Multidisciplinary Minor

Energy Technology

Course code		SET4351	L	T	P	Total
Course title		**Conventional Energy and Combustion Chemistry of Fuels**				
Scheme & Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Prerequisites		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 Fuel and 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; **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**	**1**	0	**5**
	2	Combustion thermodynamics Combustion mechanism, elementary steps, chain reaction Adiabatic Flame Temperature, Equilibrium constant and free energy, Combustion Kinetic Elementary, consecutive and parallel reactions Transition state theory,	**4**	**1**	0	**5**
	3	**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, briquetting, carbonization, gasification and liquefaction of coal, Coal derived chemicals.	**4**	**2**		**6**
	4	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.	**5**	**1**	0	**6**
	5	Natural Gas	**3**	**1**	0	**4**
	6	Nuclear Energy	**3**	**1**	0	**4**
Total			**23**	**7**	**0**	**30**
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	"An Introduction to Combustion: Concepts and Applications," Third Edition, by Stephen R. Turns, McGraw-Hill (2012)				
	5	Principles of Combustion , Kenneth Kuan-yun Kuo				
	6	Jaccard M. (2006); Sustainable Fossil Fuels, Cambridge University Press				
Outcomes		On completion of the course, the students will be able to				
	CO 1	List forms of energy, conversion processes				
	CO 2	Categorize renewable and non renewable energy sources				
	CO 3	Estimate calorific value from fuel analyses				

CO 4	Explain energy generation and distribution systems
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

Course code		SET4352	L	T	P	Total
Course title		**Renewable Energy Systems**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre-requisites		Material and Energy Balance Calculations, Chemical Engineering Thermodynamics II, Physics II and Chemistry II				
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**	0	**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**	**1**	0	**5**
	3	**Thermochemical conversion:** Charcoal production, Biomass gasification; 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**	**1**	0	**5**
	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	**3**	**1**	0	**4**
	5	**Photovoltaic:** Principle of photovoltaic conversion; Solar cell basics and materials; Different solar cell technologies: 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	**4**	**1**	0	**5**
	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**	0	**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**	**1**	0	**5**
Total			**23**	**7**	**0**	**30**
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

Course code		SET4353	L	T	P	Total
Course title		**Energy Conversion and Storage**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre- requisites		Chemical Engineering Thermodynamics II, Conventional Energy Technology				
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**	**0**	**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**	**0**	**3**
	3	Flywheel and compressed air storage; Pumped hydro storage; Hydrogen energy storage	**2**	0	**0**	**2**
	4	Capacitor and super capacitor, Electrochemical Double Layer Capacitor: Principles, performance and applications.	**2**	**1**	**0**	**3**
	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.	**5**	**1**	**0**	**6**
	6	Hydrogen as energy carrier and storage; Hydrogen resources and production; Basic principle of direct energy conversion using fuel cells	**4**	**1**	**0**	**5**
	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**	**1**	**0**	**5**
	8	Application of Energy Storage: Food preservation, Waste heat recovery, Solar energy storage	**2**	**0**	**0**	**2**
Total			**24**	**6**	**0**	**30**
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	**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				

Course code		SET4354	L	T	P	Total
Course title		**Materials for Energy Applications**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre- requisites		Renewable Energy Systems, Combustion and Chemistry of Fuels				
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**	**1**	0	**7**
	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**	**1**	0	**13**
	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**	**1**	0	**5**
	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**	**1**	0	**5**
			26	**4**	**0**	**30**
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	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.				

Course code		SET4355	L	T	P	Total
Course title		**Advanced Thermodynamics of Energy Systems**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre- requisites		Chemical Engineering Thermodynamics II, Energy conversion and storage				
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**	**2**	0	**8**
	2	Kinetic theory and transport phenomena in energy systems	**6**	**2**	0	**8**
	3	Exergy analysis for energy conversion systems	**6**	**2**	0	**8**
	4	Case studies: fossil fuels, electrochemical cells, fuel cells, photovoltaics, supercritical and combined power generation cycles	**5**	**1**	0	**6**
			23	**7**	**0**	**30**
Suggested books/ reference	**1**	Renaud Gicquel, Energy Systems: A New Approach to Engineering Thermodynamics, 2012, CRC Press, ISBN 9780415685009				
	2	Chandler, David (1987). Introduction to Modern Statistical Mechanics. Oxford University Press. ISBN 0-19-504277-8.				
	3	Ibrahim Dincer and Marc A. Rosen, Exergy, 2013, 2nd edition, Elsevier, ISBN: 978-0-08-097089-9				
Outcomes	**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.				

Course code		SEP4351	L	T	P	Total
Course title		**Energy Laboratory-1**				
Scheme and Credits		**0 L: 0 T: 4 P 2 Credits**	**0**	**0**	**60**	**60**
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	**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**	**60**	**60**
Outcomes	**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		SEP4352	L	T	P	Total
Course title		**Energy Laboratory-2**				
Scheme and Credits		**0 L: 0 T: 4 P 2 Credits**	**0**	**0**	**60**	**60**
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	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**	**60**	**60**
Outcomes	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.				

Multidisciplinary Minors

Foods Technology

Course code			**SFT4351**				
Course title			**Food Chemistry**				
Scheme and Credits			**2 L: 0T : 0P 2 credits**	**2**	**0**	**0**	**2**
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, 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	**3**	**0**	**0**	**3**
	2		Carbohydrates: Classification, Analysis, Physicochemical and functional properties of carbohydrates	**7**	**0**	**0**	**7**
	3		Proteins: Classification, Analysis, Physicochemical and functional properties	**6**	**0**	**0**	**6**
	4		Lipids: Classification, Analysis, Physicochemical and functional properties	**6**	**0**	**0**	**6**
	5		Vitamins: Classification, Analysis, Physicochemical and functional properties	**4**	**0**	**0**	**4**
	6		Minerals: Classification, Analysis, Physicochemical and functional properties	**4**	**0**	**0**	**4**
				30	**0**	**0**	**30**
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		Principles of food chemistry - John DeMan, Springer, (2018)				
	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				

Course code			**SFT4352**				
Course title			**Food Processing Technology - I**				
Scheme and Credits			**2L: 0T: 0P 2 credits**	**2**	**0**	**0**	**2**
Pre-requisites			Food Chemistry				
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.)	**6**	**0**	**0**	**6**
	2		Technology of fruits and vegetables processing: Current scenario of production of fruits and vegetables; post-harvest technology; commercial canning of fruits and vegetables; processing and preservation of fruit beverages; commercial processing technology for value addition.	**10**	**0**	**0**	**10**
	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.	**6**	**0**	**0**	**6**
	4		Technology of meat, fish, poultry and egg processing: Meat processing operations; egg processing and preservation; processing of fish and marine products.	**8**	**0**	**0**	**8**
				30	**0**	**0**	**30**
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				
	4		Food Processing Technology by P. J. Fellows, CRC Publishers				
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				

Course code			**SFT4353**				
Course title			**Food Processing Technology - II**				
Scheme and Credits			**2L: 0T: 0P 2 credits**	**2**	**0**	**0**	**2**
Pre-requisites			Food Processing Technology - I				
Objectives of the course	**1**		To understand the basics of various unit operations in food processing				
	2		To understand the processing and milling of cereals				
	3		To differentiate various dairy products and the equipment's used for its processing				
	4		To differentiate various bakery and confectionary 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; CGMP/HACCP.	**4**	**0**	**0**	**4**
	2		Technology of cereal, legume and oilseed processing: Types of cereal, legumes and pulses; Grain storage principles; wheat milling; paddy processing; legume and oilseed processing with newer techniques.	**8**	**0**	**0**	**8**
	3		Technology of milk and dairy processing: Dairy developments in India; sampling and quality testing of milk; processing technology of dairy products.	**8**	**0**	**0**	**8**
	4		Technology of bakery and confectionary: Quality and functionality of raw materials used in bakery; Dough chemistry; Various methods of bread production; Biscuits and cookie manufacturing technology; Chocolate processing; Sugar candy manufacturing.	**10**	**0**	**0**	**10**
				30	**0**	**0**	**30**
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				
	5		Bakery Technology by Jenkis,S.M, Lester and orpen (1975)				
	6		Confectionary products manufacturing processes by Gutterson, M, Noyes developments corporation(1969)				
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				

Course code			**SFT4354**				
Course title			**Food Additives and Toxicology**				
Scheme and Credits			**L:2 T:0 P:0 2 credits**	**2**	**0**	**0**	**2**
Pre-requisites			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 food hazards and food safety aspects				
	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		Additives used in food preservation such as preservatives, antioxidants, 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**	**0**	**0**	**8**
	2		Additives used as aids in food processing such as sequesterants, emulsifier, hydrocolloids, sweeteners, acidulants etc, and their functions in food processing and storage.	**8**	**0**	**0**	**8**
	3		Safety aspects of Food Additives: Tolerance levels & Toxic levels in Foods, Legal safeguard, Risks of food additives, Contaminants, Toxicants, and anti-nutritional compounds in food systems	**8**	**0**	**0**	**8**
	4		Types of food hazards: biological, chemical and physical; Risk assessment; Existing and emerging pathogens due to globalisation of food trade.	**6**	**0**	**0**	**6**
				30	**0**	**0**	**30**
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				
	5		Food Toxicology by Debasis Bagchi and Anand Swaroop CRC Press; 1st edition				

Outcomes			On completion of the course, the students will be able to				
	CO1		Understanding on hazards to food products the importance of food safety evalution system				
	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				

Course code			**SFT4355**				
Course title			**Food Preservation and Packaging**				
Scheme and Credits			**2L: 0T: 0P 2 credits**	**2**	**0**	**0**	**2**
Pre-requisites			Food Chemistry, Food Processing Technology - I & II				
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 preseravtion and Packaging; causes of food spoilage; factors affecting food spoilage; packaging as a method for preservation of foods.	**6**	**0**	**0**	**6**
	2		Different materials used in food packaging such as paper, glass, metal containers, plastics, laminates/composites; Food and Packaging material interactions including migration.	**8**	**0**	**0**	**8**
	3		Newer packaging technologies-VP/CAP/MAP; aseptic processing and packaging; active and intelligent packaging; Non-thermal preseravation technology.	**12**	**0**	**0**	**12**
	4		Testing of various packaging materials and packages for evaluation of quality; Shelf life analysis.	**4**	**0**	**0**	**4**
				30	**0**	**0**	**30**
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)				
	3		Food Processing Technology by P. Fellows				
	4		Food Science by N. Potter				
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		Justify the role of food packaging in food preservation				
	CO3		Describe different food packaging materials and their properties and application to various food commodities				
	CO4		Comprehend food and packaging material interactions				

	CO5		Ability to develop the strategies to preserve the food products				

Course code			**SFP4351**				
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			**8**	**8**
	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.			**4**	**4**
	11		Microbial assay			**4**	**4**
	12		Enzyme assay			**4**	**4**
				0	**0**	**#**	**60**
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				

Course code			**SFP4352**				
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**	**6**	**6**
	2		Preparation of fruit preserves from selected fruits (minimum three types)	**0**	**0**	**6**	**6**
	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**	**4**	**4**
	10		Preparation of non-alcoholic beverages (minimu three types)	**0**	**0**	**4**	**4**
	11		Preparation of soy based food products (minimum three types)	**0**	**0**	**4**	**4**
	12		Demostration and preparation of dehydrated food product using spray, cabinet or vaccum dryer	**0**	**0**	**4**	**4**
				0	**0**	**#**	**60**
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,New Delhi.				
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).				

Multidisciplinary Minors

Pharmaceutical Technology

Course code			**SRT4351**				
Course title			**Introduction to Pharmaceutical Technology**				
Scheme and Credits			**2L: 0T: 0P 2 credits**	**2**	**0**	**0**	**2**
Pre-requisites			OE: Biology				
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 and explain morphology, diversity, cultivation methods, physiology and metabolism of microorganisms				
	2		Understand basics of monophasic, biphasic, topical formulation, and aerosols				
	3		Know the different drug categories				
Syllabus	**1**		Introduction to Prokaryotes and Eukaryotes; Study of ultra-structure and morphological classification of bacteria, viruses, fungi; nutritional requirements, raw materials used for culture media, growth curve, isolation and preservation methods for pure cultures, Identification of bacteria using staining techniques (simple, Gram's&Acid fast staining)	**4**	**0**		**4**
	2		Overview of Pharmaceutical Industry; Origin & development of the pharmacopoeia – IP/BP/USP, Introduction to monograph and Biopharmaceutics	**4**	**0**		**4**
	3		Dosage form: Definition and classification based on route of administration, physical form along with special emphasis on Monophasics (Oral and Topicals) (solution, syrups, elixirs, linctus, glycerites, nasal drops, ear drops, etc.) , Biphasic, Ointments, Creams, Gels, Suppositories, Aerosols - Suspensions and Emulsions	**8**	**0**		**8**
	4		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.	**14**	**0**		**14**
				30	**0**		**30**
Suggested books/reference	**1**		Microbiology, Pelczar, McGraw-Hill Education				
	2		Prescott's Microbiology 11th Edition, Joanne Willey, Kathleen Sandman, Dorothy Wood; McGraw-Hill Education (2019)				
	3		Remington-The Science And Practice Of Pharmacy (Vol.1& 2), David B.Troy, 21st edition,2006, Lippincott Williams &Wilkins				
	4		Pharmacology H. P. Rang, M. M. Dale, J. M. Ritter 5				
	5		J. McMurry, Brooks/Cole, Organic Chemistry				
Outcomes			On completion of the course, the students will be able to				
	CO1		Know the cultivation/control methods for the diversity of microorganisms, and their physiology				

	CO2		Understand general principles of Pharmacology including pharmacokinetics and Pharmacodynamics.				
	CO3		Know the different drug categories				
	CO4		Conceptualize and develop monophasic, biphasic and other products				

Course code			**SRT4352**				
Course title			**Pharmaceutical Chemistry**				
Scheme and Credits			**2L: 0T: 0P 2 credits**				
Pre-requisites			Introduction to Pharmaceutical Technology				
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**	**0**	**0**	**2**
	2		To train the students with the basics of Medicinal Natural Products and Phytochemistry				
Syllabus	**1**		Classification of Drugs and their molecular targets: Enzymes, proteins and receptors as drug targets	**4**	**0**		**4**
	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	**15**	**0**		**15**
	3		Introduction to Anti inflammatory drugs; Cardiovascular Drugs; Drugs acting on hormonal systems; Other miscelleneous Classes of drugs	**11**	**0**		**11**
				30	**0**	**0**	**30**
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				

Course code		**SRT4353**				
Course title		**Formulation Technology and Drug Delivery**				
Scheme and Credits		**2L: 0T: 0P 2 credits**	**2**	**0**	**0**	**2**
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; quality control test; Packaging; Tablet coating: Need, stages and types	**8**	**0**		**8**
	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;	**4**	**0**		**4**
	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.	**8**	**0**		**8**
	4	Introduction to Quality by Design, Validation, Documentation and Regulatory bodies for pharmaceuticals.	**4**	**0**		**4**
	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**			
			30	**0**	**0**	**24**
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.				
	10	An introduction to Ayurveda, M.S. Valiathan, 2013, Orient Blackswan Private Limited - New Delhi				
	11	Handbook of Ayurvedic Medicines with Formulation, Eiri Board, 2009, Engineers India Research Institute				
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	Describe product and process validation and documentation required for the pharmaceuticals				
	CO6	Execute the preparation of polyherbal formulations as per the standard Ayurvedic texts				

Course code			**SRT4354**				
Course title			**Pharmaceutical Technology and Drug Design**				
Scheme and Credits			**2L: 0T: 0P 0 credits**	**2**	**0**	**0**	**2**
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**	**0**		**4**
	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	**4**	**0**		**4**
	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**	**0**		**4**
	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	**5**	**0**		**5**
	5		Docking by different techniques	**3**	**0**		**3**
	6		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	**5**	**0**		**5**
	7		Potential uese of natural products: Plant-derived molecules for perfumery, cosmetic, agrochemicals, dyes and pigments	**5**	**0**		**5**
				30	**0**	**0**	**30**
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				
	7		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				
	8		Phytochemistry of Medicinal Plants, Vol. 29, J.T. Arnason, R. Mata, J. T. Romeo, 1995, Springer Science, Business Media New York				
	9		Total Synthesis of Natural Products, Jie Jack Li and E. J. Corey, 2012, Springer				
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 design				
	CO4		Design new potential therapeutic molecules using ligand based drug design				
	CO5		Rationalize the contribution of natural products in new drug discovery				

Course code			**SRT4355**				
Course title			**Process Development for Fine Chemicals and API**	**2**	**0**		**2**
Scheme and Credits			**2L: 0T: 0P 2 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**	**0**		**8**
	2		Status of pharmaceutical industry: Status of bulk drugs, natural products and formulations in India vis-a-vis industrialized nations	**3**	**0**		**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.	**6**	**0**		**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	**5**	**0**		**5**
	5		Selected Fine Chemical Technologies with examples: Alkylation, Halogenation, Oxidation, Reduction, Esterification, Nitration, and Hydrogenation	**4**	**0**		**4**
	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	**4**	**0**		**4**
				30	**0**	**0**	**30**
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				

Course code			**SRP4351**				
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			**8**	**8**
	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)			**8**	**8**
	12		Accelerated stability testing of any suitable drug/ formulation, Problems based on Arrhenius equation for shelf life calculations			**8**	**8**
				0	**0**	**60**	**60**
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				

Course code			**SRP4351**				
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 pediatric elixir			**4**	**4**
	6		Representative examples of microencapsulation (Preparation and evaluation)			**8**	**8**
	7		Solubilization of drugs by at least two novel techniques			**8**	**8**
	8		Evaluation of Glass containers (as per IP)			**8**	**8**
	9		Synthesis of one 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			**16**	**16**
				0	**0**	**60**	**60**
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				

Multidisciplinary Minors

Materials and Polymers Technology

	Course Code: SMT4351	**Course Title: Introduction to Material Technology**	**Credits = 2**			
	Semester: III	**Total contact hours: 30**	**L**	**T**	**P**	
			2	**0**	**0**	
	List of Prerequisite Courses					
	Basic Physics, Chemistry and Mathematics					
	Description of relevance of this course in the Int. M. Tech. Program					
	This course aims to acquaint the students with fundamental knowledge of materials. The course content discusses the basic structure of solids, classification of materials and the correlation between the structure and properties.					
	Course Contents (Topics and subtopics)					**Reqd. hours**
1	**Introduction to Materials:** Introduction, history and evolution of materials, classification of materials, need to study of materials, bonding in atoms- Primary bonding and Secondary bonding. Crystal Structure: Concepts of unit cell and Bravais lattice, crystallographic directions and planes, Miller indices, linear and planar density, crystal defects.					**4**
2	**Metals and its Alloys:** Introduction, Classification, Concept of stress-strain, shear stress, torsion, tensile strength, ductility, brittleness, resilience, toughness, impact strength, hardness, creep, Mechanical behavior of Metals- Deformation of metals, Material Properties of interatomic bonding force/energies, Stiffness versus Modulus, Ferrous and Non-Ferrous alloys, effect of impurities, Heat treatment.					**6**
3	**Thermodynamics:** Phase rule, phase diagrams, Lever rule, Solid solutions and alloys, Invariant reactions, Fick's laws of diffusion, Mechanisms of diffusion, Phase transformation, Nucleation kinetics and growth.					**4**
4	**Ceramics:** Introduction, classification, Glass and glass ceramics, Mechanical behavior of Ceramics, Crystal structure and bonding of Ceramics, Imperfection in Ceramics, Application of Ceramics in advanced technologies					**4**
5	**Polymer:** Basics of polymers, classification criteria, applications, concept of molecular weight, crystallinity, tacticity, glass transition temperature, experimental methods to determine glass transition temperature, factors affecting glass transition temperature, stress-strain relationships in polymers, stress-strain behaviour, fracture and fatigue, factors affecting mechanical behaviour.					**6**
6	**Composites:** Introduction, definition, composite classification, fiber reinforced composites (polymer matrix, metal matrix, ceramic matrix, carbon-carbon composites), structural composites, Composite interfaces, Bonding mechanisms, other interfacial properties, manufacturing and processing of composites (hand lay-up, spray lay-up, pultrusion, prepreg, resin-transfer moulding, pressure bag and vacuum bag techniques).					**6**
						30
	List of Text Books/ Reference Books					
	1. Introduction to Material Science and Engineering, William J Callister, John Wiley & Sons, Inc. 2. Material Science and Engineering, V. Raghavan, Prentice Hall of India 3. Polymer Science and Technology, Joel Fried, Prentice Hall. 4. Foundation of Material Science & Engineering, William Smith, Javad Hashemi, McGraw Hill.					
	Course Outcomes (Students will …..)					
CO1	Understand the various engineering materials knowledge					

CO2 **CO3** **CO4**	Understand the significance of material science in domestic and engineering applications. Interpret structure property relationship and selection of appropriate material for specific applications. Explain fundamental properties of materials, along with the fundamental aspects of phase diagrams and the concepts of degradation and failure.	

	Course Code: SMT4352	Course Title: Polymer Science and Technology- I	Credits = 2			
	Semester: IV	Total contact hours: 30	L	T	P	
			2	0	0	
	List of Prerequisite Courses					
	Applied Chemistry I, II and Introduction to Materials Technology					
	Description of relevance of this course in the Int. M. Tech. Program					
	This course will enable the students to understand the basic concept of polymer and its classification, mechanism of formation and various techniques of Polymerization.					
	Course Contents (Topics and subtopics)					**Reqd. hours**
1	**Introduction to Materials:** Historical developments in polymeric materials, Basic concepts & definitions: monomer & functionality, oligomer, polymer, repeating units, degree of polymerization, molecular weight & molecular weight distribution, Classification of Polymers, Natural polymers, Chemical & Physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latex, vegetable oils and gums, proteins etc.					**6**
2	**Polymerization Methods and Techniques:** Addition Polymerization- Free Radical Polymerization, Anionic Polymerization, Cationic Polymerization, Coordination Polymerization etc. Condensation Polymerization- Kinetics of Condensation Polymerization, Copolymerization, Carothers Equation, Reactivity ratio, Bulk, Solution, Suspension, Emulsion, Interfacial, Comparison of these systems with Advantages and Disadvantages.					**6**
3	**Thermoplastic Polymers:** Synthesis, structure-property relationship, and applications of Styrenic polymers - Polystyrene, HIPS, SAN, ABS, Polyamides- Nylon 6, Nylon 6,6, Nylon 11, Acrylic polymers & copolymers, Polyvinyl chloride & its copolymers, Poly vinyl acetate, modified cellulosic.					**4**
4	**Thermoset Polymers:** Synthesis, structure-property relationship, and applications of Polyster resins, phenolic, Amino resins, Epoxy resins, Polyurethanes, Alkyd resins, Thermosetting acrylics, Silicones thermoplastics and thermosets.					**4**
5	**Polymer Rheology:** Overview and importance of rheology, stress, strain, viscosity, modulus, damping parameter, compliance, elasticity, plasticity, viscoelasticity, Newtonian and non- Newtonian fluids, thixotropy and rheopexy, thermal dependence of viscous flow (free volume), Deborah number, Taylor number, Weissenberg effect, die swell, Rheological concepts of Polymer solutions and melts.					**6**
6	**Polymer Testing and Characterization:** Molecular weight determination, viscosity of polymers and polymer solutions, electrical properties, chemical properties, flammability, mechanical properties, Miscellaneous Test- Melt flow index, weathering test etc.					**4**
						30
	List of Text Books/ Reference Books					
	1. Polymer Science by Gowarikar, John 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.					
	Course Outcomes (Students will …..)					
CO1 **CO2**	develop the knowledge of concept of polymers, their classifications and nomenclature. be able to assess 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.	

	Course Code: SMT4353	**Course Title: Polymer Science and Technology- II**	**Credits = 4**			
	Semester: V	**Total contact hours: 30**	**L**	**T**	**P**	
			2	**0**	**0**	
	List of Prerequisite Courses					
	Applied Chemistry I, II and Polymer Science and Technology- I					
	Description of relevance of this course in the Int. M. Tech. Program					
	This course will enable the students to understand various polymer processing techniques considering the equipment, material behavior, processing parameters etc.					
	Course Contents (Topics and subtopics)					**Reqd. hours**
1	**Injection Molding:** Introduction, basic components and processes, types of machines, machine specification and rating, materials, drying, moulding cycle, co-injection moulding, gas/water assisted injection moulding, Injection Blow Molding, advantages and limitations of the process, troubleshooting and safety measures, process parameters and their effects on product quality, Injection molding of thermosets.					**8**
2	**Extrusion:** Introduction, components of extrusion and extruder screw, process, materials, extruder output, extrusion blown film, sheet extrusion, pipe extrusion, Extrusion blow molding, process parameters & their effects on product quality, Mixing sections, co-extrusion, troubleshooting, twin screw extruder.					**8**
3	**Compression Molding:** Introduction, basic process, moulding cycle, moulding materials, bulk factor, process parameters, types of molds, advantages and limitation of process, troubleshooting.					**4**
4	**a) Rotational Molding:** Introduction, basic process, moulding cycle, moulding materials, bulk factor, process parameters, types of molds, advantages and limitation of process, troubleshooting. **b) Calendering:** Introduction, material, process, types of calendar roll, process parameters, film and sheet lines, Advantages, disadvantages, troubleshooting.					**6**
5	**Composite Processing:** Introduction, basic process, moulding cycle, moulding materials, types of machines, process parameters and their effect on product quality, troubleshooting.					**4**
						30
	List of Text Books/ Reference Books					
	1. Plastics Engineering Handbook, J. Frados, Van Nostrand Reinhold Company 2007. 2. Plastics Processing Handbook, A. S. Athalye, Colour Publications (Pvt.) Ltd. 2002. 3. SPI Plastics Engineering Handbook, Michael Berins, Springer, 1991. 4. Principles of Polymer Processing, A. Tadmor and C. G. Gagos, John Wiley & Sons, New York, 2006 5. Plastics Materials and Processing, A. Brent Strong, Prentice Hall, 2000					
	Course Outcomes (Students will …..)					
CO1 **CO2** **CO3** **CO4**	understand the basics of polymer process design and analyses the polymer processes. understand the melt behaviour of polymers and its application in processing. understand the basics of different extrusion die geometries, their design and problems associated. Understand different moulding techniques and their applications.					

	Course Code: SMT4354	**Course Title: Structure-Property Relationship**	**Credits = 4**			
	Semester: VI	**Total contact hours: 30**	**L**	**T**	**P**	
			30	**0**		
	List of Prerequisite Courses					
	Applied Chemistry I, II and Polymer Science and Technology- I					
	Description of relevance of this course in the Int. M. Tech. Program					
	This course will enable the students to understand various polymer processing techniques considering the equipment, material behavior, processing parameters etc.					
	Course Contents (Topics and subtopics)					**Reqd. hours**
1	**General structural features of polymers:** Effects of atoms types of bonds, bond dissociation energy and functional groups on properties of polymers, Configuration & conformation and structure properties of polymers, Molecular mass heterogeneity and structure properties.					**5**
2	**Polymer Solutions:** Thermodynamics of dissolution, factors effecting dissolution and swelling of polymers, phase equilibrium of polymer-solvent systems, Flory-Huggins theory.					**6**
3	**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, factors affecting crystallinity, properties affected by crystallinity of polymers.					**5**
4	**Thermal Properties:** Lattice vibrations, Heat capacity, Thermal expansion, Thermal conductivity thermal stress in materials. Structure property relationship in anisotropic media, fire retardant polymers, factors affecting glass transition (Tg) temperature, heat stability etc. with case studies					**4**
5	**Degradation and stabilization:** Various stresses acting on polymers and their influence, method of improving the stability of polymers with case study					**4**
6	**Effect of Additives:** Concepts of degradation of plastics due to UV, heat, ageing etc.; Use of different additives to prevent this- Plasticizers, Lubricants, Processing aids & various rheology modifiers, UV stabilizers, Impact modifiers, Flame retardants, nucleating agents, blowing agents, Cross linking agents and miscellaneous additives					**6**
						30
	List of Text Books/ Reference Books					
	1. Polymer Structure, Properties and application, R.D. Deanin, American Chemical Society, 1974 2. Polymer Science by Gowarikar, John Wiley & Sons 1986. 3. Structure – Property Relationships in Polymers, Raymond B. Seymour and Charles E. Carraher, Jr., Plenum Press New York and London, 1984. 4. Polymer Solutions; Introduction to Physical Properties, Teraoka, Iwao, John Wiley and Sons. Inc, 2002. 5. Plastics Additive Handbook, Gachter and Mullar, Hanser Publishers, 1987.					
	Course Outcomes (Students will …..)					
CO1 **CO2** **CO3**	understand the importance of structure-property correlation study of materials and its suitable applications. understand difference between different type of materials, and their structures. able to explain the structural dependence of properties of materials.					

	Course Code: SMP4351	**Course Title: Materials Processing Laboratory**	**Credits = 2**			
	Semester: VI	**Total contact hours: 60**	**L**	**T**	**P**	
			0	**0**	**4**	
	List of Prerequisite Courses					
	Applied Chemistry I, II and Polymer Science and Technology- II					
	Description of relevance of this course in the Int. M. Tech. Program					
	This course will enable students to learn about the production, properties and applications of thermoset and thermoplastic polymers.					
	Course Contents (Topics and subtopics)					**Reqd. hours**
1	To study injection moulding & batch mixer, extrusion process					
2	Compounding of Polymeric material using two roll mill.					
3	To produce an article from blow moulding machine.					
4	Compounding of Polymeric material using compressing molding.					
5	Study of construction and working of thermoforming.					
6	Study of construction and working of rotational moulding for multilayered product.					
	List of Text Books/ Reference Books					
	Course Outcomes (Students will …..)					
CO1 **CO2**	able to handle processing techniques of given material sample. understand the design and development of the functionally gradient materials for desired application.					

	Course Code: SMT4355	**Course Title: Material Processing**	**Credits = 2**			
	Semester: VII	**Total contact hours: 30**	**L**	**T**	**P**	
			2	**0**	**0**	
	List of Prerequisite Courses					
	Polymer science and technology I, Structural property relationship, Material science and engineering					
	Description of relevance of this course in the Int. M. Tech. Program					
	To acquaint students with fundamental knowledge of material processing techniques which will be helpful in practical implementation of processing.					
	Course Contents (Topics and subtopics)					**Reqd. hours**
1	**Metal Processing:** Manufacturing Process, Classifications of manufacturing process. Solidification- Pure metal and alloy, Mechanism of solidification-Dendrites growth, Effect of grain and dendrites growth in metal properties.					**4**
2	**Metal Casting:** Moulding materials and their requirements; Patterns: Types and various pattern materials. Various casting methods, viz., sand casting investment casting- Mould sand composition, Testing sand properties, pressure die casting, centrifugal casting, continuous casting, thin roll casting; Mould design; Casting defects and their remedies.					**6**
3	**a) Metal Forming:** Various metal forming techniques and their analysis, Deformation work, Hot and cold Working, viz., forging, rolling, extrusion, wire drawing, sheet metal working, spinning, swaging, thread rolling; Super plastic deformation; Metal forming defects. **b) Metal joining:** Metal joining process- Concepts of Fusion and solid-state welding processes, Brazing and soldering, Welding defects.					**8**
4	**Ceramic Processing:** Processing of traditional ceramics- spray granulation, Pressing, CIP, HIP, Slurry processing, Slip casting, Pressure casting, Tape casting, Gel casting, Injection molding, Extrusion; Rapid- prototyping through Additive manufacturing, Electrophoretic deposition, Production of ceramic fibers, Electro-spinning; Drying, Binder burnout, Green machining, Sintering; Sol-gel processing, Thermal and plasma spraying, Thick and thin film coatings- PVD and CVD techniques; Vapor infiltration techniques					**6**
5	**Composite Manufacturing Techniques:** Hand lay-up, Filament winding, Pultrusion, Resin transfer molding, Vacuum beg moulding-Basic operation process, materials, economic aspect, trouble shooting and remedies					**6**
						30
	List of Text Books/ Reference Books					
	1. Manufacturing Technology, Foundry, forming and welding, P N Rao, McGraw Hill Education, ISBN-13: 978-93-5316-051-7.					
	Course Outcomes (Students 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					

	Course Code: SMP4352	**Course Title: Synthesis and Characterization of Resins and Polymers**	**Credits = 2**			
	Semester: V	**Total contact hours: 60**	**L**	**T**	**P**	
			0	**0**	**4**	
	List of Prerequisite Courses					
	Applied Chemistry I, II and Polymer Science and Technology- I					
	Description of relevance of this course in the Int. M. Tech. Program					
	This course will enable the students to apply various techniques for polymer synthesis and learn about different polymerization techniques.					
	Course Contents (Topics and subtopics)					**Reqd. hours**
1	To synthesis polymer using Bulk, solution, suspension & emulsion polymerization method.					
2	Synthesis of copolymers by emulsion Bulk, solution & suspension and emulsion, Polymerization.					
3	Synthesis of Novolac and its analysis.					
4	Synthesis of Resol and its analysis.					
5	Synthesis of Epoxy resin and its analysis.					
6	Synthesis of Unsaturated Polyester resin and its analysis.					
7	Synthesis of Amino Resin and its analysis.					
	List of Text Books/ Reference Books					
	Course Outcomes (Students will …..)					
CO1	understand essential fundamentals and chemistry of the polymerization processes.					
CO2	understand general concepts, principles, kinetics and methodology of polymerization.					

Multidisciplinary Minors

Petroleum and Petrochemicals Technology

		SEM III	**Contact Hours**			
			L	**T**	**P**	**Total**
Course code		**SPT4351**				
Course title		**Introduction to Petroleum Technology.**				
Scheme and Credits		**2L: 0T: 0P 2 Credits**	**2**	**0**	**0**	**2**
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, fuels from crude oil and gas, petroleum derived synthetic organic chemicals, future trends and developments.	**4**			**4**
	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.	**6**			**6**
	3	Introduction to refinery, Types of refineries: simple, intermediate and complex refineries, history and current status of Indian refineries, general refinery setup and function of various units, refinery flow diagram.	**4**			**4**
	4	Crude oil fractionation: Pipe still heaters, atmospheric distillation unit (ADU), vacuum distillation unit (VDU), different petroleum fractions.	**4**			**4**
	5	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. Treatment techniques: Fraction impurities, treatment of LPG, kerosene, gasoline, lube oil.	**6**			**6**
	6	Major petrochemical products, Feed stock for petrochemicals	**6**			**6**
		Total	**30**			**30**
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.				

		SEM IV	Contact Hours			
			L	T	P	Total
Course code		**SPT4352**				
Course title		**Petroleum refining processes**				
Scheme and Credits		**2L: 0T: 0P 2 Credits**	**2**	**0**	**0**	**2**
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**			**2**
	2	Thermal cracking, thermal processing like visbreaking, delayed coking, fluid coking, flexicoking.	**4**			**4**
	3	Catalytic cracking: Cracking reactions, cracking catalysts, cracking units, fluidized bed catalytic cracking (FCC), new designs for FCC units.	**4**			**4**
	4	Hydrocracking and hydro-processing: Hydrocracking reactions, hydrocracking catalysts, hydrocracker unit, hydro-processor, hydrogen production and purification.	**4**			**4**
	5	Catalytic reforming: Reforming reactions, feed preparations, reforming catalyst, reactor design, catalytic reformer.	**8**			**8**
	6	Light end processes: Isomerization, alkylation and polymerisation.	**8**			**8**
		Total	**30**		**0**	**30**
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				
	CO 1	to identify the process/technique to improve quality of given petroleum fraction.				
	CO 2	Draw process flow diagrams/process block diagrams for any given refinery operation.				

		SEM V	Contact Hours			
			L	T	P	Total
Course code		**SPT4353**				
Course title		**Reservoir Technology**				
Scheme and Credits		**2L: 0T: 0P 2 Credits**	**2**	**0**	**0**	**2**
Pre-requisites		Introduction to petroleum technology, momentum transfer, mass transfer operations, Materials physics.				
Objectives of the course		This course focuses on typical engineering operations/processes carried out on crude oil prior to its refining. These operation are: drilling, exploration, and oil recovery. This will also provide student with a broad outline of reservoir engineering.				
Detailed contents						
	1	Petroleum geology, types of rocks, sedimentary rocks, Oil and gas traps, migration and accumulation of oil and gas, Petroleum reservoir, properties of petroleum and gas in rocks, fundamentals of oil and gas flow in porous media. Natural gas and gas hydrates.	**4**			**4**
	2	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.	**4**			**4**
	3	Reserve estimation: resource & reserve concept, Different reserve estimation techniques: Volumetric, MBE, decline curve analysis, latest SPE/ WPC/ IS classification, predicting reservoir performance, introduction to reservoir simulation.	**4**			**4**
	4	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**			**4**
	5	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.	**6**			**6**
	6	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.	**8**			**8**
		Total	**30**			**30**
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	Learn the basic operations and challenges during drilling.				
	CO2	Learn the various techniques of oil recovery.				
	CO3	Understand the key concepts of petroleum geology.				

		SEM VI	Contact Hours			
			L	T	P	Total
Course code		**SPT4354**				
Course title		**Refinery engineering**				
Scheme and Credits		**2L: 0T: 0P 2 Credits**	**2**	**0**	**0**	**2**
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**			**3**
	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**			**6**
	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**			**6**
	4	Multicomponent liquid - liquid equilibrium relations, estimation of number of stages by triangular and rectangular diagrams for complex petroleum oils.	**3**			**3**
	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.	**6**			**6**
	6	Adsorption, breakthrough phenomena, concept of adsorption zone height, unsteady state fixed bed operation, LUB concept, design of absorbers. Sorbex technologies and its concepts.	**6**			**6**
		Total	**30**			**30**
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.				

		SEM VII	Contact Hours			
			L	T	P	Total
Course code		**SPT4355**				
Course title		**Petrochemicals Technology**				
Scheme and Credits		**2L: 0T: 0P 2 Credits**	**2**	**0**	**0**	**2**
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**			**4**
	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**			**4**
	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**			**4**
	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**			**4**
	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**			**2**
	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.	**6**			**6**
	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 specialty oils viz. insulating oil, transformer oil, white oil, etc.	**6**			**6**
		Total	**30**			**30**
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.				

		SEM V	Contact Hours			
			L	T	P	Total
Course code		**SPP4351**				
Course title		**Petroleum laboratory I**				
Scheme and Credits		**0L: 0T: 4P 2 Credits**	**0**	**0**	**4**	**4**
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				**60**
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.				

		SEM VI	Contact Hours			
			L	T	P	Total
Course code		**SPP4352**				
Course title		**Petroleum laboratory-II**				
Scheme and Credits		**0L: 0T: 4P 2 Credits**	**0**	**0**	**4**	**4**
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 naphtha reformer				
	9	Designing of FCC unit				
		Total				**60**
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.				

Multidisciplinary Minors

Oils Technology

List of MDM

MDM	**Subject code**	**Semester**	**Subject Name**
MDM 1	SOT4351	SEM-3	Chemistry of Oils and Fatty Acids
MDM 2	**SOT4352**	SEM-4	Technology of Oleochemicals and Surfactant
MDM 3	**SOT4353**	SEM-5	Lipid Processing Technology I
MDM 4	**SOT4354**	SEM-6	Lipid Processing Technology II
MDM 5	**SOT4355**	SEM-7	Production and Applications of Soaps, Surfactants and Detergents

MDM	Course Code: SOT4351	Course Title: MDM1: Chemistry of Oils and Fatty Acids	Credits = 2		
			L	T	P
	Semester: III	Total contact hours:30	1	1	0

List of Prerequisite Courses

HSC (Science), Organic Chemistry I, Organic Chemistry II

List of Courses where this course will be prerequisite

All the Lipid Technology Special Courses

Description of the relevance of this course in the Integrated M.Tech [Chemical Engg. (Major), Lipid (Minor)] programme

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.

Sr. No.	Course Contents (Topics and Subtopics)	Required Hours
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.	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.	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.	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 vitamins, hydrocarbons, pigments, phenolic compounds etc.	4
5.	**Separation and isolation of fatty acids**: Distillation, crystallization and counter current distribution. Methods of structure determination.	3
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
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.	10
	Total	**30**

List of Text Books/ Reference Books

1.	The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses, Frank D. Gunstone, Blackwell Publishing Ltd, UK (2004).
2.	Fatty Acids in Industry, R. W. Johnson, and E. Fritz, eds., Marcel Dekker, Inc., New York, (1989).

3.	Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 1: Edible Oil and Fat Products: Chemistry, Properties, and Health Effects, Ed. FereidoonShahidi, John Wiley & Sons, Inc., Wiley Interscience Publication (2005).
4.	Oils and Fats Manual, Eds. A. Karleskind and J.-P. Wolff, Vols. I and II, Intercept Ltd., Andover, U.K. (1996).
5.	Fatty Acid and Lipid Chemistry, F. D. Gunstone, Blackie Academic and Professional, London, U.K. (1996).
Course Outcomes (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)

MDM	Course Code: SOT4352	Course Title: MDM2: Technology of Oleochemicals and Surfactants	Credits = 2		
			L	T	P
	Semester: IV	Total Contact Hours: 30	1	1	0

List of Prerequisite Courses

HSC (Science)

List of Courses where this course will be prerequisite

All the Oils, Oleochemicals& Surfactants Special Courses

Description of relevance of this course in the Integrated M.Tech [Chemical Engg. (Major), Lipid (Minor)] programme

Students will be able to understand the industrial chemistry of Surfactants and Oleochemicals. They will be trained with respect to techniques of synthesis of oleochemicals and surfactants, colloidal behavior, interfacial phenomenon, and related analytical tools.

Sr. No.	Course Contents (Topics and subtopics)	Required Hours
1.	Oleochemical and Surfactant raw materials and their derivatives as feedstock for Chemical Industries, Worldwide Statistics of Oleochemical and Surfactant Industries	04
2.	Different techniques of synthesis of Fatty Acid Methyl Esters (FAME), Glycerol and Fatty Alcohols, Fatty Amines, Amides, and Nitriles and their physical and chemical characteristics	04
3.	Introduction to the nature of colloidal solutions, Surface Tension and Energy, Definition and classification of surfactants, Hydrophilic and hydrophobic groups and HLB balance, Theory of Surface Actions.	03
4.	Self-assembly and packing features of surfactants (bi and multilayers, direct & reverse micelles, vesicles, Microemulsions). Thermodynamics of Adsorption and Micellization, structure of micelles	03
5.	Different surface activity phenomenon: Emulsification & de-emulsification, foaming &defoaming, Solubilisation, Dispersion, Wetting, Detergency Prediction of emulsion type from packing geometry, general phase behaviour and Solubility–Temperature Relationship for Surfactants, phase inversion, Kraft and Cloud point	03
6.	Synthesis, analysis and applications of Anionic surfactants: Sulphonates (FAMES , AOS, LABS , Paraffin S., Ester & Amide S.), Sulphates (Alcohol & Alcohol ether sulphates, TRO , Sulphated MG, Sulphated Alkanolamides), N-acylated amino acids, Alkyl Phosphates, Sulphosuccinates etc.	05
7.	Synthesis, analysis and applications of Nonionic Surfactants: Fatty Alcohol ethers, Alcohol Polyglycol Ethers, Alkyl phenol ethers, Mono and diglycerides, Lecithin, Polyol esters (TWIN, SPAN, Sucrose polyester), Alkanolamides etc. Polymeric and Gemini Surfactants	04
8.	Synthesis, analysis and applications of Cationic and Amphoteric Surfactants: Alkoxylated amines, Amine oxide, 2-Alkyl imidazoline, N-alkyl-β-Alanine, Quaternary Ammonium Compounds, Betains, Sulphobetains etc. Speciality Fluorocarbon and Silicone Surfactants	04
	Total	**30**

List of Text Books/ Reference Books

1.	Synthetic Detergents, Davidson, A. S.; Milwidsky, B. 7th Ed. John Wiley and Sons, New York, (1987).
2.	Handbook of Surfactants, Porter, M. R., Springer Science and Business Media (1993).
3.	Surfactants in Consumer Products: Theory, Technology and Applications, Ed. J. Falbe, Springer-Verlag, Berlin (1987).
4.	Industrial Applications of Surfactants-II, D. R. Karsa, Royal society of Chemistry (1990).
5.	Richard M.; Marilyn E. K.; Pashley. Applied Colloid and Surface Chemistry, *John Wiley and Sons Ltd*, Chichester, UK (2004).

MDM	Course Code: SOT4353	Course Title: MDM3: Lipid Processing Technology I	Credits = 2		
			L	T	P
	Semester: V	Total contact hours: 30	2	0	0

List of Prerequisite Courses

HSC (Science), MDM1, MDM2, Organic Chemistry Lab

List of Courses where this course will be prerequisite

All the Lipid Technology Special Courses

Description of the relevance of this course in the Integrated M.Tech [Chemical Engg. (Major), Lipid (Minor)] programme

This course will give an overview of applications of technology and engineering principles in oil and lipid industry as well as a practical exercise of the same.

Sr. No.	Course Contents (Topics and subtopics)	Teaching Hours
1.	Storage, sampling, grading, cleaning, crushing, and heat treatment of oilseeds	06
2.	Mechanical expression, solvent extraction, rendering and other methods of recovering oils and fats. Economic aspects of these processes.	04
3.	Specific methods for the production of palm oil, palm kernel oil and rice bran oil.	02
4.	Technical refining of oils for industrial uses, detoxification and technical products from oil cakes, edible products from oil meals, synthetic fatty material.	02
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	02
6.	Processes and equipment employed for refining, bleaching, deodorization, hydrogenation and winterization of oils or edible purposes	02
7.	Newer techniques of refining of oils and fats	04
8.	Composition and properties of these spoilage during storage of fats, and fat products, protection against auto oxidation	08
	Total	**30**

List of Text Books/ Reference Books

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

MDM	Course Code: SOT4354	Course Title: MDM4: Lipid Processing Technology II	Credits = 2		
			L	T	P
	Semester: VI	Total contact hours: 30	2	0	0

List of Prerequisite Courses

MDM1, MDM3

List of Courses where this course will be prerequisite

All the Lipid Technology Special Courses

Description of the relevance of this course in the Integrated M.Tech [Chemical Engg. (Major), Lipid (Minor)] programme

This course will give an overview of applications of technology and engineering principles in oil and lipid industry as well as a practical exercise of the same.

	Course Contents (Topics and subtopics)	Reqd. hours
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;	06
2	Fatty acid fractionation: distillation, crystallization, high purity fatty acid products blends, etc	04
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.	08
8 4	Production of fatty alcohols	08
5	Production of bio diesel and green diesel	04
	Total	**30**

List of Text Books/ Reference Books

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

MDM	Course Code: SOT4355	Course Title: MDM5: Production and Applications of Soaps, Surfactants and Detergents	Credits = 2		
			L	T	P
	Semester: VII	Total Contact Hours30:	1	1	0

List of Prerequisite Courses

MDM5

Description of relevance of this course in the Integrated M.Tech [Chemical Engg. (Major), Lipid (Minor)] programme

Students will understand the mechanism, theory and practice of Surfactant production.

Sr. No.	Course Contents (Topics and subtopics)	Required Hours
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
2	Phases in soap boiling, processes employed in the manufacture of soap, various types of soaps and cleaning preparations	2
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.	8
4	Plant & processes for the production of important anionic, non-ionic, cationic and amphoteric surfactants.	5
5	Fluorinated surfactants, new generation surfactants such as Gemini surfactants, silicon surfactants and sugar based surfactants.	5
6	Fluorinated surfactants, new generation surfactants such as Gemini surfactants, silicon surfactants and sugar based surfactants.	3
7	Application of soaps, surfactants and detergents in food, pharmaceuticals, textile, leather, surface coating, adhesives and other industries	5
	Total	**30**

List of Text Books/ Reference Books

1. Soaps by Prof. J. G. Kane
2. Synthetic Detergents, Davidson, A. S.; Milwidsky, B. 7th Ed. John Wiley and Sons, New York, (1987).
3. Handbook of Surfactants, Porter, M. R., Springer Science and Business Media (1993).

			L	T	P	Total
Course code		SOP4351				
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				
	2	Determination of physical and chemical characteristics of Vanaspati, margarine, ghee and waxes				
	3	To detect castor oil and soyabean oil mixture using TLC, Detection of adulteration oils/ Identification of Oils in mixture				
	4	Acid Oil analysis: FAME-GC analysis				
	5	Analysis of Butter: Salt content, TFM, MP				
			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		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				

Course code		SOP4352				
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				
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 Interscience				
	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					

Multidisciplinary Minor

Textiles Technology

			L	T	P	Total
Course code		**STT4351**				
Course title		**Introduction to Textile Substrate**				
Scheme & Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Prerequisites		Material and Energy Balance Calculations, Physics II and Chemistry II				
Objectives of the course	**1**	To present an overview of Textile mechanical processes				
	2	To impart understanding of different textile fibres				
Syllabus	**1**	Basics of Fibres: 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 property,	**4**	**1**	0	**5**
	2	Basics of Natural Fibres: 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.	**4**	**1**	0	**5**
	3	Basics of Semi-synthetic fibres: viscose rayon, cuprammonium rayon, acetate rayon, and lyocell with respect to chemistry, manufacturing process, morphology, physical and chemical properties and structure property relationship with applications.	**3**	**1**		**4**
	4	Basics of Synthetic fibres: 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 properties	**5**	**1**	0	**6**
	5	General polymer chemistry; Classification of polymers, synthesis and mechanism, Techniques of polymerization.Types of polymeric Molecular weight and its determination. Microstructure of polymers, Fibre modification through texturization, TiO2 and chemical modification	**3**	**1**	0	**4**
	6	High-tech Fibres: Definition of High Tech fibres, Differences between conventional and High Tech fibre, Carbon fibre, Aramid Fibres, Ultra High Molecular weight Polyethylene Fibres, Polyurethane /Elastomeric Fibres, Glass fibres, Brief discussion about different biodegradable fibres	**5**	**1**	0	**6**
		Total	**24**	**6**	**0**	**30**
Suggested books/ reference	**1**	Kothari, V. Manufactured Fibre Technology. Netherlands: Springer Netherland, 2012				
	2	Man-made Fibres, Moncriff, R.W., Butterworth Science, London, 6th edition, 1975				
	3	Textile Fibres, Shenai V.A., Vol-1, Sevak Publications, Bombay, 3rd edition, 1991.				
	4	Textile Chemistry, Peters R.H, Vol-1, Elsevier Publishing Company, London, 1963.				
	5	Ghosh, P. . Fibre Science and Technology. United States: McGraw Hill Education (India) Private Limited, 2004				
	6	New millennium fiber ,Thongu,CRC press,2005				
Outcomes		On completion of the course, the students will be able to				
	CO 1	Understand fibre forming properties with different textile terms as well as their classification (K2).				
	CO 2	Acquire deeper understanding and insights in basic chemistry, production processes and physical and chemical properties of Natural and Synthetic fibers. (K2).				
	CO 3	Understand different areas of applications of these fibres vis a vis their properties. (K2).				
	CO 4	Comprehend fundamental knowledge of polymers, their classifications, as well as techniques and mechanism of polymerization. (K2)				
	CO5	Describe the manufacturing of Carbon fibres, aramid, PU, Glass, Ultra-high Mol weight PE fibres using different precursors, their applications, and properties. (K2)				

CO6 Predict end-use applications of conventional and hi-tech fibres (K3)

			L	T	P	Total
Course code		**STT4352**				
Course title		**Technology of Textile Dyeing**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre-requisites		Introduction to Textile Fibres, Chemisrty -II				
Objectives of the course	**1**	**Understand various stages of textile wet processing**				
	2	**Undrstand types of machinery used**				
	3	**Gain a basic idea about the wet processing operations**				
Syllabus	**1**	**Pretreatment:** Singeing, Desizing, Scouring and Bleaching, Mercerization, Pretreatment of Blends.	**3**	**1**	0	**4**
	2	**Introduction of coloration:** Parameters of quality dyeing, machines used and terms used; Classification of dyes based on application, Performance characteristics of dyed textiles, Earlier developments in processes and machinery for dyeing of textiles in various forms such as fibres, yarns, woven and knitted fabric	**4**	**1**	0	**5**
	3	**Coloration of Cellulosic Fibres:** Dyeing with Direct, Reactive, Azoic, Vat, Sulphur, Indigo, Natural dyes and OBA's.	**8**	**1**	0	**9**
	4	**Coloration of Polyamide Fibres:** Dyeing with Acid, Mordant and Metal Complex dyes	**3**	**1**	0	**4**
	5	**Coloration of Synthetic Fibres:** Dyeing of Polyester with Disperse dyes, Dyeing of Acrylic with Cationic dyes	**4**	**1**	0	**5**
	6	**Dyeing Machinary:** Batch, semi-continuous and continuous type dyeing machinery for all forms of textiles.	**2**	**1**	0	**3**
		Total	**24**	**6**	**0**	**30**
Suggested books/ reference	**1**	Basic Principles of Textile Coloration by A D Broadbent, SDC Publ., 2001				
	2	Technology of Dyeing, Shenai V.A., Vol. 6, Sevak Publication, Bombay, 1994.				
	3	Textile preparation and dyeing, A K Roy Choudhury, Science Publishers, 2006				
	4	Handbook of Synthetic Dyes and Pigments, K.M.Shah, Multitech Publishing, 1998.				
	5	Chemical Proc2 of Synthetic Fibres and Blends by K V Datye and A A Vaidya, John Wiley and Sons, New York, 1984				
Outcomes		On completion of the course, the students will be able to				
	CO1	Understand the importance of various textile processing parameters for quality dyeing. (K1)				
	CO2	Explain the developments in dyes, machinery, and processes in tune with the constantly changing industry requirements. (K2)				
	CO3	Analyze the dyeing process, type, and form of the substrate, and suggest corrective measures. (K4)				

Course code		STT4353	L	T	P	Total
Course title		**Technology of Textile Printing**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre- requisites		Technology of Textile Dyeing				
Objectives of the course	1	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.				
	2	To Understand the Different Styles of Textile Printing				
Syllabus	1	Introduction to various printing techniques, Stages in printing of textiles, History of textile printing.	**4**	**1**	**0**	**5**
	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, Printing of Cellulosics, polyamides, polyester and acrylic with different dyes.	**8**	**2**	**0**	**10**
	3	Three Basic styles of Printing and various special styles of printing	**3**	1	**0**	**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**	**1**	**0**	**7**
	5	Various methods of fixation, Selection of fixation method, Machines for fixation and its working; various after treatment of printed materials.	**3**	**1**	**0**	**4**
Total			**24**	**6**	**0**	**30**
Suggested books/ reference	1	Textile Printing by L. W. C. Miles, revised second edition published by SDC, 2003				
	2	Technology of Printing, V. A. Shenai, Sevak Publications, Bombay, Vol. 4, 1990.				
Outcomes		On completion of the course, the students will be able to				
	CO1	Describe and use different types of printing methods and styles, fixation conditions, after treatments used for printing. (K3)				
	CO2	Identify and evaluate thickening agents, chemicals and dyestuffs for printing; Formulation and rheological properties of printing pastes(K4)				
	CO3	Evaluate quality of printed goods and suggest remedial actions to overcome faults in printing (K4)				

Course code		STT4354	L	T	P	Total
Course title		**Technology of TextileFinishing and Speciality Chemicals**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre- requisites		Introduction to Textile Substrate, Technology of Textile Dyeing, Technology of Textile Printing				
Objectives of the course	**1**	To understand effect of various mechanical and chemical finishes in terms of imparting desired functionality to meet the end use application.				
	2	To understanding about the role of different functional groups on the properties of various specialty chemicals used in different industries.				
Syllabus	**1**	Objective of textile Finishing and type of finishing techniques.	**2**	**0**	0	**2**
	2	Mechanical finishes like Calendaring, raising, sueding, crabbing, compacting, sanforising and machinery involved. Heat Setting of Synthetic Fibre	**6**	**1**	0	**7**
	3	Chemical finishing – conventional softeners, stiffeners, binders, weighting agents, silicone finishes, wrinkle resistance finish	**6**	**1**	0	**7**
	4	Functional finishes - antibacterial, flame retarding, water/oil repelling, soil release, antistatic finishes, Moisture management, UV Protection, Bio Polishing	**6**	**1**	0	**7**
	5	Nomenclature, functions, and classification of textile auxiliaries, Surfactants: Chemistry, Properties, and applications, The structure-property relationships of Antimigrant, Defoamers, Peroxide Stabilizers, Printing Binders, Thickeners, Warp Sizes, Dye Fixatives. Evaluation of auxiliaries	**6**	**1**	0	**7**
			26	**4**	**0**	**30**
Suggested books/ reference	**1**	Chemical Finishing of Textiles, Schindler, W.D and Hauser P.J., Woodhead, 2004				
	2	Principles of Textile Finishing, Choudhury A. R, Woodhead Publishing, 2017				
	3	An Introduction to Textile Finishing, Marsh J.T., B.I. Publication, Bombay, 1979.				
	4	Colourants and Auxiliaries: Organic Chemistry and Application Properties, Shore, J., SDC, Bradford, 1990.				
Outcomes	**CO1**	Explain different methods and machineries available for application of finish and calculate finish add on onto fabric. (K2)				
	CO2	Understand the fundamentals of textile auxiliaries. (K1)				

Course code		STT4355	L	T	P	Total
Course title		**Effluent Characterisation and Treatment**				
Scheme and Credits		**1L: 1T: 0P 2 credits**	**1**	**1**	**0**	**2**
Pre- requisites		Introduction to Textile Substrate. Technology of Textile Dyeing, Technology of Textile Printing, Technology of TextileFinishing and Speciality Chemicals				
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**	Water requirement by textile wet processing industry, quality of incoming process water, standard norms for process water,	**4**	**2**	0	**6**
	2	Methods to treat incoming water such as, screening, filtration, clarification, disinfection etc.,	**4**	**2**	0	**6**
	3	Design of effluent treatment plant, primary, secondary and tertiary treatments	**6**	**2**	0	**8**
	4	Activated sludge and its modification, trickling filters, rotating biological contractors, suspended and attached growth and aerobic systems. Stabilisation ponds, aerated lagoons, etc. Sludge treatment and disposal. Treated effluent disposal in inland waters and marine environment.	**8**	**2**	0	**10**
			22	**8**	**0**	**30**
Suggested books/ reference	**1**	Economy Energy & Environment in textile Wet Processing - ACT, Edited by S.S. Trivedi.				
	2	Environmental Success - America Textile Industry, AATCC Symposium - 1996.				
Outcomes	**CO1**	Comprehend requirements of water and energy conservations during textile processing. (K2)				
	CO2	Explain methods to determine presence of metal or other impurities in the effluent. (K2).				
	CO3	Analyze various effluent treatment procedures and their application to textile processing waste-water. (K4)				

Course code		STP4351	L	T	P	Total
Course title		Textile Laboratory-1				
Scheme and Credits		0 L: 0 T: 4 P 2 Credits	0	0	60	60
Pre-requisites		Chemistry and Physics Basics, Understanding of Textile Substrate				
Objectives of the course	1	To learn about the Textile Subtrates				
	2	To learn about the Textile Chemicals				
	3					
Detailed contents	1	Identification of fibres – Hand feel, Microscopic structure, Burning behavior, Chemical analysis of fibres			8	8
	2	Blend analysis - polycotton, polyvis, woolycot, polywool			4	4
	3	Properties of Yarn – Twist, Twist behavior, Crimp characterization of texturised yarn, Yarn numbering determination			8	8
	4	Properties of Fabric –, Drape, Bending length, Crease recovery angle measurement, Tensile strength, Tear strength, Bursting strength, Abrasion resistance, Pilling.			8	8
	5	Specification of fabric - GSM, EPI-PPI, Cover factor, Basic structure			4	4
	6	Basic Textile Chemical Analysis				16
	7	Evaluation of Auxuliaries				12
	8					
	9					
Total			0	0	60	60
Outcomes	CO1					
	CO2					
	CO3					
	CO4					
	CO3					

Course code		STP4352	L	T	P	Total
Course title		Textile Laboratory-2				
Scheme and Credits		0 L: 0 T: 4 P 2 Credits	0	0	60	60
Pre - requisites		Renewable Energy Technology				
Objectives of the course	1	Understand Textile Pretreatment				
	2	Understand Textile Colouration				
	3					
Detailed contents	1	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				
	2	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				
	3	Bleaching of cotton with oxidative and reductive bleaching agent, Scouring and bleaching of polyester/cotton blends.				
	4	Mercerisation of cotton, Evaluation of mercerization – Shrinkage, Barium Activity no., dye uptake, strength and elongation; microscopic observation.				
	5	Colouration of Different Natural and Synthetic Fibres				
Total			0	0	60	60
Outcomes	CO1					
	CO2					
	CO3					
	CO4					