer to the Earth • Use of Solar Energy • Concentrating Solar Power (CSP) • Photovoltaics	6
	3	Wind Energy • Harvesting Energy from Wind • Energy and Power from Wind • Turbine Types	6

		• Industrial Wind Turbines • Low Frequency Noise form Wind Turbines	
	4	Hydro-power • Hydropower systems • Hydro-turbines • Hydropower System Efficiency	6
	5	Ocean Energy • Ocean Energy Potential against Wind and Solar • Wave Characteristics and Statistics • Wave Energy Devices • Tide characteristics and Statistics • Tide Energy Technologies • Ocean Thermal Energy • Osmotic Power	6
	4	Geothermal Energy • Geothermal Resources • Geothermal Technologies	4
	5	Bioenergy • Energy Source of Biomass • Composition of Biomass • Biomass Resources, Land Requirement, and Production • Biomethane and biofuel • Biofeedstock for Industrial Chemicals	4
	6	Ethanol • Ethanol Production from Corn • Sugar Crop Fermentation • Production of Ethanol from Cellulosic Biomass	1
	7	Hydrogen energy • Hydrogen Internal Combustion Engine • Hydrogen Production Methods • Hydrogen Storage	2
	TOTAL		**36**
Suggested text/reference books	4. Tushar K. Ghosh, Mark A. Prelas (eds.) - Energy Resources and Systems_ Volume 2_ Renewable Resources (2009, Springer Netherlands) 5. John Twidell, Tony Weir - Renewable Energy Resources-Taylor & Francis (2005) 6. Aldo V. da Rosa - Fundamentals of Renewable Energy Processes-Elsevier Academic Press (2005)		
Outcomes	Students will be able to • Understand the various renewable resources for energy utilization • Analyse the mechanism for producing energy from renewable resources • Develop the correlations and methodologies to calculate the power ratings of renewable energy devices		

Course code	**SET3403**		
Course title	**Energy and Sustainability**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Thermodynamics, Heat transfer, Mass and Energy balance		
Objectives of the course	This course deals with Sustainable developments in energy sector and the relevant ongoing advancements in this domain. The course also includes different strategies for meeting sustainable Goals.		
Course title	**Detailed contents**		**Total contact h**
	1	Introduction to the Topic; Sustainable Energy Systems, Sustainability Challenges and Opportunities	3

Energy and Sustainability	2	Energy Demand; Industrial and Commercial Sectors, Residential Sector, Transportation Sector	3
	3	Conventional and Unconventional Fossil Fuel Sources; Green House Gas Emissions	3
	4	Climate Mitigation Policies	3
	5	Energy Poverty and Cooking; Clean Cooking	3
	6	Renewable Energy Technologies; Solar, Wind, Hydro, Geothermal, Tide/Wave; Nuclear Power	4
	7	Sustainable Biofuel; First Generation, Second Generation, Third Generation, Fourth Generation; Bioenergy with Carbon Capture and Storage	4
	8	Carbon Sequestration Technologies	4
	9	Energy Analysis and Carbon Accounting; Life Cycle Analysis	3
	10	Energy Efficiency Technologies; Green Building, Industrial Energy Efficiency, Sustainable Energy Design	3
	11	Energy Security and Sustainable Development	3
	Total		36

Course code	**SET3404**		
Course title	**Coal Engineering and Coal to Chemicals**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Thermodynamics, Heat transfer, Mass and Energy balance		
Objectives of the course	This course deals with all the processes and technologies associated with coal right from extraction to power generation and production of other chemicals. The course also includes the pollution from coal combustion, control strategies and clean coal technology.		
Course title	**Detailed contents**		**Total contact h**
Coal Engineering	1	Introduction to the Topic; Role of coal in Energy Growth and CO_2 Emissions; Worldwide distribution of coal, Global coal consumption, Coal usage in power generation, Iron and Cement industry	3
	2	Origin of coal; Coalification; Classification; Chemical and Physical Characteristics of Coal	3
	3	Coal Mining; Underground Mining, Surface Mining, Impact of mining on environment	2
	4	Introduction to coal utilization technologies; Coal combustion, Carbonization, Gasification, Liquefaction	4
	5	Coal Gasification; Types of gasifiers, Commercial gasifiers; Coal to liquid fuels, Direct and Indirect coal liquefaction	4
	6	Coal Fired Power Plant; Coal Transport, Handling, Storage, Size reduction; Steam Turbines & Electricity Generation; Ash and by-product handling	4
	7	Coal based electricity generation; pulverized coal combustion (PC), PC combustion using subcritical, supercritical, or ultra-supercritical steam cycles, circulating fluidized bed combustion	4
	8	Coal Gasification; Basics of gasification, Products of gasification	3
	9	Direct Coal Liquefaction; Single-Stage direct liquefaction, Two-Stage direct liquefaction	3
	10	Coal to Olefins; Coal to Methanol, Methanol to Olefin, Coal to Gasoline and LPG and jet fuels	4
	11	Clean Coal Technology in India	2
	Total		36

Course code	**SET3405**
Course title	**Electrochemical Technology**
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**

Pre-requisites		Thermodynamics, Momentum transfer, Electrochemistry	
Objectives of the course		This part of the course deals with the production of energy from electrochemical sources. It is intended to help the young minds to understand the basic chemistry of electrochemical cells. At the same time this topic is going to give an insight on different electrochemical technology application in industries.	
Course title	**Detailed contents**		**Total contact h**
Electrochemical Technology	1	Introduction to the Topic; Overview of application of electrochemical technology, Atomic structures	2
	2	Properties of solutions, electrolytic dissociation, activity and activity coefficient, acid and bases, pH, ionic product of water, Hydrolysis of salts,	4
	3	Electrochemical double layer – supercapacitors, Determination of power and power density, energy density	4
	4	Fine structure of double layer - Helmholtz' approach, Gouy and Chapman model, model by Otto Stern, Bockris–Müller–Devanathan Model	6
	5	Electrochemical analytical techniques - Kirchhoff's Law, redox processes, metal and semiconductor conductivity, Electrogravimetry, conductivity,	6
	6	Electrochemical analytical techniques- Potentiometry	4
	7	Electrochemical analytical techniques- voltammetry and polarography, ion selective electrodes,	4
	8	Karl fischer titration, Electrochemical Sensors	2
	9	Electrochemical cells - Faraday's law, Clark cell, Weston cell, Electrolyzer cells, Water electrolysis	4
	Total		36
Suggested text/reference books	1. Electrochemical Energy Systems: Foundations, Energy Storage and Conversion by Artur Braun 2. Electrochemical technologies for energy storage and conversion by Ru-Shi Liu, et al		

Course code	**SET3506**		
Course title	**Energy Storage Devices**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Thermodynamics, Electrochemical technology		
Objectives of the course	This part of the course deals with the storage of energy primarily from electrochemical sources. It is intended to make the students aware of different types of energy storage devices available presently. At the same time the future prospects of the energy cells will be focused.		
Course title	**Detailed contents**		**Total contact h**
Energy Storage Devices	1	Definition of Primary and secondary battery	2
	2	Thermodynamics of electrochemical energy storage – reaction free energy and equilibrium cell voltage, terminal velocity, current-voltage diagram, Overcharge Reactions, Coulometric Efficiency and Energy Efficiency, Cycle Life and Shelf Life	8
	3	Aqueous Electrolyte Batteries- Materials and electrochemistry - Manganese Oxides, Nickel Hydroxides, Lead Oxides, Bromine-Storage Materials, Metal Hydride Electrodes	6
	4	Alkali Metal Batteries- Lithium Intercalation Cathode Materials for Lithium-Ion Batteries, Rechargeable Lithium Anodes, Lithium Alloy Anodes, The Anode/Electrolyte Interface, Liquid Nonaqueous Electrolytes. Materials for High-Temperature Batteries	8

	5	Fuel cells- Comparison of efficiency of the combustion engine and fuel cell, development of battery vehicles, Hydrogen fuel cell	4
	6	Variety of fuel cells, The proton exchange membrane fuel cell, Solid oxide fuel cell (SOFC), Electronic structure and conductivity of SOFC cathode materials	4
	7	Photoelectrochemical cells	4
	Total		36
Suggested text/reference books	1. Electrochemical Energy Systems: Foundations, Energy Storage and Conversion by Artur Braun 2. Electrochemical technologies for energy storage and conversion by Ru-Shi Liu, et al		

Course code	**SET3507**		
Course title	**Advances in Solar and wind energy**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Thermodynamics, Renewable energy, Heat transfer		
Objectives of the course	This part of the course deals with two most important renewable energy sources- solar and wind energy. This course focuses mainly on the progressive development of solar as well as wind energy. The future prospects of these two as sustainable energy forms will also be discussed.		
Course title	**Detailed contents**		**Total contact h**
Energy Storage Devices	1	Solar radiation – Geometry of collector and the solar beam, measurement of solar radiation	2
	2	Solar water heating- heat balance, different types of solar water heater, Social and environmental aspects, Concentrating Solar Power	4
	3	Photovoltaic generation- band theory, silicon p–n junction, current voltage characteristics, fabrication of silicon, thin film deposition	6
	4	Dye sensitized solar cells, quantum dot solar cells, organic solar cells, Perovskite solar cells,	6
	5	Wind energy: Turbine types, terms and theories	6
	6	Characteristics and power generation from wind energy	6
	7	Wind farm, small wind systems, Low frequency noise from wind turbines	6
	Total		36
Suggested text/reference books	1. Tushar K. Ghosh, Mark A. Prelas (eds.) - Energy Resources and Systems, Volume 2 2. John Twidell, Tony Weir - Renewable Energy Resources-Taylor & Francis		

Course code	**ST**		
Course title	**Special Lab – I- Energy Engineering**		
Scheme and Credits	**0 L: 0 T: 4 P 2 Credits**		
Pre-requisites	Special subject – Energy Engineering – Renewable and non-renewable energy basics		
Objectives of the course			
Course title	**Detailed contents**		**Total contact h**
Special Lab -I	1	Determination of flash point and fire point of petroleum cuts	4
	2	Determination of viscosity of petroleum cuts	4
	3	Determination of calorific value of a solid and liquid fuel	4

	4	ASTM distillation of diesel fuel	4
	5	Copper strip corrosion of liquid fuel	4
	6	Working principle of Solar, wind and hydraulic power generation – analysis of circuits	4
	Total		24
Suggested text/reference books			
Outcomes			

Course code	**ST**		
Course title	**Special Lab – 2- Energy Engineering**		
Scheme and Credits	**0 L: 0 T: 4 P 2 Credits**		
Pre-requisites	Special subject – Energy Engineering – Renewable and non renewable energy basics		
Objectives of the course			
Course title	**Detailed contents**		**Total contact h**
Special Lab -II	1	Performance analysis of Solar PV Electricity Generator	4
	2	Study of Solar Thermal Heater using the solar concentrator	4
	3	Performance analysis of Wind turbine electricity generator	4
	4	Estimation of calorific value of biomass versus petroleum	4
	5	Estimation of energy requirement for biomass fractionation	4
	6	To study the power storage of electrochemical cells	4
	Total		24
Suggested text/reference books			
Outcomes			

Petroleum and Petrochemicals

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SPT3302	SPT4302	Theory	Introduction to petroleum technology
2	SPT3403	SPT4403	Theory	Petroleum refining processes
3	SPT3404	SPT4404	Theory	Refinery engineering
4	SPT3506	SPT4506	Theory	Reservoir Technology
5	SPT3405	SPT4405	Theory	Petrochemicals technology
6	SPT3507	SPT4507	Theory	Industrial Catalysis
7	SPT3508	SPT4508	Theory	Petroleum economics and management
1	SPP3402	SPP4402	Laboratory	Petroleum Chracterization Laboratory-I
2	SPP3403	SPP4403	Laboratory	Petroleum Laboratory-II

				L	T	P	Total
Course code			**SPT4302**				
Course title			**Introduction to Petroleum Technology.**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Chemistry I & II, Physics I & II, Material and energy balance calculations, Mass transfer operations.				
Objectives of the course							
			To give students an overview of: Petroleum industry, its history, important petroleum product, there characterization and general refinery setup.				
Detailed contents							
	1		Introduction to petroleum and petrochemical industry, history of petroleum, Current Indian and global scenario, oil pricing, future trends and developments.	**2**	**1**		**3**
	2		Origin of petroleum, organic and inorganic theories of origin of petroleum, Kerogen composition, composition of crude oil, hydrocarbons and non-hydrocarbons present (type, functional groups, name, structure, role etc.), classification of crude oil.	**4**	**2**		**6**
	3		Introduction to refinery, Types of refineries: simple, intermediate and complex refineries, history and current status of Indian refineries, general refinery setup	**2**	**1**		**3**
	4		Major petroleum products (LPG, gasoline, kerosene, diesel, aviation turbine fuel, lube oil etc.,), their specification (Indian context), additives used to meet requirements and testing methods for petroleum products.	**2**	**1**		**3**
	5		Major petrochemical products, Feed stock for petrochemicals.	**4**	**2**		**6**
	6		Exploration: Geological, geophysical and geochemical methods of exploration, basin and exploration strategies, application of remote sensing in petroleum resource development, instruments used – principles and working; magnetometers, seismogram, radiation counters and gravimeters.	**4**	**2**		**6**

	7		Drilling: Drilling methods (vertical, deviated and horizontal), cable tool, rotary and turbo drilling, drilling equipment: Drilling rigs and drilling string, drilling fluid- composition and functions.	**2**	**1**		**3**
	8		Oil recovery: Well logging and well completion, well testing and control, free flow and gas lifting, mechanical pumping, primary oil recovery, secondary oil recovery and enhanced oil recovery methods, gravity drainage, water flooding.	**4**	**2**		**6**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Petroleum refining, Technology and Economics by J H Gary and G E Handwork.				
		2	The Chemistry and Technology of Petroleum by James G Speight,				
		3	Composition and properties of Petroleum by H J Neumann, B P Lahme and B Severin				
		4	Modern Petroleum Technology : G D Hobson and W Pohl				
		5	Modern petroleum refining processes by B K Bhaskara Rao				
Outcomes							
	CO1		Student will know the history and origin of petroleum.				
	CO2		Student will understand the importance of petroleum technology.				
	CO3		Student will know the specifications of various petroleum products.				
	CO4		Student will be able the list out different processes involved in petroleum refinery.				
				L	**T**	**P**	**Total**
Course code			**SPT4303**				
Course title			**Petroleum refining processes**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Chemistry I & II, Material & Energy Balance Calculations, Physical Chemistry, Introduction to petroleum technology.				
Objectives of the course			Students will learn the thermodynamics, kinetics, mechanism and process flow diagram of various refining processes used to improve the quality of different petroleum fraction.				
Detailed contents							
	1		Separation of oil and gas, pre-treatment methods, removal of moisture and salts, transportation and storage.	**2**	**1**		**3**
	2		Thermal cracking, thermal processing like visbreaking, delayed coking, fluid coking, flexicoking.	**4**	**2**		**6**
	3		Catalytic cracking: Cracking reactions, cracking catalysts, cracking units, fluidized bed catalytic cracking (FCC), new designs for FCC units.	**4**	**2**		**6**
	4		Hydrocracking and hydro-processing: Hydrocracking reactions, hydrocracking catalysts, hydrocracker unit, hydro-processor, hydrogen production and purification.	**4**	**2**		**6**
	5		Catalytic reforming: Reforming reactions, feed preparations, reforming catalyst, reactor design, catalytic reformer.	**4**	**2**		**6**

	6		Light end processes: Isomerization, alkylation and polymerisation.	**6**	**3**		**9**
			Total	**24**	**12**	**0**	**36**
Suggested books.							
		1	Petroleum Refining Engineering by W L Nelson.				
		2	Petroleum Processing, Principles and Applications by R J Hengstebeck.				
		3	Modern Petroleum Technology by G.D. Hobson				
Outcomes			Students will learn				
	CO1		to identify the process/technique to improve quality of given petroleum fraction.				
	CO2		Draw process flow diagrams/process block diagrams for any given refinery operation.				
				L	**T**	**P**	**Total**
Course code			**SPT4404**				
Course title			Reservoir Technology				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Introduction to petroleum technology, momentum transfer, mass transfer operations, Materials physics.				
Objectives of the course			To impart knowledge in the basic concepts like PVT analysis for oil, Material balance applied to oil reservoir, Darcy's law and applications, well inflow estimation for stabilized flow conditions.				
Detailed contents							
	1		Petroleum geology, types of rocks, sedimentary rocks, Oil and gas traps, migration and accumulation of oil and gas,	**4**	**2**		**6**
	2		Petroleum reservoir, properties of petroleum and gas in rocks, fundamentals of oil and gas flow in porous media. Natural gas and gas hydrates.	**4**	**2**		**6**
	3		Reservoir Fluids: Phase behaviour of hydrocarbon system, ideal & non ideal system, equilibrium ratios, reservoir fluid sampling, PVT properties determination, different correlations and laboratory measurements, data reduction, evaluation and application.	**6**	**3**		**9**
	4		Reserve estimation: resource & reserve concept, Different reserve estimation techniques	**4**	**2**		**6**
	5		Volumetric, MBE, decline curve analysis, latest SPE/ WPC/ IS classification, predicting reservoir performance, introduction to reservoir simulation.	**6**	**3**		**9**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Advanced Reservoir Engineering by T. Ahmed and P. McKinney.				
		2	Principles of Petroleum Reservoir Engineering by G.L. Chierici.				
		3	Applied Petroleum Reservoir Engineering by R.E, Terry, M. Hawkins and B.C. Craft.				
		4	Fundamentals of Reservoir Engineering by L.P. Dake.				
Outcomes			Students will				
	CO1		Do calculations on basic PVT analysis of the specific reservoir of various sands				
	CO2		Estimate the reserves of various sands of the reservoir from well data.				

	CO3		Understand the key concepts of petroleum geology.				

				L	**T**	**P**	**Total**
Course code			**SPT4403**				
Course title			**Refinery engineering**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Mass transfer operations, Separation processes, Heat transfer, Chemical reaction engineering, Petroleum refining processes..				
Objectives of the course			In this student will learn to apply their knowledge of mass transfer, heat transfer, equipment design and chemical reaction engineering to complex processes of petroleum refineries.				
Detailed contents							
	1		Design aspects of pipe still heaters, radiant and convection sections, calculation of heat flux, radius and number of pipes. Furnace design: Heat load calculations for furnace heaters, typical heat flux values, basic constructional features, different furnace types, factors to be considered in the design of fired heaters.	**3**	**2**		**5**
	2		Distillation curves: ASTM, TBP, EFV distillation curves; experimental details, their comparison and inter relations by Nelson and Edmister correlations. Multicomponent vapour liquid equilibrium, flash distillation, key components, dew point and bubble point calculations. Multicomponent distillation, calculation of number of stages in distillation, calculation of minimum reflux and number of plates, feed plate location.	**6**	**3**		**9**
	3		Atmospheric distillation tower: Types of refluxes, concept of overflash, overall material balance, estimation of top, bottom, side draw tray temperatures, energy balance for atmospheric distillation tower. Vacuum distillation tower: Type of operations, vacuum distillation column internals, flash zone and tower base calculations, flash zone pressure, steam requirements, heat and material balance calculations.	**6**	**3**		**9**
	4		Multicomponent liquid - liquid equilibrium relations, estimation of number of stages by triangular and rectangular diagrams for complex petroleum oils.	**3**	**1**		**4**
	5		Multicomponent absorption and stripping in refinery operations, absorption and stripping factors and their significance. Mathematical analysis of multi- component absorbers and strippers, Kremser-Brown absorption factor methods.	**3**	**2**		**5**
	6		Adsorption, breakthrough phenomena, concept of adsorption zone height, unsteady state fixed bed operation, LUB concept, design of absorbers. Sorbex technologies and its concepts.	**3**	**1**		**4**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Petroleum Refining Engineering by W L Nelson.				
		2	Petroleum Refinery Distillation by R.N.Watkins,				
		3	Refinery process modelling by G. L. Kaes.				

		4	Chemical Reactor Design and Process Plants, Vol I and II, H.F.Rase.				
		5	Heterogeneous Reactions, Analysis, Examples and Reactor Design, L. K. Doraiswamy and M. M. Sharma.				
Outcomes			Students will				
	CO1		Analyse multicomponent VLE data.				
	CO2		Perform multicomponent distillation calculation.				
	CO3		Carry out multicomponent liquid-liquid extraction.				
	CO4		Identify best reactor configuration for given process and design it.				
				L	**T**	**P**	**Total**
Course code			**SPT4405**				
Course title			**Petrochemicals Technology**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Chemistry I & II, Material & Energy Balance Calculations, Physical Chemistry, Introduction to petroleum technology.				
Objectives of the course			This course focusses on manufacturing processes of all important petrochemical products.				
Detailed contents							
	1		Chemicals derived from C1-C2. Chemicals from natural gas, naphtha etc. Principal reactions of Methane, ethane, ethylene and acetylene. Naphtha and gas cracking to produce C2-C4 olefins, dienes and aromatics.	**4**	**2**		**6**
	2		Chemicals from C3 and C4. Production of isopropanol, acrylonitrile, acrylic acid, propylene oxide, propylene glycol, polymers and copolymers of propylene, dehydrogenation of butane, production of MTBE, acetic acid from butene, butadiene from butane, maleic anhydride.	**4**	**2**		**6**
	3		Chemicals from high molecular weight n-paraffin: Oxidation of n-paraffin to fatty acids and fatty alcohols, chlorination and sulfonation of n-paraffin.	**4**	**2**		**6**
	4		Petroleum aromatics. Chemicals based on benzene, toluene and xylene (BTX), synthesis of ethylbenzene, phenol, aniline, nitrobenzene, chlorobenzene, styrene, cumine, benzoic acid, o-cresols, benzaldehyde, phthalic anhydride.	**4**	**2**		**6**
	5		Polymerization fundamentals, Ziegler Natta catalysts, polymerization of simple olefins such as ethylene and propylene. Synthetic rubbers, manufacture, general characteristics, raw materials for synthesis, range of synthetic rubbers, PBR, SBR, NBR, butyl rubber.	**2**	**1**		**3**
	6		Waxes - Introduction, History of waxes and their applications, definitions, classification- natural, partially synthetic and fully synthetic wax. Petroleum wax: Macro-crystalline wax (paraffin wax), microcrystalline wax, division into product classes of paraffin wax.	**2**	**1**		**3**
	7		Lubricating oils, specifications, characteristics, production of lube specialities, additives, refining of lubricating oil: solvent chemicals & hydrogenation method, dewaxing, deasphalting etc. Manufacturing of grease, manufacture of	**2**	**1**		**3**

			specialty oils viz. insulating oil, transformer oil, white oil, etc.				
			Total	**22**	**11**		**33**
Suggested books.							
		1	Fundamentals of Petroleum Chemicals Technology by P.Belov				
		2	Encyclopedia of Chemical Technology, Kirk-Othmer.				
		3	Ulmann's Encyclopedia of Industrial Chemistry				
		4	Dryden's Outlines of Chemical Technology				
		5	A Text Book on Petrochemicals, B.K.Bhaskara Rao.				
Outcomes			Students will				
	CO1		Draw process flow diagrams/process block diagrams for the manufacture of various petrochemicals from process description.				
	CO2		List out various alternatives for carrying out a particular process and provide recommendations for the best choice.				
				L	**T**	**P**	**Total**
Course code			**SPT4506**				
Course title			**Industrial Catalysis**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Chemistry I, II & III, Chemical reaction engineering I, Petroleum refining processes, Petrochemical technology.				
Objectives of the course			Objective of this course is to give students an overview of different types catalyst, their characterization, synthesis and application in petroleum refining and petrochemical synthesis				
Detailed contents							
	1		Catalyst - activation energy concept, types of catalysis, comparison of homogeneous & heterogeneous catalysis, enzyme catalysis, green catalysis, nano catalysis, phase transfer catalysis.	**2**	**1**		**3**
	2		Fundamentals of heterogeneous catalysts, steps in heterogeneous catalyzed reactions, different kinetic models, steric effects, electronic factors.	**2**	**1**		**3**
	3		Catalyst charecterization, SEM, TEM, XRD.	**2**	**1**		
	4		Redox catalysts, Acid/Base catalysts, Supported catalysts, Metal catalysts, bimetallic catalysts, promoters, inhibitors.	**4**	**2**		**6**
	5		Methods for synthesis of catalysts: precipitation, fusion and alloy leaching, sol -gel synthesis, hydrothermal synthesis, impregnation, coprecipitation, adsorption/ion exchange.	**6**	**3**		**9**
	6		Zeolite catalysts , composition and structure of zeolites, reactant selectivity, product selectivity, acidity of zeolites, Applications of zeolites in petroleum refinery and petrochemical synthesis.	**4**	**2**		**6**
	7		Catalyst deactivation, poisoning of metalic catalyst, oxides and solid acids, thermal processes and sintering, regeneration and recycling of heterogeneous catalysts.	**4**	**2**		**6**
			Total	**24**	**12**		**33**
Suggested books.							
		1	Handbook of Heterogeneous Catalysis by Gerhard Ertl, 2008				

		2	Concepts of Modern Catalysis and Kinetics, Second Edition. I. Chorkendorff, J. W. Niemantsverdriet				
		3	Elements of Chemical Reaction Engineering by H. Scott Fogler				
		4	Industrial catalysis: A practical approach by Jens Hagen				
Outcomes			Students will				
	CO1		understand importance of heterogeneous catalysis.				
	CO2		know different catalyst characterization techniques				
	CO3		Understand mass and heat transport phenomena occurring during catalytic reactions				
	CO4		learn different methods of catalyst synthesis				
				L	**T**	**P**	**Total**
Course code			**SPT4507**				
Course title			**Petroleum economics and management**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Introduction to petroleum technology, Petroleum refining processes, Petrochemical technology.				
Objectives of the course			To provide students with an understanding of global petroleum market, tools of economic analysis of petroleum project and key management concepts related to oil and gas industry.				
Detailed contents							
	1		Introduction to oil and gas industry: World oil and gas supply and demand, structure of oil and gas business, oil and gas reserves, crude oil pricing and volatility, Oil and gas industry value chain. International & National Institutions of Oil & Gas: API,OPEC, OECD, OIDB, DGH, PNGRB, CHT, PII, PPAC, PCRA.	**2**	**1**		**3**
	2		Indian oil and gas industry, oil resreves, Strategic Reserves concepts, crude oil import statistics, government policies and laws related to petroleum and petrochemical industry, petroleum contracts, Indian petrochemical market, major products, imort and export statistics for India, factors affecting pricing. Overview of major Indian oil & gas and petrochemical companies.	**2**	**1**		**3**
	3		Upstream economics: main challenges, Finding oil, access and development rights, leasing and exploration, key figures in upstream, players: IOC, NOC, Independents, contractors etc., reservoir management, upstream profitability, Midstream: Trading and crude transportation.	**4**	**2**		**6**
	4		Downstream economics : Refining and marketing, Refining economics: Current refining context, refining costs, refining margins and profitability. Sales and marketing of petroleum products, costing of major petroleum products: motor fuel, aviation fuel, lubricants, fuel oils, asphalts.	**3**	**1**		**4**
	5		Petrochemicals economics: Petrochemical products- base, intermediate and consumable products, petrochemical Industry structure, capital investement, Economic analysis of key processes: eg. olefine production, ethane	**4**	**2**		**6**

			cracking, LPG cracking. Marketing and distribution.				
	6		Oil and gas project management: Developemnt of project, joint developments, contractor relationships, cost management, partenership management, political risks, innovations and technology, fiscal regimes, financing and financial performance.	**3**	**1**		**4**
	7		Project Risk Analysis: Definition of risk, sources of project uncertainty, impact of government regulations, methods of risk analysis, managing attitudes towards risk, expected utility theory, assessing the utility function, risk premium and risk aversion.	**3**	**1**		**4**
	8		Recent advances, Future of the Global Oil and Gas Industry, analysis of petroleum alternatives for energy and speciality chemicals.	**2**	**1**		**3**
	9		Case studies.	**2**	**1**		**3**
			Total	**25**	**11**		**36**
Suggested books.							
		1	Fundamentals of Oil and Gas Accounting - Charlotte Wright				
		2	Petrochemical Economics: Technology Selection in a Carbon Constrained World by D. Seddon				
		3	The Global Oil & Gas Industry: Management, Strategy and Finance by Andrew Inkpen, Michael H. Moffett				
		4	Petroleum economics and engineering by Hussein K. Abdel-Aal, Mohammed A. Alsahlawi.				
		5	Project management for the oil and gas industry : a world system approach by Adedeji Badiru, Samuel Osisanya				
Outcomes			Students will				
	CO1		get knowledge of the role of oil and gas industry in global economy.				
	CO2		understand the key business issues related to energy markets, pricing, project finance, energy policy and geopolitical issues impacting the Oil and Gas industry.				
	CO3		be able to perform economics analysis for the petrochemical business				
	CO4		able to explain the fundamental concepts of oil and gas industrial Management				
				L	**T**	**P**	**Total**
Course code			**SPP4301**				
Course title			**Petroleum Characterization Laboratory-I**				
Scheme and Credits			**0L: 0T: 4P 2 Credits**				
Pre-requisites			Chemistry I, Introduction to petroleum technology.				
Objectives of the course			To apply various testing methods for assessing various properties of petroleum products.				
Detailed contents							
		1	Determination of vaporization characteristics of given petroleum product by ASTM distillation.				
		2	Determination of flash point and fire point.				
		3	Determination of diesel index of given petroleum sample.				
		4	Determination of carbon residue of given petroleum fraction.				

		5	Determination of drop point of given sample.				
		6	Determination of viscosity of given petroleum sample.				
		7	Determination of cloud point and pour point.				
		8	Determination of the smoke point.				
		9	Determination of calorific value of fuel by Bomb calorimeter.				
			Total				**48**
Suggested books.							
		1	Handbook of Petroleum Analysis by G.G Speight.				
		2	Modern petroleum refining processes by B.K. Bhaskara Rao.				
		3	ASTM Standard Manual				
Outcomes			Student will be able to				
	CO1		Describe the basic principles of different petroleum characterization techniques.				
	CO2		Suggest possible characterization techniques for given petroleum sample.				
	CO3		Strengthen the theoretical knowledge of petroleum products.				
				L	**T**	**P**	**Total**
Course code			**SPP4403**				
Course title			**Petroleum laboratory-II**				
Scheme and Credits			**0L: 0T: 4P 2 Credits**				
Pre-requisites			Refinery engineering, Petroleum refining processes, Simulation Lab I and II				
Objectives of the course			In this course students will enhance their knowledge of design and optimization of various refinery operations with the help of professional software				
Detailed contents							
		1	Determination of bromine number by color indicator method.				
		2	Determination of the penetration index of petroleum sample. Determination of Electrical strength of transformer oil.				
		3	Determination of water content by Dean and stark method.				
		4	Detection of copper strip corrosion of petroleum product.				
		5	Designing of debutanizer column using ASPEN				
		6	Designing of atmospheric distillation unit (ADU)				
		7	Designing of vacuum distillation unit (VDU)				
		8	Designing of naptha reformer				
		9	Designing of FCC unit				
			Total				**48**
Suggested books.							
		1	Distillation design and control using Aspen simulation by WL Luben				
		2	Process simulation and control using ASPENTM				
		3	ASPEN Manual				
		4	Handbook of Petroleum Analysis by G.G Speight.				
Outcomes			Student will be able to				
	CO1		Strengthen the theoretical knowledge of refinery operations design.				
	CO2		Be able to suggest possible characterization techniques for given petroleum sample.				

Course code	**SPT3201**		
Course title	**Special Subject I – Reservoir Technology**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Chemistry and Physics learnt at +2 level		
Objectives of the course	This is an introductory course in Petroleum Technology, which covers the chemistry of hydrocarbons, its formation and upstream processing.		
Course title	**Detailed contents**		**Total contact h**
Special Subject I	1	Introduction to oil and gas sector, Origin and occurrence of petroleum, History of petroleum in India and scope, Theories of formation, Geology of petroleum rock, Classification of rocks, Reservoir rock properties (porosity, permeability, wettability), Sedimentary rocks, Structure of traps for oil and gas	6
	2	Exploration techniques – surface and sub-surface methods (geological, geophysical, geochemical, etc.) Types of surveys, Remote sensing technology	4
	3	Drilling of oil well, Types of drilling, Drilling bits, Drilling fluid and its application, Cementing, fracturing of oil well, Completion and testing of oil wells, logging and primary recovery	8
	4	Well testing and production of crude oil, Free flow, Mechanical pump flow, Material Balance of reservoir	6
	5	Enhanced oil recovery, Water flooding, Chemical and Polymer Flooding, Microbial enhanced oil recovery, Secondary and Tertiary oil recovery	6
	6	Separation of oil and condensates, stabilization, desalting and dehydration, Transporting of crude oil, Classification of crude oil – physical properties (API, Sulfur content, UOP Characterization, etc.)	6
	Total		36
Suggested text/reference books	4. Fundamental Aspects of Petroleum geochemistry : Negi and Colombo 5. Modern Petroleum Technology : G D Hobson and W Pohl 6. An introduction to Physics and Chemistry of Petroleum : R R F Kinghorn 7. Reservoir Engineering Handbook: Tarek Ahmad		
Outcomes	Students will be able to • Understand the formation of crude oil inside the earth crust • Analyse the various sensing techniques to detect oil and gas reservoirs • Have the fundamental knowledge of drilling fluids and drilling techniques • Understand the various steps in production of crude oil from reservoir.		

Course code	**SPT3302**		
Course title	**Special Subject II – Fundamentals of Refineries**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Chemistry and Physics learnt at +2 level, Basic knowledge of petroleum formation and production		
Objectives of the course	This course will cover the various processes and products involved in refinery operation. Refinery operations includes physical separation, thermal operations (Cracking, coking, etc.) and catalytic upgradation of crude oil (Catalytic cracking, reforming, isomerization, polymerization, etc.).		
Course title	**Detailed contents**		**Total contact h**
Special Subject I	1	Brief review of Petroleum, Its composition, Non-hydrocarbon impurities, Characterization and classification of crude oil, Pretreatment methods, General refinery set-up and various processes	6

	2	Refinery product pattern, Fractionation concept, Atmospheric Distillation Unit, Vacuum Distillation Unit, Indian Specifications of important petroleum products and its testing methods	8
	3	Thermal processes to upgrade crude residues – Visbreaking, Thermal Cracking and Coking process. Their types and reactor configuration	8
	4	Catalytic processes to upgrade petroleum products – Catalytic cracking, Reforming, Isomerization, Polymerization, Hydrotreatments, etc.	10
	5	Finishing processes in modern refinery – blending, dewaxing, solvent extraction, etc. Application of advanced analysis techniques (UV, MS, IR, NMR, GLC, etc.) in petroleum and product analysis	4
	Total		36
Suggested text/reference books	8. Petroleum Refining Engineering : W L Nelson 9. Modern Petroleum Technology : G D Hobson and W Pohl 10. The Chemistry and Technology of Petroleum : James G Speight 11. Petroleum refining, Technology and Economics : J H Gary and G E Handwork		
Outcomes	Students will be able to • Understand the product pattern in the refinery based on supply and demand • Understand the various thermal and catalytic operations in refinery • Evaluate and analyse the petroleum product specifications • Analyse the need of Indian petroleum industry.		

Course code	**SPT3403**		
Course title	**Special Subject III – Fluidization Engineering**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Mass transfer operation, Heat transfer, Momentum transfer, Chemical reaction engineering		
Objectives of the course	This course will cover the fundamentals of fluidization and its application in various chemical/petroleum processes.		
Course title	**Detailed contents**		**Total contact h**
Special Subject I	1	The phenomenon of fluidization; Advantages and disadvantages of fluidized beds over packed bed and moving bed; Industrial applications of fluidized beds	4
	2	Characteristics of solids: Classification of solids; Flow characteristics and its outline in the different types of fluidization	4
	3	Flow pattern of fluidization system: Flow patter, flow pattern transition ,flow pattern map, Frictional pressure drop and its model to analyze, Solid movement, mixing, segregation and staging	8
	4	Gas distribution: Type of gas distributors in small and large scale industries, Design of distributor.	4
	5	Bubbling fluidized beds: Gas dispersion and gas interchange in bubbling beds, mixing characteristics	2
	6	Mass transfer phenomena: Particle togas mass transfer phenomena and its analysis by model in two and three phase system and modeling	4
	7	Heat Transfer phenomena: Heat transfer between fluidized beds and surfaces and modeling	4
	8	Design of fluidized bed reactors: Design for physical operation, catalytic and non-catalytic systems	6
	Total		36
Suggested text/reference books	12. Fluidization Engineering: D. Kunii and O. Levenspiel 13. Particle Technology and Engineering : Jonathan P.K. Seville Chuan-Yu Wu 14. Handbook of Fluidization and Fluid-Particle Systems: Wen-Ching Yang		
Outcomes	Students will be able to • Understand concept of fluidized bed		

	• Evaluate the types of fluidization based on particle properties as well as feed velocity • Analyse the need of fluidization in chemical as well as petrochemical industry. • Understand the working of various geometries of fluidizing bed

Course code	**SPT3404**		
Course title	**Special Subject IV – Introduction to Petrochemicals**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Basic knowledge of Chemistry at +2 level		
Objectives of the course	This course covers the fundamentals as well as state of art development in petrochemical industry.		
Course title	**Detailed contents**		**Total contact h**
Special Subject I	1	History and importance of Petrochemical industry, growth in India, Classification of Petrochemicals, Feedstock of the Petrochemicals, Preparation of feedstrock from ethane/ propane and naphtha/gas oil cracking, syngas.	6
	2	Petrochemicals from C1, C2, C3, C4 and Syngas Ethylene to ethylene oxide, ethylene glycol, ethanol amine; Propylene to acrylic acid, methyl ethyl ketone, acrylonitrile and Butenes to iso and n butanols, MIBK, MTBE	12
	3	Petrochemicals from BTX aromatics, naphathalene etc. Aromatics to maleic and phathalic anhydride, DMT, phenols and acetones	8
	4	Polymerization - polyethylene, polypropylene, synthetic rubbers etc.	4
	5	Hydration: Technologies for production of alcohols such as ethanol, isobutyl alcohol and higher alcohols. Esterification: Process for production of few esters such as acrylates, terephthalates, ester for flavoring industries etc.	6
		Total	36
Suggested text/reference books	15. Chemicals from Petroleum: A. L. Waddams, 16. Petrochemical Processes 1 & 2: Chauvel and B. Lefebvre 17. Introduction to Petrochemicals: S. K. Maiti		
Outcomes	Students will be able to • Understand petrochemical Industries, its requirement and usefulness • Understand and analyse the manufacturing of petrochemical feedstock • Understand the complexity in technology for different petrochemicals		

Course code	**SPT3405**		
Course title	**Special Subject V– CNG and LNG Technology**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Primary knowledge of Petroleum refining technology, Chemical Engineering Thermodynamics		
Objectives of the course	This course covers the essential treatments in utilizing natural gas as fuel		
Course title	**Detailed contents**		**Total contact h**
Special Subject I	1	Overview of natural gas industry, sources of natural gas, composition, properties and its classification	6
	2	Pretreatment processes for natural gas – hydrotreatment, dehydration, metal recovery, liquefaction, etc.	8
	3	CNG – Fundamentals, compression strategy, Thermodynamics, types of compressor, capacity, power calculations, storage, transportation and safety	12

	4	LNG – Pretreatments, liquefaction cycles, cost, storage, transportation and safety	10
		Total	36
Suggested text/reference books	18. Natural Gas Processing: A. Bahadori 19. Natural Gas Production Engineering: C. U. Ikoku 20. Fundamentals of Natural Gas Processing: L. L. Faulkner		
Outcomes	Students will be able to • Understand the scope of natural gas industry • Analyse the various pretreatment processes in natural gas industry • Understand the various thermodynamic cycles and processes for CNG and LNG		

Course code	**SPT3506**		
Course title	**Special Subject VI– Hydrotreatment Technology**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Primary knowledge of Petroleum refining technology, Chemical Reaction Engineering, Mass transfer operation.		
Objectives of the course	This course covers the role of hydrotreatments commonly used in petroleum refining		
Course title	**Detailed contents**		**Total contact h**
Special Subject I	1	Hydrotretments and types, pretreatment, quality improvement, product finishing treatment	4
	2	Source of hydrogen in refinery, process chemistry, purification and storage	4
	3	Hydrodesulfurization, process configuration, reactor types, catalysts, process parameters, feedstock preparation.	10
	4	Hydrocracking, commercial processes, catalyst, feed preparation, process parameters	10
	5	Hydrovisbreaking, Asphaltenic Bottom Cracking process	4
	6	Hydrotreatment for products, heteroatom removal such as sulfur and nitrogen	4
		Total	36
Suggested text/reference books	21. Modern Petroleum Technology : G D Hobson and W Pohl 22. The Chemistry and Technology of Petroleum : J. G Speight 23. Petroleum Refining Processs: J. G. Speight and B. Ozum		
Outcomes	Students will be able to • Understand the importance of hydro-processes petroleum industry • Analyse and understand the various processes in petroleum refining • Understand the complexity of refinery operations.		

Course code	**SPT3507**		
Course title	**Special Subject VII– Catalysis in Petroleum Industry**		
Scheme and Credits	**2 L: 1 T: 0 P 3 Credits**		
Pre-requisites	Chemical Reaction Engineering, Chemical Technology.		
Objectives of the course	This course covers the scope of catalyst in petroleum refining and petrochemical sector		
Course title	**Detailed contents**		**Total contact h**
Special Subject I	1	Introduction to catalytic processes in petroleum industry, types of catalyst, reaction mechanism of catalyst, catalyst testing, performance and regeneration, Catalysts promoters, Inhibitors, catalyst deactivations	4
	2	Zeolite synthesis reactions, unit cell structure, classification, acidity, and basicity in Zeolites, cation exchange dealumination and isomorphus substitution principles, Applications of Zeolites in catalysis and in separation processes- a few case studies	8

	3	Reforming Catalyst, Nobel metal catalyst, types, promoters, Inhibitors, catalyst deactivations	6
	4	Alkylation and isomerization catalyst, advancement in design from homogeneous to heterogeneous	4
	5	Catalysis for hydrotreatments, manufacturer, selectivity, promoters	4
	6	Vanadium based catalyst, polymerization catalyst, Ziegler Natta catalyst for petrochemicals	6
	7	New development in solid catalysis, monolith catalysts, Nano catalysts, Insitu characterization. simulation techniques	4
	Total		36
Suggested text/reference books	24. Modern Petroleum Technology : G D Hobson and W Pohl 25. The Chemistry and Technology of Petroleum : J. G Speight 26. Petroleum Refining Processs: J. G. Speight and B. Ozum		
Outcomes	Students will be able to • Understand the importance of catalysis petroleum industry • Analyse and understand the design of catalysis and its role in various processes • Understand the complexity of efficient catalyst development.		

Petroleum Product Testing Lab-1

1. Determination of flash point of petroleum sample (Able's and Pensky Martin Apparatus)
2. Determination of flash and fire point of petroleum sample (Cleveland Open cup apparatus)
3. Determination of API Gravity of petroleum fractions
4. Determination of Aniline point of a given sample
5. Determination of Cloud and Pour point of a given sample
6. Determination of Raid Vapor pressure of petroleum sample
7. Determination of ASTM distillation curve for the given petroleum sample

Petroleum Product Testing Lab-2

8. Determination of viscosity and viscosity index of a given petroleum sample using Redwood viscometer
9. Determination of carbon residue of a petroleum fraction using Codradson carbon residue apparatus
10. Determination of copper strip corrosion of a given sample
11. Determination of calorific value of a liquid fuel sample using bomb calorimeter
12. Determination of smoke point of a petroleum sample
13. Determination of water contamination in lube oil using Dean and Stark Apparatus
14. Determination of moisture content in a petroleum sample using Karl-Fisher apparatus

Materials and Polymers

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1	SMT3201	SMT4201	Theory	Introduction to Material Technology
2	SMT3302	SMT4302	Theory	Polymer science and Technology-I
3	SMT3403	SMT4403	Theory	Structure-Property Relationships
4	SMT3404	SMT4404	Theory	Polymer science and technology -II
5	SMT3405	SMT4405	Theory	Materials processing
6	SMT3506	SMT4506	Theory	Nanomaterials
7	SMT3507	SMT4507	Theory	Functional materials
1	SMP3303	SMP4303	Laboratory	Materials Characterization Laboratory
2	SMP3402	SMP4402	Laboratory	Materials processing and characterization laboratory

				Contact Hours			
				L	T	P	Tot
Course code			SMT4201				
Course title			**Introduction to Materials Technology**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Physics I & II, Chemistry I & II.				
Objectives of the course		**1**	Understand the basic principles of material science and engineering.				
		2	Apply various testing methods assessing mechanical, thermal and rheological properties of polymers.				
		3	Analyze the properties and applications of the materials.				
		4	Create basic platform for students to develop newer materials used in industry applications				
Detailed contents							
	1		Introduction to Materials: Thermoplastics, Thermosets, Elastomers, cellulose Polymer and Metal Composites., Smart and advanced materials	**2**	**1**		**3**
	2		Mechanical and Electrical Properties of Materials: stress-strain behavior, Tensile, Flexural and Impact properties, true stress and true strain, brittle and ductile materials, stress-strain curve of single crystal, hardness, creep, fatigue, mechanism to improve the mechanical properties and fracture properties. Electrical properties, conductivity, dielectric properties, Impedance technique	**4**	**2**		**6**
	3		Thermal Properties of Materials: Glass transition temperature (Tg), Melting temperature (Tm), Crystallization temperature (Tc), Heat distortion temperature (HDT) etc. Sample preparation, standardization, conditioning of sample, processability test, dynamic mechanical analysis, melt flow rate, Vicat softening temperature. Study of a dilatometer. Study of thermo-chemical analysis and differential scanning calorimeter.	**4**	**2**		**6**
	4		Surface Properties of Materials: Importance of surfaces and wear surface properties in engineering applications, X-ray diffraction spectrometry, scanning electron microscopy, travelling electron microscope, contact angle, surface energy, adhesion properties.	**4**	**2**		**6**
	5		Optical Properties of Materials: fundamentals of atomic theory of optical materials, quantum theory of optical materials,	**4**	**2**		**6**

			excitons and colour centers, classifications of optical materials, scattering, refraction, theory of refraction and absorption, reflection and transmission, introduction to Refractive Index, optical Density,.				
	6		Composite and Nanomaterial: Introduction, classification of the composite materials, particle reinforced composites, fiber reinforced composites, processing techniques for composite materials and applications. Synthesis of nanostructured materials, top-down approach-nanomaterials-synthesis, bottom-up process-synthesis of nanoparticles, vapor phase deposition, epitaxial techniques-synthesis of nanomaterials, chemical methods-nanomaterial synthesis, hybrid methods-synthesis of nanomaterials, nanotechnology and environment, properties and possible applications and storage.	**6**	**3**		**9**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Plastics Materials by J.A. Brydson,				
		2	Handbook of Industrial Chemistry: Organic Chemicals by Mohammad Farhat Ali,				
		3	Materials Science by V Rajendran,				
		4	Introduction to Material Science for Engineers by J F Shackelford.				
		5	Materials Science and Engineering: An Introduction by William D Callister.				
		6	SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc. by Berins, Michael L.				
		7	Handbook of Plastics Analysis, H. Lobo and J. V. Bonilla, Marcel Dekker.				
		8	Handbook of polymer Testing Roger Brown, Marcel Dekker Inc.				
		9	Instrumental Methods by Dyer.				
		10	Developments in Polymer Characterization by J. V Dawkins.				
		11	Engineering Material by R K Rajput				
		12	Materials Science by R.S. Khurmi, R.S. Sedha,				
		13	Materials Science by M S Vijaya and G Rangarajan				
Outcomes			Student will				
	CO1		Understand the various engineering materials knowledge.				
	CO2		Learn Various characterization techniques principle, mechanism.				
	CO3		Understand the significance of material science in domestic and engineering applications.				

				Contact Hours			
				L	**T**	**P**	**Tot**
Course code			SMT4302				
Course title			**Polymer science and Technology-I**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Chemistry I, II & III, Physics I & II, Material physics.				
Objectives of the course			To enable the students to understand the basic concept of polymer, its classification, mechanism of formation and various techniques of polymerization.				
Detailed contents							
	1		Historical developments in polymeric materials, Basic concepts & definitions : monomer & functionality, oligomer, polymer , repeating units, degree of polymerization, molecular weight & molecular weight distribution.	**2**	**1**		**3**
	2		Natural polymers, Chemical & Physical structure, properties, source, important chemical modifications, applications of	**4**	**2**		**6**

			polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins etc.				
	3		Classification of polymers thermoplastic/ thermoset, addition/ condensation, natural /synthetic, crystalline/amorphous, step growth /chain growth, ,commodity/specialty, homochain/ heterochain, confirmation: homo & copolymers, configuration cis/trans; tacticity, branched/ crosslinked, Classification of polymers based on end use etc.	**4**	**2**		**6**
	4		Techniques of polymerization: bulk, solution, suspension, emulsion, plasma etc. Different initiating systems such as free radicle polymerization, redox, cationic & anionic polymerization (different terms such as living polymers, inifers, telechelics). Their kinetics & control over structure of polymer.	**6**	**3**		**9**
	5		Condensation polymerization, different catalysts used, case studies of condensation polymerization, carothers equation, Comparison of these systems with advantages & disadvantages. Copolymerization, reactivity ratios & kinitics of copolymerization (copolymer composition equation).	**4**	**2**		**6**
	6		Evaluation and testing of polymers: molecular weight determination, thermal properties, viscosity of polymers and polymer solutions, electrical properties, mechanical properties, optical properties.	**4**	**2**		**6**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Polymer Science by Gowarikar, Johan wiley and Sons 1986.				
		2	Encyclopedia of Polymer Science and Technology, John Wiley and Sons, Inc 1965.				
		3	Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.				
		4	Introduction to Polymer Science and Technology, H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977				
		5	Handbook of polymer Testing Roger Brown, Marcel Dekker Inc, 1999.				
Outcomes			Students will				
	CO1		develop the knowledge of concept of polymers, their classifications and nomenclature.				
	CO2		be able to asses the kinetics and mechanism of free radical cationic and anionic polymerization.				
	CO3		be able to evaluate the mechanism and kinetics of copolymer free radical synthesis technique.				
	CO4		understand the techniques used for determination of various polymer properties like molecular weight, viscosity.				

				Contact Hours			
				L	**T**	**P**	**Tot**
Course code			**SMT4403**				
Course title			**Structure-Property Relationships**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Physics I & II, Material physics, Polymer science and technology I.				
Objectives of the course			To give students the comprehensive exposure of crystal structure, defects and their effect on material properties for engineering materials.				
Detailed contents							
	1		Basic crystallography and crystal structures, Bonding in materials and atomic packing in metals, co-ordination number concepts,	**2**	**1**		**3**

			Covalent bonding, glasses and polymers, Crystal defects and their significance				
	2		Phase diagrams, Solid solutions, Hume Rothery rules, Intermediate phases and compounds, Various phase reactions, Introduction to different phase diagrams, Lever rule, Cooling curve and its use for drawing phase diagrams.	**4**	**2**		**6**
	3		Thermal Properties: Lattice vibrations, Heat capacity, Thermal expansion, Thermal conductivity thermal stress in materials. Optical Behavior: Interaction of radiation with matter (metals and non-metals), Phosphorescence, luminescence and optical active materials, Structure property relationship in anisotropic media.	**6**	**3**		**9**
	4		General structural features of polymers: Effects of atoms types of bonds, bond dissociation energy and functional groups on properties of polymers	**2**	**1**		**3**
	5		Configuration & conformation and structure properties of polymers, Molecular mass heterogeneity and structure properties. Polymer solutions, thermodynamics of dissolution, Florry-Huggins theory.	**4**	**2**		**6**
	6		Polymer chain flexibility: concept of flexibility, various factors deciding flexibility of polymers, properties affected by flexibility. Intermolecular orders: Amorphous, crystalline and oriented forms of polymers, crystallinity of polymers.	**4**	**2**		**6**
	7		Thermal properties of polymers, Degradation and stabilization of polymers.	**2**	**1**		**3**
			Total	**24**	**12**	**0**	**36**
Suggested books.							
		1	Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 2006.				
		2	Callister, W.D., Materials Science & Engineering: An Introduction, Wiley & Sons, (2001)				
		3	Fundamentals of Materials Science-the microstructure-property relationship using metals as model systems, E.J. Mittemeijer, Springer, 2010				
		4	Polymer Structure, Properties and application, R.D. Deanin, American Chemical Society, 1974				
		5	Relating Materials Properties to structure, D. J. David, Technical Publishing Company Inc, 1999.				
		6	Polymer Solutions; Introduction to Physical Properties, Teraoka, Iwao, John Wiley and Sons. Inc, 2002.				
Outcomes			Students will				
	CO1		understand the importance of structure-property correlation study of materials and its suitable applications.				
	CO2		achieve ability to differentiate between different type of materials, and their structures.				
	CO3		able to explain the structural dependence of properties of materials.				

				Contact Hours			
				L	**T**	**P**	**Tot**
Course code			SMT4404				
Course title			**Polymer Science and technology -II**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Chemistry I, II & III, Physics I & II, Material physics, Polymer science and technology -I				
Objectives of the course			To enable students to learn about the general methods of preparation of individual class of plastics materials, their general properties, processing behavior and applications.				
Detailed contents							

	1		Engineering Polymers Polyesters such as PET, PBT, PTT, Polycarbonates, Polyacetal etc. Polyethylenes; modified polyethylenes, Polypropylene and copolymer of PP, modified Polyolefins.	**2**	**1**		**3**
	2		Thermoplastics: Styrenic polymers - Polystyrene, HIPS, SAN, ABS, Polymamides- Nylon 6, Nylon 6,6, Nylon 11, Acrylic polymers & copolymers, Polyvinyl chloride & its copolymers, Poly vinyl acetate, Modified cellulosics.	**6**	**3**		**9**
	3		Thermoset resins: Polyster resins, phenolic, Amino resins, Epoxy resins, Polyeurethanes, Alkyd resins, Thermosetting acrylics, Silicones thermoplastics and thermosets.	**8**	**4**		**12**
	4		Elastomers: Definition of elastomers, classifications of elatomers, Vulcanization, Synthesis of various rubbers natural rubber/ synthetic polyisoprene, Synthesis of various rubbers.	**4**	**2**		**6**
	5		Additives for polymers: Pigments, Plasticizers, Lubricants, Processing aids & various rheology modifiers, UV stabilizers, Impact modifiers, Flame retardants, nucleating agents, blowing agents, Cross linking agents and miscellaneous additives	**4**	**2**		**6**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Polymer Science by Gowarikar, Johan wiley and Sons 1986.				
		2	Encyclopedia of Polymer Science and Technology, John Wiley and Sons, Inc 1965.				
		3	Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.				
		4	Introduction to Polymer Science and Technology, H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977				
		5	Plastics Additive Handbook, Gachter and Mullar, Hanser Publishers, 1987.				
Outcomes			Students will				
	CO1		acquire skills in selecting additives for plastic materials for specific applications				
	CO2		have knowledge of manufacturing, properties and applications of resins, elastomers and theroplastics.				
	CO3		have knowledge of manufacturing, properties and applications of special purpose plastics				

				Contact Hours			
				L	**T**	**P**	**Tot**
Course code			**SMT4405**				
Course title			**Material Processing**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Material physics, Polymer science and technology I, Structural property relationship, Material science and engineering.				
Objectives of the course			To acquaint students with fundamental knowledge of material and polymer processing techniques which will be helpful in practical implementation of processing.				
Detailed contents							
	1		Introduction to material processing, macro, micro and nanostructures, Micro-structural evolution, Introduction to solidification, Stefan condition, Solidification in a thick mold.	**2**	**1**		**3**
	2		Interface resistance-limited solidification, Single crystal production, Introduction to binary solidification, Zone refining, Solidification with finite diffusion in liquid, Plane front single phase solidification, Plane front poly phase alloy solidification, nucleation and growth kinetics, Engineering binary alloy microstructures.	**4**	**2**		**6**

	3		Sand casting, lost foam & cooled molds, Molding sand- types, properties and testing, Molding – types, equipment's, tools and machines.	**2**	**1**		**3**
	4		Metal Forming Processes, Material behavior in metal forming, strain rate sensitivity, friction and lubrication in metal forming, Rolling, Forging, extrusion.	**2**	**1**		**3**
	5		Joining processes, Welding, Arc welding, Stud welding. Resistance welding, Gas welding, Soldering, brazing and braze welding, Joint through Adhesive. Sheet metal working. Introduction to powder processing, Sintering, slurry processing, colloid processing.	**4**	**2**		**6**
	6		Polymer processing: Extruders, single screw and twin screw extruders, Film blowing, coextrusion of multilayred films, Fiber spinning, Pipe extrusion, Extrusion of profiles, coextrusion of pipes, Extrusion of cable material, extrusion of sheet, Calendaring, Thermoforming.	**4**	**2**		**6**
	7		Polymer Molding, Injection molding Blow molding, Compression molding, Injection stretch blow molding, Resin transfer molding, Gas and water assisted injection molding and other three dimensional molding.	**4**	**2**		**6**
	8		Fillers and reinforcement, Polymer composites such as DMC, SMC, FRP etc. using fillers reinforcement and other polymeric fillers.	**2**	**1**		**3**
			Total	**24**	**12**		**36**
Suggested books.							
		1	J. T. Black – Degormos Materials and process in manufacturing – John Willey and sons, 2019				
		2	Materials Science and Engineering, Raghavan V.				
		3	Chester T. Sims, Williams C. Hagel: The Super Alloys, John Wiley & Sons, 1992.				
		4	Fundamentals of Polymer Processing, S. Middleman, Houghton Mifflin Compony, 1997.				
		5	Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.				
		6	Polymer Processing Fundamentals, Osswald, A. Tim, Hanser Publishers, 1998.				
Outcomes			Student will				
	CO1		understand the different materials processing techniques.				
	CO2		understand the basics of Microstructural aspects with the different processing of materials.				
	CO3		able to design and develop the functionally gradient materials for desired application				

				Contact Hours			
				L	**T**	**P**	**Tot**
Course code			SMT4506				
Course title			**Nanomaterials**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Physics I & II, Material physics, Material science and engineering, Structure property relationship.				
Objectives of the course			To give students the comprehensive exposure of nanomaterials, their properties, synthesis methods, charecterization techniques and applications				
Detailed contents							
	1		Introduction to nanomaterials, forces at nanoscale, scaling laws, surface effects and physical properties of nanomaterials, electrical, magnetics and optical properties of nanomaterials.	**4**	**2**		**6**

	2		Overview of nanstructures and nanomaterials, Atomic bonding, Multiscale hierarchy, self assembly, Isotropic and anisotropic nanoparticles, one, two and three-dimensional nanomaterials, quantum dots, nano rods, nanowires, core shell nanoparticles etc.	**4**	**2**		**6**
	3		Synthesis techniques of nanomaterials: Top-down synthesis method (ball milling, nanolithography), Bottom-up synthesis method (sol-gel, soft chemistry, self assembly, inkjet printing, scanning probe techniques), Nucleation, growth and agglomeration of nanoparticles.	**4**	**2**		**6**
	4		Carbon based materials, Silicon nanomaterials, Metal nanomaterials, Metal oxide nanomaterials, Nanocomposites, Biological nanomaterials, Nanomachines and Nanodevices (FETs, MOSFETs, Logic Devices, nanosensors, imaging and display devices), Nanomaterials in energy, Safety issues in nanomaterials	**4**	**2**		**6**
	5		Applications of nanomaterials: Ferroelectric materials coating, molecular electronics, nanoelectronics, biological and environmental, membrane based, nano optics, biomedical applications, drug delivery system, photovoltaic, fuel cell, batteries, nano sensors and devices.	**4**	**2**		**6**
	6		Charecterization of nanomaterials: Scanning electron microscope (SEM), atomic force microscopy (AFM), FESEM, TEM, STM, SPM, diffraction and scattering techniques, vibrational spectroscopy, x-ray diffraction (powder diffraction method), Three Dimensional atom probe (3DAP), particle size measurement techniques like DLS, DCS etc.	**4**	**2**		**6**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Chemistry of Nanomaterials: synthesis, properties and applications- CNR Rao, Achim Müller, A. K. Cheetham, Wiley VCH 2004				
		2	Nanotechnology, By Lynn E. Foster, Pearson 2011				
		3	The physics and chemistry of nanomaterials- Frank J. Owens and Charles P. Poole Jr. Wiley interscience 2008.				
		4	Introductory Nanoscience, by Masuro Kuno, Garland Science 2011				
		5	Fundamentals and Applications of Nanomaterials, by Z. Guo and Li Tan				
		6	Hand Book of Nanoscience and Engineering and Technology- W. Gaddand D. Brenner, S. Lyshers Ki and G. J. Infrate-, CRC press 2002.				
Outcomes			Students will				
	CO1		Understand the basics of nanomaterials and nanotechnology.				
	CO2		able to suggest charecterization technique for the nanomaterials				
	CO3		identify the applications of nanomaterials and nanotechnology in various fields.				

				Contact Hours			
				L	**T**	**P**	**Tot**
Course code			**SMT4507**				
Course title			**Functional materials**				
Scheme and Credits			**2L: 1T: 0P 3 Credits**				
Pre-requisites			Physics I & II, Material physics, Material science and engineering, Structure property relationship, Nanomaterials.				
Objectives of the course			To give students the exposure to newer functional materials used in domestic and industry applications.				
Detailed contents							

	1		Introduction to functional materials: Definition of functional materials, Types of functional material.	**2**	**1**		**3**
	2		Biomaterials: Introduction to biomaterials for biomedical applications, chemical structure and property of biomaterials, Degradation of biomaterials, Polymeric biomaterials: Introduction, preparation, hydrogel biomaterials, Bio conjugation techniques, Biocompatibility, Biomaterials implantation, Evaluation of biomaterials, Nano-biomaterials, Biomaterials for imaging and diagnosis, Cell-Biomaterials interaction, Biomaterial and tissue engineering.	**4**	**2**		**6**
	3		Soft & Hard magnetic materials and their applications, DC, low frequency, RF, microwave and recording applications of magnetic oxides and alloys; CMR Materials, Magneto caloric materials and spin glasses, Super paramagnetism, Ferrofluid Magneto electronics. Recent developments in the applications of Magnetic Materials, Functionalised magnetic nanoparticles.	**4**	**2**		**6**
	4		Conducting Polymer Sensors, Actuators and Field-Effect Transistors: Introduction, Synthesis of Conducting Polymers, Conducting Polymer Gas Sensors, Electrochemical Actuators, Conducting Polymer FETs.	**4**	**2**		**6**
	5		Ferroelectric crystals and applications, Relaxor Materials, Spintronic: Spin polarization and application, Piezoelectrics for energy harvesting applications, Materials for optoelectronic devices: solar cells & OLED's	**4**	**2**		**6**
	6		Energy materials: Polymer electrolytes, Solar energy materials, hydrogen storage materials, electroceramics for batteries, fuel cells and sensors.	**4**	**2**		**6**
	7		Nuclear Materials: Materials for nuclear reactors such as fuels, moderators, control rods, coolants, reflectors and structural materials. Fabrication of fuel and cladding materials	**2**	**1**		**3**
			Total	**24**	**12**		**36**
Suggested books.							
		1	Functional Materials by S. Banerjee, A.K. Tyagi, 1st edition, imprint by elseiver				
		2	Smart materials and structures. By M. V. Gandhi and B. S. Thompson, Chapman and Hall, London 1992.				
		3	Energy Materials by Duncan W. Bruce, Dermot O'Hare, Richard I. Walton, John Wiley & sons, 2011.				
		4	Handbook of Advanced Materials: Enabling New Designs by James K. Wessel, John Wiley & sons, 2004.				
Outcomes			Students will				
	CO1		acquire detailed knowledge of different advanced functional materials.				
	CO2		identify the functional materials suitable for given applications.				

				Contact Hours			
				L	**T**	**P**	**Tot**
Course code			**SMP4301**				
Course title			**Material Physics laboratory**				
Scheme and Credits			**0L: 0T: 4P 2 Credits**				
Pre-requisites			Physics, Physics II and Material Physics.				
Objectives of the course			To apply various testing methods for assessing the mechanical, thermal, electrical and optical properties of materials.				
Detailed contents							
		1	To find the Young's modulus of given material.				

		2	To estimate the Dielectric constant and curie temperature of given sample.				
		3	Characterization of photoresistors (LDR characterization).				
		4	Evaluation of moisture content.				
		5	Measurement of contact angle and surface energy using surface Goniometer.				
		6	Hardness measurement using Durometer.				
		7	Solar cell characterization.				
		8	Determination of Refractive index of given liquid using travelling microscope.				
		9	Four probe method for Band gap measurement.				
		10	B-H Characterization of given sample.				
			Total				**48**
Suggested books.							
		1	Handbook of Plastics Analysis, H. Lobo and J. V. Bonilla, Marcel Dekker.				
		2	Instrumental Methods by Dyer.				
		3	Handbook of polymer Testing Roger Brown, Marcel Dekker Inc.				
Outcomes			Student will				
	CO1		Able to carry out appropriate characterization of given material sample.				
	CO2		Identify the application of engineering materials and physical properties.				
	CO3		Strengthen the theoretical knowledge of material physics.				

				L	**T**	**P**	**Tot**
Course code			**SMP4402**				
Course title			**Materials processing and characterization laboratory.**				
Scheme and Credits			**0L: 0T: 4P 2 Credits**				
Pre-requisites			Polymer science and technology I, Structural property relationship, Material science and engineering.				
Objectives of the course			To acquaint students practical knowledge of polymeric material processing techniques and charaterization.				
Detailed contents							
		1	Compounding of Polymeric material using two roll mill				
		2	Compounding of Polymeric material using compressing molding				
		3	Injection Molding				
		4	Melt compounding and processing of Polymeric materials using twin screw extruder				
		5	Electrospinning				
		6	Physical Vapor Deposition (PVD)				
		7	Sintering				
		8	Chemical methods of Polymeric materials by Fourier Transform Infrared Spectrophotometer (FTIR)				
		9	Structure analysis of Polymeric materials by X-Ray Diffraction (XRD)				
			Total				**48**
Suggested books.							
		1	Polymer Processing Fundamentals, Osswald, A. Tim, Hanser Publisher, 1998.				
		2	Polymer Processing and Characterization, Sabu Thomas, AAP, 2012.				

		3	Polymer Extrusion by Chris Rauwendaal, Carl Hanser Verlag GmbH & Co, 3rd Revised edition, 1994				
Outcomes							
	CO1		Able to handle processing techniques of given material sample.				
	CO2		Identify the application of engineering materials and physical properties.				
	CO3		Able to carry out appropriate characterization of given material sample.				

Textiles

SP #	Course Code (IOCB)	Course Code (MARJ)	Type	List of Subjects
1			Theory	
2			Theory	
3			Theory	
4			Theory	
5			Theory	
6			Theory	
7			Theory	
1			Laboratory	

Course Code: STT3201	Course Title: Technology of Fibres and Polymers	Credits = 4		
		L	T	P
	Total contact hours: 36	2	1	0

Students will have better understanding of different natural and synthetic fibres, their properties as well as important concept of polymer chemistry which will help in manufacturing as well as designing processing parameters.

Sr No.	Course Contents (Topics and subtopics)	Reqd. hrs
1	Introduction to textile fibre as polymer, Fibre forming characteristics of polymers, Definition of various basic textile terms, Introduction to Fibre, Yarn, Fabric,Classification of fibres based on sources of origin and on chemical	4
2	Natural fibres of plant, animal and mineral origin, chemistry, morphology, physical and chemical properties, structure property relationship with application, commercially important fibres like cotton, jute, linen, bamboo, wool, silk etc., Fibre to fabric conversion steps.	8
3	Semi-synthetic fibres such as viscose rayon, cuprammonium rayon, acetate rayon, bamboo rayon and lyocell with respect to chemistry, manufacturing process, morphology, physical and chemical properties and structure property relationship with applications.	4
4	Synthetic fibres such as polyester and its variants, polyamides, acrylic, polypropylene, etc with respect to their raw materials, synthesis, manufacturing processes including LOY, FOY, POY, FDY, draw ratio, physical and chemical	10
5	General polymer chemistry; Classification of polymers, synthesis and mechanism, Techniques of polymerization.	4
6	Types of polymeric Molecular weight and its determination.	2
7	Microstructure of polymers, Fibre modification through texturization, TiO2 and chemical modification (using co monomer, other monomers and grafting), Brief idea about polymer composites; Polymer waste and techniques of utilization	4

List of Text Books/ Reference Books

1	Textile Fibres-I, Mathews, J.M, 4th edition, 1924.
2	Textile Chemistry, Peters R.H, Vol-1, Elsevier Publishing Company, London, 1963.
3	Man-made Fibres, Moncriff, R.W., Newnes Butterworth, London, 6th edition, 1965.
4	Man-made Fibres, Moncriff, R.W., Butterworth Science, London, 6th edition, 1975.

5	Textile Fibres, Shenai V.A., Vol-1, Sevak Publications, Bombay, 3rd edition, 1991.
6	Joseph's Introductory Textile Science, Joseph, M.L., Hudson P.B., Clapp A. C., Fortworth: Harcourt Brace Jovanovich College Publication, 6th edition, 1993.
7	Microscopy of Textile Fibres, Greaves, P.H., Saville B.P.Oxford : BIOS Scientific Publishers Ltd., 1995.
8	Modern Textile Characterization Methods, Raheel, M. Marcel Dekker Inc., New York, 1996.
9	Handbook of Fibre Chemistry, Lewin Menachem, Eli M. Pearce, Marcel Dekker Inc., New York, 2nd edition, 1998.
10	Mishra, S. P. A Text Book of Fibre Science and Technology. India: New Age International,
11	Ghosh, P. . Fibre Science and Technology. United States: McGraw Hill Education (India) Private Limited, 2004
11	Kothari, V. Manufactured Fibre Technology. Netherlands: Springer Netherland, 2012
13	Natural Polymer man-made Fibres, Carrol and Porczynski C.Z., National Trade Press Ltd., London,1965
14	Visco-Elastic Properties of Polymers, Ferry, J.D., John Wiley and Sons, New York, 3rd
15	Textbook of Polymer Science, Billmeyer F.W., John Wiley and Sons, New York, 3rd edition, 1984.
16	Polymer Science, V R Gowarikar, New Age international (P) Ltd Publications, New

Course Outcomes (students will be able to…..)

1	**Understand** fibre forming properties with different textile terms as well as their classification (K4).
2	**Acquire** deeper understanding and insights in basic chemistry, production processes and physical and chemical properties of Natural and Synthetic fibers. (K2).
3	**Understand** different areas of applications of these fibres vis a vis their properties. (K4).
4	C**omprehend** fundamental knowledge of polymers, their classifications, as well as techniques and mechanism of polymerization(K2).
5	D**escribe** chemical and physical methods used for fibre modification and recycling. (K2)

Course Code: STT3302	**Course Title:** Technology of Textile Dyeing	**Credits = 4**		
		L	**T**	**P**
	Total contact hours: 36	**3**	**1**	**0**

Student will understand the importance and relevance of textile coloration, the problems and remedies to solve them, the developments in machinery with respect to growth of industry, the quality of dyed textiles and environmental relevance of dyeing processes

Sr.No.	**Course contents (topics/subtopics)**	**Required hrs**
SECTION I		
1	Physical and chemical characteristics of textile fibres in relation to dyeing, Pretreatments of textiles and quality of water in relation to dyeing	2
2	Parameters of quality dyeing, machines used and terms used; Classification of dyes based on application, Performance characteristics of dyed textiles	2
3	Earlier developments in processes and machinery for dyeing of textiles in various forms such as fibres, yarns, woven and knitted fabric	2

4	Dyeing of cellulosic fibres with Direct, Azoic, Vat, Solubilized Vat, Sulphur, Oxidation colours and OBA's	4
5	Dyeing of polyamide fibres with Acid, Mordant and Metal Complex dyes	2
6	Dyeing of Acrylic with Basic and modified cationic dyes	2
7	Dyeing of Indigo and Natural dyes	2
8	Dyeing of Polyester with Disperse dyes	4
9	Dyeing of Cellulosics with Reactive dyes	2
10	Dyeing of blends, Dyeing of union fabrics; Dyeing of micro fibre fabrics	2
11	Batch, semi-continuous and continuous type dyeing machinery for all forms of textiles.	4
12	Dosing systems for dyeing, automatic colour and chemical dispensing systems, automated inventory management systems for dyes and chemicals	2
13	Right First Time approach, Faults in dyed materials and their correction. (4) (14)	2
14	Machinery used for washing and soaping of dyed materials, Recent developments in machinery and dyeing techniques	2
15	Concept of conservation of chemicals and water in dyeing	2

List of Text Books/ Reference Books

1	The Theory and Practice of Wool Dyeing, Bird, C.L., SDC Publ., Bradford, 1972
2	Chemical Processing of Synthetic Fibres and Blends by K V Datye and A A Vaidya, John Wiley and Sons, New York, 1984
3	Wool Dyeing by D M Lewis, SDC Publication, 1992
4	Batchwise Dyeing of Woven Cellulose Fabric by John Shore, SDC Publ., 1993
5	Colour for Textiles-User's Handbook, W. Ingamells, SDC Publ., 1993
6	Technology of Dyeing, Shenai V.A., Vol. 6, Sevak Publication, Bombay, 1994.
7	Cellulosic Dyeing by John Shore, SDC Publ., 1995
8	Blends Dyeing by John Shore, 1998
9	Handbook of Synthetic Dyes and Pigments, K.M.Shah, Multitech Publishing, 1998.
10	Reactive Dyes for Textile Fibres, A. Hunter and M. Renfrew, SDC Publ., 1999.
11	Basic Principles of Textile Coloration by A D Broadbent, SDC Publ., 2001
12	Synthetic Fibre Dyeing by C Hawkyard, SDC Publ., 2004

Course Outcomes (students will be able to.....)

1	Understand the importance of various textile processing parameters for quality dyeing. (K1)
2	Identify the correct process to be carried out based on type and form of the substrate (K2)
3	Explain the developments in dyes, machinery and processes in tune with constantly changing requirements of the industry (K2)
4	Analyse the quality of dyeing and suggest corrective measures. (K4)
5	Design the process for dyeing of novel fibres and blends based on its physico-chemical characteristics. (K4)

Course Code: STT3403	Course Title: Technology of Textile Printing	Credits = 3		
		L	T	P
	Total contact hours: 36	2	1	0

The course will make student to understand printing as one of the most versatile method of colouration of textiles and its significance in value addition of textiles.

Sr. No.	Course contents (topics/subtopics)	Req. hrs.
	SECTION I	
1	Introduction to various colouration technics, Stages in printing of textiles, History of textile printing.	4
2	Preparation of print paste, functions of various ingredients of print paste, Various Natural, modified and synthetic thickeners, classification of thickeners, Preparation of stock thickening, Selection of thickening agents based on dye class, style and method, Rheology of printing pastes	6
3	Three Basic styles of Printing and various special styles of printing	4
4	Methods of Printing, Block, stencil, Screen; hand screen, flat bed, rotary, Roller, Transfer and digital printing, Defects and remedial actions in various methods of printing, Machines used for printing, Brief idea about preparation of block, stencil, flat and rotary screens, rollers for printing.	6
5	Various methods of fixation, Selection of fixation method, Machines for fixation and its working; various after treatment of printed materials.	4
6	Printing of Cellulosics, polyamides, polyester and acrylic with different dyes. Printing of blended fibre/fabrics Special printing techniques; Printing of velvet, carpets and knits	6
7	Evaluation of printed fabrics, Ecological aspects in printing of textiles; Recent developments in printing machinery and techniques;	6

List of Text Books/ Reference Books

1	Dyeing and Printing, Cockett S.R., Hilton K.A., Leonard Hill Books Ltd., London, 1961.
2	Introduction to Textile Printing, W. Clarke, Newness Butterworths, London, 4th edition, 1977.
3	Guide to Printing Techniques, Naoharu Oyabu, Mahajan Brothers Publish Ltd., Ahmedabad, 1978.
4	Technology of Printing, V. A. Shenai, Sevak Publications, Bombay, Vol. 4, 1990.
5	Textile Printing by L. W. C. Miles, revised second edition published by SDC, 2003
6	Design and Printing Textiles by June Fish, 2005
7	Digital Printing of Textiles by H. Ujiiye, Woodhead Publishing Series in Textiles, 2006
8	Dyeing and Screen-Printing on Textiles by Joanna-Kinnersly Taylor, Revised and Updated, 2012.

Course Outcomes (students will be able to.....)

1	**Comprehend** fundamental knowledge on stages of printing (K2)

2	**Describe and use** different types of printing methods and styles, fixation conditions, after treatments used for printing. (K3)
3	**Identify and evaluate** thickening agents, chemicals and dyestuffs for printing; Formulation and rheological properties of printing pastes(K4)
4	**Evaluate** quality of printed goods and suggest remedial actions to overcome faults in printing (K4)
5	**Comprehend and apply** the recent developments in the machinery techniques and special printing techniques. (K3)

Course Code: STT3404	**Course Title:** Chemistry & Applications of Specialty Chemicals	**Credits = 3**		
		L	**T**	**P**
	Total contact hours: 36	**2**	**1**	**0**

The course will provide student deep understanding about the role of different functional groups on the properties of various specialty chemicals used in different industries.

Sr. No.	**Course contents (topics/subtopics)**	**Reqd Hrs**
1	Nomenclature, functions and classification of textile auxiliaries	2
2	Surface activity phenomenon, Surfactants and their chemistry and applications.	2
3	Anionic Surfactants: Properties and uses of anionics from carboxylic acids, alkylaryl sulphonates, alkyl sulphates, alkane sulphonates and phosphate esters, etc.	4
4	Cationic Surfactants: Chemistry, Properties and applications	2
5	Nonionic Surfactants: Chemistry, Properties and applications	2
6	Processing Aids: The structure property relationships of Antimigrants, Defoamers, Dyeing Assistants, Enzymes in Preparation, Lubricants, Peroxide Stabilizers, Printing Binders, Surfactants (Scouring and Wetting Agents), Thickeners Warp Sizes	6
7	Performance Enhancers: The structure property relationships of Antimicrobial Finishes, Antipilling Agents, Antistatic Agents, Durable Press Agents, Dye Fixatives, Elastomeric Finishes, Enzymes in Finishing, Flame Retardants, Hand Modifiers (Softeners and Hand Builders), Repellent Finishes, Soil Release Agents, Stain blockers and Ultraviolet Absorbers	6
8	Qualitative and quantitative evaluation of auxiliaries; Testing of surfactants, detergency, identification of ionic nature.	4
9	Biodegradability of surfactants	2
10	Banned chemicals in pretreatments, Natural textile auxiliaries	3
11	Recent developments in textile auxiliaries	3

List of Text Books/ Reference Books

1	Textile Chemicals and Auxiliaries, Speel H.C., Reinhold Processing Corporation, New York, 1952
2	Textile Auxiliaries, Batty, J.W., Dergamon Press, Oxford, 1967.
3	Colourants and Auxiliaries: Organic Chemistry and Application Properties, Shore, J., SDC, Bradford, 1990.
4	Laundry Detergents, Smulders, E., Wiley VCH, Weinheim, 2002.
5	Chemistry and Textile Auxiliaries, Shenai V.A., Vol. 65, Sevak Publication, Bombay, 2nd edition, 2002.

6	Textile finishing, D. Heywood, ed., Society of Dyers and Colourists, Bradford, England, 2003
7	Chemical finishing of textiles, W.D. Schindler and P.J. Hauser, Woodhead Publishing, Cambridge, England, 2004
Course Outcomes (students will be able to.....)	
1	**Understand** fundamental of textile auxiliaries. (K1)
2	**Describe** the role of surfactants in textile and their different types (K2)
3	**Write** synthesis of important textile auxiliaries (K2)
4	**Evaluate** surfactants and identify the ionic nature. (K3)
5	**Explain** biodegradability of surfactants and eco-friendly textile auxiliaries. (K2)

Course Code: STT3405	**Course Title:** Technology of Finishing	**Credits = 4**		
		L	**T**	**P**
	Total contact hours: 36	**3**	**1**	**0**

This course will help students understand effect of various mechanical and chemical finishes in terms of imparting desired functionality to meet the end use application.

	Course contents (topics/subtopics)	**Required hrs**
1	Objective of textile Finishing and type of finishing techniques.	2
2	Mechanical finishes like Calendaring, raising, sueding, crabbing, potting, compacting, sanforising, pressing, etc and machinery involved.	4
3	Heat setting of synthetic fabrics; Machinery used and principle involved.	4
4	Drying equipment; stenters, vertical drying ranges, curing ranges. Process control systems to enhance efficiency of drying.	4
5	Evaluation and durability of mechanical finishes	2
6	Chemical finishing – conventional softeners, stiffeners, binders, weighting agents, silicone finishes. Machinery involved in finishing of Yarn, Knit, Woven, Denim, Terry towel, Garments	5
7	Effect finishes - wrinkle resistance, wash and wear, and durable press properties of fabrics; different technologies for resin finishing- Pad-dry cure and Moist cross linking, machinery involved.	4
8	Functional finishes - antibacterial, flame retarding, water/oil repelling, soil release, antistatic finishes, Moisture management, UV Protection, Cellulase Bio Polishing etc.	8
9	Performance evaluation of conventional and effect finishes.	3
List of Text Books/ Reference Books		
1	Textile Finishing, Hall A.J., Heywood book, London, 1966.	
2	An Introduction to Textile Finishing, Marsh J.T., B.I. Publication, Bombay, 1979.	
3	Technology of Finishing, Shenai V.A., Vol. 10, Sevak Publication, Bombay, 1990.	
4	Handbook of Fibre Finish Technology, Slade, P.E., Marcel, New York, 1998.	
5	Encyclopedia of Textile Finishing, Rouette, H.K., Springer Verlag, New York, 2001.	

6	Chemical Finishing of Textiles, Schindler, W.D and Hauser P.J., Woodhead, 2004
7	Principles of Textile Finishing, Choudhury A. R, Woodhead Publishing, 2017
8	Textile Finishing; Recent Developments and Future Trends, Mittal K.L., Scrivener Publishing, 2017
Course Outcomes (students will be able to.....)	
1	**Explain** different methods and machineries available for application of finish and calculate finish add on onto fabric (K2)
2	**Describe** different types of softeners, fastness improving agents , antimicrobial, antistatic, flame retardant, their chemistry, application on fabric and evaluation tests (K2)
3	**Determine** use of appropriate machine and process parameters for finishing(K3)
4	**Compare and choose** various mechanical and thermal process control systems to enhance efficiency of drying and heat setting (K4)
5	**Explain** different methods for evaluation and durability of finishes. (K2)

Course Code: STT3507	**Course Title:** Effluent Characterisation and Treatment	**Credits = 2**		
		L	**T**	**P**
	Total contact hours: 36	**3**	**1**	**0**

List of Prerequisite Courses

Technology of pretreatment, dyeing, printing, and finishing

List of Courses where this course will be prerequisite

Process house management

Description of relevance of this course in the B.Tech. Program

Understand importance and relevant of environmental aspects related to sustainability in textile wet processing and the effluent parameters

Sr No.	Course contents (topics/subtopics)	Reqd Hrs
1.	Water requirement by textile wet processing industry, quality of incoming process water, standard norms for process water, overview of methods used to test incoming water	8
2.	Methods to treat incoming water such as, screening, filtration, clarification, disinfection etc.,	8
3.	Design of effluent treatment plant, primary, secondary and tertiary treatments	10
4.	Activated sludge and its modification, trickling filters, rotating biological contractors, suspended and attached growth anaerobic systems. Stabilisation ponds, aerated lagoons, etc. Sludge treatment and disposal. Treated effluent disposal in inland waters and marine environment.	10

List of Text Books/ Reference Books		
1	Economy Energy & Environment in textile Wet Processing - ACT, Edited by S.S. Trivedi.	
2	Environmental Issues - Technology option for Textile Industry Edited by R. B. Chavan, Indian Journal of Fibre &	Textile
3	Eco-friendly Textiles Challenges to Textile Industry - Textile Committee.	
4	Environmental Success - America Textile Industry, AATCC Symposium - 1996.	
Course Outcomes (students will be able to.....)		

1	**Comprehend** requirements of water and energy conservations during textile processing (K2)
2	**Explain** methods to determine presence of metal or other impurities in the effluent. (K2).
3	**Demonstrate** fundamentals about environment and its charactertics (K3).
4	**Describe** various ecosystems and ecolables. (K2)
5	**Explain** effluent treatment procedures and their application to textile processing waste-

Course Code: STT3506	**Course Title:** **High-tech and Industrial Fibres**	**Credits = 3**		
		L	**T**	**P**
	Total contact hours: 36	**2**	**1**	**0**

The course will be helpful to understand manufacturing, properties and applications of the most commonly used high tech fibres

Sr No	**Course contents (topics/subtopics)**	**Reqd. Hrs.**
1.	Introduction to fibres and their manufacturing techniques, terminology, Definition of High Tech fibres, Differences between conventional and High Tech fibres	4
2.	Manufacturing of carbon fibres from PAN precursors, viscose and pitch fibres. Differences between them wrt properties and Application of each type in different areas/fields	4
3.	Aramide Fibres, Synthesis of polymer, manufacturing, Discussion on Liquid crystals, Difference between regular aliphatic and aramid fibre, Application in different areas/fields	4
4.	Ultra High Molecular weight Polyethylene Fibres, Synthesis, manufacturing, Special focus on its structure, Discussion on Sheesh Kebab structure , Gel spinning, Super drawing, , Difference between regular olefin and UHMW fibre, Application in different areas/fields	6
5.	Polyurethane/Elastomeric Fibres, Synthesis of polymer along with precursors, manufacturing, Discussion on block/segmented structure, comparison with rubber, stretchability, Application in different areas/fields	6
6.	Glass fibres including optical glass fibres , their manufacturing, Rotary jet spinning technique , different types like C,E and S, Sizing and its reasons. Properties vis a vis Aramide and Carbon and other High Tech fibres, Application in different areas/fields	6
7.	Brief discussion about different biodegradable fibres, monomers used, polymers synthesis, nano fibres, application in medical field	6

List of Text Books/ Reference Books

1	Natural and man-made Textile fibres,G.E Linton, New York duell,sloan and pearce 1966
2	Turbak, A. F., Vigo, T. L. High-tech Fibrous Materials: Composites, Biomedical Materials, Protective Clothing, and Geotextiles. United States: American Chemical Society, 1991
3	Bicomponent fires.,Jeffries,Merrow publishing,1996
4	Hongu, T., Phillips, G. O. New Fibers. United Kingdom: Elsevier Science, 1997
5	High Performance Fibers, J.W.S. Hearle, Wood head Publishing,2001
6	Advanced fiber spinning Technology,T.Nakajima,Wood head publication,2002
7	New millennium fiber ,Thongu,CRC press,2005

8	Phillips, G. O., Takigami, M., Hongu, T. New Millennium Fibers. United Kingdom: Elsevier Science, 2005
9	Medical Textiles and biomaterial for healthcare,Anand S.C. Wood head publishing,2006
10	High-Performance and Specialty Fibers: Concepts, Technology and Modern Applications of Man-Made Fibers for the Future. (n.d.). Japan: Springer Japan
11	High Performance Technical Textiles. United Kingdom: Wiley, 2019

Course Outcomes (students will be able to.....)	
1	**Recognise** the need, technology and difference between conventional and High Tech fibres (K2)
2	**Describe** manufacturing of Carbon fibres using different precursors, their applications and properties (K2)
3	**Understand** manufacturing of Glass and Aramide fibres, their applications including optical fibres and properties (K1)
4	**Explain** manufacturing of Ultra high molecular weight Polyethylene and Poly urethane fibres, their applications and properties (K2)
5	**Predict** end use applications and performance evaluation criteria of hi-tech fibres (K3)

Special lab-1- Analysis of fibres and fabrics

Sr No.	Course Contents (Topics and subtopics)
1	Identification of fibres – Hand feel, Microscopic structure, Burning behavior, Chemical analysis of fibres,
2	Blend analysis - polycotton, polyvis, woolycot, polywool.
3	Properties of Yarn – Twist, Twist behavior, Crimp characterization of texturised yarn, Yarn numbering determination.
4	Properties of Fabric –, Drape, Bending length, Crease recovery angle measurement, Tensile strength, Tear strength, Bursting strength, Abrasion resistance, Pilling.
5	Specification of fabric - GSM, EPI-PPI, Cover factor
6	Structure of fabric – basic structure, Understanding common names of polyester fabric varieties - Crepe, Georgette, and chiffon. Cotton fabric varieties – poplin, denim, cord.
7	Hand weaving using frames
8	Characterization - DSC, FTIR, TGA and XRD demo

Special lab 2- Treatment of textiles

Sr No	Course Contents (Topics and subtopics)
1	Stain removal by spotting, chemicals used and methods of stain removing.
2	Methods of Desizing of cotton woven fabric – acidic, enzymatic, and oxidative, qualitative and quantitative evaluation of desizing efficiency- TEGEWA scale staining, loss in weight, water absorbency.
3	Scouring of cotton-open boil, pressure boil; Scouring of knitted cotton fabric – conventional and bio-scouring; Evaluation of scouring efficiency-Drave's test, sinking time, wicking property, loss in weight, core alkali determination – boil fabric and check pH, phenolphthalein.
4	Bleaching of cotton with oxidative and reductive bleaching agent, Scouring and bleaching of polyester/cotton blends.
5	Scouring and bleaching of wool, Degumming and Bleaching of Silk
6	Drumming and weight reduction of polyester fabric, Bleaching of polyester with hydrogen peroxide and nylon with sodium chlorite.

7	Evaluation of bleaching efficiency – whiteness index and bleach clean-up (peroxide killer – enzymatic and reducing agent).
8	Mercerisation of cotton with and without tension, Evaluation of mercerization – Shrinkage, Barium Activity no., dye uptake, strength and elongation; microscopic observation.
9	Assessment of cotton for degradation by Methylene Blue Absorption.
10	Application of OBA/FBA on natural and synthetic fabrics and evaluation of fabric for whiteness index – exhaust and pad application
11	Pre-treatment by semi-continuous process – combined desizing, scouring, bleaching; Pre-treatment by continuous process – separate and combined scouring, bleaching
12	To study effect of heat setting on dye uptake, dimensional stability and strength

Annexure I

R.26 Credit System and Mode of evaluation for Trimester Pattern

For Integrated M. Tech. in Chemical Engineering offered by Institute of Chemical Technology (ICT) at Bhubaneswar and Marathwada, Jalna Campus

1. Introduction

Integrated M. Tech. course after 12th Standard (HSSC) of 5 year duration consisting of 15 trimesters with alternate term in industry, with major in Chemical Engineering and minor in 6 different disciplines has been started to ensure improved quality and industry relevance in curricula in the field of Chemical Engineering as major branch with minor in Petrochemicals, Textiles, Polymers and Materials, Foods and Pharmaceuticals, and Energy Engineering, Food Engineering (in Marathwada, Jalna). The salient features are:

1. Four-month Trimester pattern with studies and In-plant training (IPT) alternate term.
2. Simultaneous 2 years' experience in various Industries.
3. Student is continuously monitored and participates in classroom discussions, home assignments, and research projects.

This concept/curriculum of Integrated M. Tech. is new and being introduced in India for the first time.

2. Course Structure

The course has a trimester-based structure. Each quarter consisting of 4 months, approximately12 weeks of teaching. The schedule of trimesters is as follows:

Year	Trimester	Scheme of trimesters
1	T1	Theory
1	T2	Theory
1	T3	In-plant
2	T4	Theory
2	T5	In-plant
2	T6	Theory
3	T7	In-plant
3	T8	Theory
3	T9	In-plant
4	T10	Theory
4	T11	In-plant
4	T12	Theory
5	T13	In-plant
5	T14	Theory
5	T15	Theory

During the Term T3, students will be asked to choose their Minor. Students will be allotted different branches based on their choices and Merit Rank based on their CGPA after T2. Maximum number of students allotted to any branch would not be more than 11 (eleven). This would ensure that all the branches get equal number of students. Once a particular Minor is allotted, students will not be allowed to change their Minor.

There are mainly two types of courses in the Institute: lecture courses and laboratory courses. Lecture courses consist of lecture (L) and tutorial (T) hours. Laboratory courses consist of practical (P) hours. The credit (C) for a course is dependent on the number of hours of instruction per week in that course, as given below:

(1) 1h/week of lecture (L) or tutorial (T) = 1 credit

(2) 2h/week of Practicals (P) = 1 credit

(3) Credit (C) for a theory course = No. of hours of lectures per week + No. of hours of tutorials per week = L + T

(4) Credits (C) for a laboratory course = 0.5 × No. of hours of laboratory course per week

Credits will be assigned to In-plant, Seminar, Projects and other mandatory course requirements also and these will be mentioned in the syllabi.

3. Evaluation

3.1 The marks allotted for evaluation to all subjects would be 100. The weightage to different modes of assessments shall be as under.

	In-term Evaluation		**End Term Exam**	**Components of continuous mode**
	Continuous Assessment	**Mid Term-Exam**		
Theory	50	-	50	Quizzes, class tests (open or closed book), home assignments, group assignments, *viva-voce* assignments, discussions
Practicals	50	-	50	Attendance, *viva -voce*, journal, assignments, project, experiments, tests

3.2. In-Term Evaluation:

(a) It is expected that the teacher would conduct at least three assessments of equal weightage and approximately equally spaced throughout the term under the continuous mode.

(b) The teacher will announce at the beginning of the respective course the method of conducting the tests under the continuous mode and the assignment of marks

(c) In-term performance of all students should be displayed and sent to the academic office by the teacher at least 5 days before the end-term examination.

(d) The in-term, continuous assessment evaluation shall be shown to the student from time to time throughout the term, as and when the evaluations are conducted by the subject teacher.

(e) The cumulative marks for all in-term evaluation would be 50.

3.3. End-Term examination:

(a) The Term end examination will cover the full syllabus of the course and will be conducted as per the Institutional timetable at the end of each term.

(b) End term examination for all subjects will be for 50 marks and 2 h duration.

(c) The end term examination answer books shall be graded by the subject teacher within a period of 7 days from the date of examination.

(d) The subject teacher shall conduct an “open house session” with the candidates registered for the course, wherein, the registered candidates can see the assessment of their answer books by the subject teacher. After conducting such a session and making changes in the marks, if any, the subject teacher shall send the marks to the Academic Office.

(e) No revaluation of these examinations will be allowed.

3.4 Evaluation in Laboratory Courses

The evaluation of Laboratory courses would be done in the following manner:

Continuous Assessment		**End Term Examination**	
Parameter	**Marks**	**Parameter**	**Marks**
Completion of all experiments (based on grades in the laboratory log book)	25	Satisfactory Performance of Experiment(s)	10
Submission of fair Journal	15		
Quality of Flow Diagram Results, Graphs, Comments	15	Quality of Flow Diagram Results, Graphs, Comments	10
Viva(s)	15	Viva	10

3.5 Evaluation of the In-Plant Training

At the end of every in-plant training term, students will have to submit:

(i) a written report of the work carried out, and

(ii) an evaluation of the student from the Industry Mentor.

(iii) After coming back to the Institute, the student would have to present the work carried out to a committee of two faculty members of the Institute. The presentation would be evaluated by the committee and student will be given a grade for the in-Plant training based on the following parameters

3.5.1 Format for Evaluation by Industry Mentor

Name of the Student: _____

Name and Designation of the Mentor: _____

Name and Address of Organization / Place of Internship: _____

_____

_____

Email: _____ Phone: _____

Internship Duration: Start Date: _____, End Date:_____

Instructions to the Mentor:

Please evaluate the student on following Parameters & tick appropriate column:

Excellent: > 80%, Good: 60 – 80%, Satisfactory: 40 – 60%, Needs Improvement: < 40%

	Needs Improvement	**Satisfactory**	**Good**	**Excellent**
General Behaviour: Ethics and Attendance				
Oral and Written Communication Skills				
Interpersonal Skills				
Technical Knowledge				
Professional Skills: Initiative and Motivation				
Managerial Skills: Time and Resource				

Any Other Remarks: _____

Signature of the Mentor: _____

3.5.2 Format for Evaluation by Faculty Members of the Institute and assigning grade

Name of the student: _____

	Item	**Marks**
Report/IPT Dairy	Background of Project/Industry	/05
	Technical work done/Industry study Any of the followings i. Experiment performed ii. Mathematical modelling if any iii. Design iv. Techno-economic feasibility v. Analysis of data vi. Process study and observations	/30
	Conclusions	/10

	Writing skills including formatting as per given instructions	/05
Presentation	i. Presentation based on the work performed and its analysis. ii. Presentation skill	/20
Industry Mentor	Marks given by industry mentor	/30
Total		/100

3.6 Pass and Fail

(a) The candidates who obtain 40% and more marks of the total marks of a subject head shall be deemed to have **passed** the respective subject head.

(b) The candidates who obtain marks less than 40% of the total marks of a subject head shall be deemed to have **failed** in the respective subject head **(Grade FF).**

3.7 Grades

(a) The performance of a student shall be documented by a **Letter grade.** Each letter grade has a **Grade point** associated with it. The Grades and Grade points shall be assigned to each head of passing and both will be indicated in the mark-list of the term examination.

(b) The total marks (in-term+end-term) of a candidate in a subject head are converted into a letter grade, based on the relative (and sometimes the absolute) performance of the student.

Letter Grade	Grade Point
AA	10.0
AB	9.0
BB	8.0
BC	7.0
CC	6.5
CD	6.0
DD	5.5
EE	5.0

(c) For granting class and calculating percentage marks secured by the candidate, CGPA will be multiplied by 10.
If CGPA is greater than 7.0, candidate would be assigned First Class with Distinction. If 6.0 ≤ CGPA ≤ 6.99 candidate would be assigned First class.

If 5.0 ≤ CGPA ≤ 5.99 candidate would be assigned Second class.

(d) The grades to be allotted in the case of students who fail or do not appear at the end-term examination shall be as under.

Letter Grade	Grade Point	Explanation
FF	0	The candidate fails in subject head. The candidate will be allowed to take end-term repeat or subsequent examinations as per rules.
XX		The candidate has not kept term for the subject head due to attendance less than requisite. Further see 3.5(g) below. In the above cases, the candidate has to repeat the respective course by paying the fees.
I	0	The candidate has kept term for the subject head, has taken all the internal examinations with satisfactory performance, but has failed to take the end-term examination or repeat examination due to genuine reasons. The candidate will be allowed to take end-term repeat or subsequent examinations as per rules.

FR	0	The candidate has exhausted all the permissible chances to clear the end-term examinations. The candidate has to register for the respective term again for all the subject heads or will be out of the respective degree course as per the rules.
DR	0	(i) The candidate hasn't participated in academic programme. (ii) The candidate has taken a drop for the subject head;
		- provided he/she intimates the same (i or ii) at least 7 days in advance of the commencement of the end-term examination for the respective year.

(e) Grades **FF** and **I** are place-holders only and do not enter into CPI/SPI calculations directly. These grades get converted to one of the regular grades after the subsequent examinations.

(f) A candidate with an **FR** grade is not eligible for any repeat examination in that course and has to re-register for that term by paying the appropriate fees.

(g) **I** grade will not be continued beyond the permissible number of end-term/repeat examinations. In the six consecutive exams conducted by the institute, irrespective of whether the candidate fails to take any of these exams.

(h) **'XX' Grade:** The grade **XX** in a course is awarded if – (i) candidate does not maintain the minimum 75% attendance in the Lecture/Tutorial/Practical classes, (ii) candidate receives less than 40% of the marks assigned for continuous assessment (iii) candidate indulges in a misconduct/uses unfair means in the examination, assignments, etc., of a nature serious enough to invite disciplinary action in the opinion of the teacher.
(**Note:** Award of the **XX** grade in the case of i(iii) above shall be done by Disciplinary Action Committee (DAC)).

(i) The names/roll numbers of students to be awarded the **XX** grade should be communicated by the teacher to the Academic office as per academic calendar before the last date of submission of the application for end-term examination.

3.8. Awarding the grades

The grading scale ranks the students on a statistical basis on the basis of the overall performance of the students of a given class in the given subject head. Therefore, statistical data on students' performance is a prerequisite for applying the grading system. While assigning grades in a given subject head, it is essential to know the **average marks (AM)** obtained by the students *who have passed the subject head* and the **highest marks (HM)** obtained in the *same subject head*.

3.8.1. If the **average marks (AM)** obtained by the students *who have passed the subject head* is <60%, the interval AM shall be awarded grade CC and the other grades shall be decided as follows:

i. AA, AB, BB, and BC grades shall be decided between the AM and HM by dividing the range in equal intervals.
ii. CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.8.2. If the **average marks (AM)** obtained by the students *who have passed the subject head* is such that **60% ≤ AM < 70%,** the interval AM shall be awarded grade BC and the other grades shall be decided as follows:

i. AA, AB, BB grades shall be decided between the AM and HM by dividing the range in equal intervals.
ii. CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.8.3. If the **average marks (AM)** obtained by the students *who have passed the subject head* is such that **70% ≤ AM < 80%,** the interval AM shall be awarded grade BB and the other grades shall be decided as follows:

i. AA and AB grades shall be decided between the AM and HM by dividing the range in equal intervals.
ii. BC CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.8.4. If the **average marks (AM)** obtained by the students *who have passed the subject head* is such that **80% ≤ AM < 90%,** the interval AM shall be awarded grade AB and the other grades shall be decided as follows:

i. AA grades shall be decided between the AM and HM by dividing the range in equal intervals.
ii. BB, BC CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.8.5. If the **average marks (AM)** obtained by the students *who have passed the subject head* is such that **AM ≥ 90%,** the interval AM shall be awarded grade AA and the other grades shall be decided as follows:

i. AB, BB, BC CC, CD, DD and EE grades shall be decided between the AM and minimum marks required for passing the head (i.e. 40%) by dividing the range in equal intervals.

3.8.6. Absolute Grading: Absolute grading is to be awarded for subjects under the following cases:

i. Subject in which candidate works under the supervision of a guide on a project involving work in individual capacity or working in a small group. The subjects where such work is involved are, for example, Seminar, Home Paper, Literature Review, Critical Review, Research Project, In-Plant Training, Summer Project, etc. Grades are awarded directly on the basis of marks secured by the student in such a subject head, as per the following table.

ii. Subject in which the registered candidates are less than 10 in number. In such cases, calculation of Average Marks (AM) intervals and intervals for awarding grades higher than AM and lower than AM becomes statistically inaccurate. In such cases, grades are awarded directly on the basis of marks secured by the student in such a subject head, as per the following table.

	Letter Grade	Grade Points
Marks secured ≥ 80%	AA	10
75% ≤ Marks secured < 80%	AB	9
70% ≤ Marks secured < 75%	BB	8
65% ≤ Marks secured < 70%	BC	7
60% ≤ Marks secured < 65%	CC	6.5
55% ≤ Marks secured < 60%	CD	6
50% ≤ Marks secured < 55%	DD	5.5
40% ≤ Marks secured < 50%	EE	5
Marks secured < 40%	FF	0

4. TPI and CPI

a) **Term Performance Index (TPI):** The performance of a student in a term is indicated by **Term Performance Index (TPI),** which is a weighted average of the grade points obtained in all the courses taken by the student in the term and scaled to a maximum of 10. (TPI is to be calculated up to two decimal places.)

A Term Grade Point Average (TGPA) will be computed for each term as follows:

$$TGPA = \frac{\Sigma\, c_i g_i}{\Sigma\, c_i}$$

Where
'c_i' is the number of credits allotted to a particular subject, and
'g_i' is the grade-points awarded to the student for the subject based on his performance as per the above table.
TGPA will be rounded off to the second place of decimal and recorded as such.

b) **Cumulative Performance Index (CPI):** An up-to-date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating the **Cumulative Performance Index (CPI)** of a student. The CPI is a weighted average of the grade points obtained in all the courses registered by the student since he entered the Institute. CPI is also calculated at the end of every term (up to two decimal places).

Starting from the first term at the end of each term (T), a Cumulative Grade Point Average (CGPA) will be computed. CGPA will be rounded off to the second place of decimal and recorded as such.

c) The CGPA, TGPA and the grades obtained in all the subjects in a term will be communicated to every student at the end of every term/beginning of the next term.

d) When a student gets the grade 'FF', or I' in any subject head during a term, the SGPA and CGPA from that term onwards will be tentatively calculated, taking only 'zero' grade point for each such 'FF' or 'I' grade. When the 'FF' grade(s) has/have been substituted by better grades after the repeat examination or subsequent term examination, the TGPA and CGPA will be recomputed and recorded.

5. Repeat End-Term Examination

5.1. For those candidates who fail in a subject head or are eligible for appearing at the repeat examination, **Repeat End-Term Examination** will be conducted, as per **Regulation R.14**. as per schedule given below. The repeat examinations for a particular trimester will be conducted in the gap between the subsequent trimesters as per the schedule shown in the table below:

Year	Trimester	Trimester Type	Repeat Exam of
1	T1	Theory	
1	T2	Theory	
			T1
1	T3	Inplant	
			T2
2	T4	Theory	
2	T5	Inplant	
			T4
2	T6	Theory	
3	T7	Inplant	
			T5
3	T8	Theory	
3	T9	Inplant	
			T8
4	T10	Theory	
4	T11	Inplant	
			T10
4	T12	Theory	
5	T13	Inplant	
			T12
5	T14	Theory	
5	T15	Theory	Repeat of T14, T15

5.2. The marks obtained by candidates in the in-term examinations (continuous assessment) will be carried forward in such cases.

5.3. Grading the performance in the Repeat Examination: The grades will be assigned as per 3.5 and 3.6 above. However, for a candidate taking any repeat examination or subsequent regular term examination shall be awarded **one grade lower** than that decided on the basis of the actual marks obtained; provided 'EE' grade obtained in such an examination shall remain 'EE'. For reference see the table below.

Grade obtained in repeat or subsequent end term examination	Grade to be assigned	Grade point
AA	AB	9.0
AB	BB	8.0
BB	BC	7.0
BC	CC	6.5
CC	CD	6.0
CD	DD	5.5
DD	EE	5.0
EE	EE	5.0

5.4 Repeat Practical Examination

Repeat examination in practical subject is permitted only under following cases: (i) Candidate has obtained 50% marks in Continuous assessment and appeared for the regular end semester practical examination and failed, (ii) Candidate has obtained 50% marks in Continuous assessment and could not appear for the regular end semester practical examination due to valid medical reason or family bereavement.

6. Passing of a Term examination

A candidate shall be declared as **'PASSED'** any term examination if he/she has

a. Cleared all heads of passing by securing grades EE or higher in all the heads;
b. Passed all the heads of passing such as project, seminar, training, etc. as per the rules;
c. Satisfactorily completed all the mandatory requirements of the course;
d. Paid all the Institute dues;
e. No case of indiscipline pending against him/her.

7. Eligibility for the Award of a Degree

A candidate shall be declared eligible for the award of a degree, if he/she has cleared all the trimester examinations as given in (6) above.

8. Allowed to keep terms (ATKT)

8.1 A candidate who has I grade in one or more heads of passing of a trimester of an academic year shall be allowed to keep terms as per Table below.

8.2. A candidate shall be allowed to keep terms for the subsequent academic Terms if he/she has FF or I grades in not more than two heads of passing from all the heads of passing of the two terms of the previous academic term taken together as per the Table below. Such a candidate shall be declared as **FAILED, ATKT**.

8.3. Candidates will be allowed to register for subsequent trimesters only if he has cleared previous trimesters indicated in the Table below:

Year	Trimester	Trimester Type	Students allowed to register for a particular term only if
1	T1	Theory	
1	T2	Theory	
1	T3	In-plant	
2	T4	Theory	
2	T5	In-plant	
2	T6	Theory	
3	T7	In-plant	Trimesters: T1-T3 are clear
3	T8	Theory	
3	T9	In-plant	
4	T10	Theory	Trimesters: T1-T6 clear
4	T11	In-plant	
4	T12	Theory	
5	T13	In-plant	Trimesters: T1-T9 are clear
5	T14	Theory	
5	T15	Theory	

9. Repeating a course

9.1 A student is required to repeat the course of a subject head under the following situations:

a. A student who gets an **XX, FR, or DR** grade in a course; or

b. A student has exhausted all permissible chances to clear the subject head.

9.2 A candidate who remains absent for the in term and end-term examination of a term and the corresponding repeat examination for **ALL SUBJECTS** shall have to take fresh admission for the corresponding term; unless the candidate has dropped out / terminated from the course.

10. Improvement of performance

A candidate will be allowed to appear at the **entire End Term examination** after the regular end term examination as per the respective rules to improve the performance. In such a case if the result of the examination repeated:

1. Is better than the previous one, the previous result shall be declared null and void; and
2. Is worse than the previous one, the result of the subsequent examination shall not be declared.

11. Exemption of subjects

A candidate who had to repeat a year due to year drop may request exemption from re-appearing for the exam in the subjects in which the marks obtained by the candidate were greater than 50%.

12. Exit rules for poorly performing students

A candidate shall be excluded from a course under the following conditions:

(a) If he/she fails to pass any term examination of any year of the course in not more than four consecutive attempts (Examination conducted by Institute) from the date of joining the course.

(b) If he/she does not keep two consecutive terms/terms without giving any reasonable justification (as prescribed by the institute) for doing so.

(c) If a candidate fails to fulfil all the requirements of his/her respective degree within the prescribed period from the date of taking admission to the course, the candidate shall be excluded from the course.