Syllabus for Integrated Master of Technology (Int. M. Tech.)
Major: Chemical Engineering
and
Multidisciplinary Minors (MDM)

(Under the National Education Policy 2020)
(NEP 2020)
in
(2023-2024)

Offered by

INSTITUTE OF CHEMICAL TECHNOLOGY MUMBAI
MARATHWADA CAMPUS, JALNA

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra

BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

www.ictmumbai.edu.in, www.marj.ictmumbai.edu.in
Tel: (91-22) 3361 1111, Fax: 2414 5614

List of Multidisciplinary Minors (MDM)

Sr. No.	Multidisciplinary Minors (MDM)
1.	Energy Technology
2.	Food Technology
3.	Pharmaceutical Chemistry & Technology
4.	Polymer and Materials Engineering
5.	Petroleum and Petrochemicals Technology
6.	Lipid Engineering
7.	Chemical Sciences
8.	Materials Physics

SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE

in

ENERGY TECHNOLOGY

[Under the National Education Policy (NEP 2020)]

2023-2024

Offered by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

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Preamble

The essence of human existence lies in energy, serving as a catalyst for a country's economic development. We are currently in a transitional phase, focusing on substituting carbon-based fuels with non-carbon alternatives to extend the lifespan of the former without causing environmental degradation. The adoption of renewable energy sources, coupled with advanced technologies, is anticipated to address challenges such as fossil fuel scarcity, potential depletion, energy security, access, and environmental sustainability. The commitments made by numerous countries necessity for widespread utilization of renewable energy sources. The design, deployment, operation, and maintenance of energy conversion systems demand a skilled workforce at all levels. Recognizing this need, The Institute of Chemical Technology Mumbai Marathwada Campus is initiated the Integrated Master of Technology (I. M. Tech.) program in Chemical Engineering with multidisciplinary minor in energy technology.

The aim of the Integrated Master of Technology (I. M. Tech.) program in Chemical Engineering, with a multidisciplinary minor in energy technology, is to equip postgraduate engineers specializing in the energy sector with versatile analytical skills. This course is tailored for the energy sector and integrates inputs from various disciplines such as chemical engineering (e.g., transport processes), mechanical engineering (e.g., thermodynamics, thermal engineering), and electrical engineering. Additionally, core energy courses are included to furnish students with the necessary knowledge for analyzing and designing energy systems.

Programme Specific Outcomes (PSOs)

Multidisciplinary Minor Degree (Energy Technology)

Students will be able to:

Program Specific Outcomes (PSOs)	
PSO1	**Understand** the core concepts underlying energy generation, conversion, storage, and distribution (Factual Knowledge) K1
PSO2	**Comprehend** engineering principles to design, develop, and optimize energy systems and technologies, considering factors such as cost-effectiveness, reliability, and safety (Conceptual Knowledge) (K2, K3)
PSO3	**Demonstrate** proficiency in designing, implementing, and troubleshooting energy systems, including power generation, distribution, and storage (Procedural Knowledge) (K4)
PSO4	**Reflect** on personal learning experiences and adapt strategies to enhance understanding and performance in energy technology and evaluate ethical implications, societal responsibilities associated with the application of energy technologies (Metacognitive Knowledge) (K5, K6)
PSO5	**Cater** to the needs of power stations, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about Energy Technology profession

1. **Recommended batch size: Minimum 10; Maximum 15**
2. **Duration: Three years**
3. **Eligibility criteria**

   Students enrolled in the Integrated Master of Technology in Chemical Engineering of Institute of Chemical Technology, Marathwada Campus, Jalna will be eligible. The allotment of minor degree programme will be as per the policy of the Institute.

4. **Pedagogy/ Teaching methods**
   - **Lecture/ Discussions:** These sessions will discuss the subject contents of the course.
   - **Experiential Learning:** The sessions will involve hands on training.
   - **Tutorials:** Problem solving / case studies / relevant real-life applications / student presentations / home assignments / individual or group projects
5. **Evaluation**

   Theory courses

   Continuous Assessment Tests (CATs): Continuous assessment will vary from course to course; the instructor will decide the evaluation mode. Two to three CATs will be conducted throughout the course, usually before and after the midsemester examination. These CATs will carry a total weightage of 20%. Depending on the instructor, class test, assignments, case studies, group discussions, report submission and seminar/presentation could also form part of the continuous assessment.

   Mid-semester: Total 30 Marks (Theory paper)

   End-semester: Total 50 Marks (Theory paper)

Practical courses

Continuous assessment: 50 Marks

Performing given experiments as per the instructions, submission of lab journal on time, viva voce, group/ personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.

End Semester: 50 Marks (Lab experiment performance followed by viva-voce examination)

6. Instructors: (Tentative)

Semester	Course Code	Subjects	Faculty
III	SET4351	Conventional Energy and Combustion Chemistry of Fuels	SKM
IV	SET4352	Renewable Energy Systems	SKM
	SEP4351	Energy Laboratory-I	AHB
V	SET4353	Energy Conversion and Storage	SKM
	SEP4352	Energy Laboratory-II	SKM
VI	SET4354	Materials for Energy Applications	SKM
VII	SET4355	Advanced Thermodynamics of Energy Systems	DK

SKM: Dr. Supriyo Kumar Mondal, AHB: Dr. Atul H. Bari, DK: Dr. Debashis Kundu

Multidisciplinary Minor Degree in Energy Technology

Subject Code	Sem	Subject	Credits	Hrs./Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
SET4351	III	Conventional Energy and Combustion Chemistry of Fuels	02	2	0	0	20	30	50	100
SET4352	IV	Renewable Energy Systems	02	2	0	0	20	30	50	100
SEP4351		Energy Laboratory-I	02	0	0	4	50	0	50	100
SET4353	V	Energy Conversion and Storage	02	2	0	0	20	30	50	100
SEP4352		Energy Laboratory-II	02	0	0	4	50	0	50	100
SET4354	VI	Materials for Energy Applications	02	2	0	0	20	30	50	100
SET4355	VII	Advanced Thermodynamics of Energy Systems	02	2	0	0	20	30	50	100
		Total	**14**	**10**	**0**	**8**				

Mapping of All Courses of Energy Technology with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Conventional Energy and Combustion Chemistry of Fuels	K1, K2	3	3	-	-	-
Renewable Energy Systems	K3	2	3	1	-	-
Energy Laboratory-I	K2, K3, K4	1	3	3	-	-
Energy Conservation and Storage	K2, K4, K5	2	3	3	1	1
Energy Laboratory-II	K3, K4	2	3	3	1	2
Materials for Energy Applications	K4, K5, K6	2	3	3	2	3
Advanced Thermodynamics of Energy Systems	K4, K5, K6	1	3	3	3	3

Semester III

Course Code: SET4351	Course Title: Conventional Energy and Combustion Chemistry of Fuels	Credits = 2		
		L	T	P
Semester: III	Total contact hours: 30	2	0	0

List of Prerequisite Courses

Material and Energy Balance Calculations, Chemical Engineering Thermodynamics II, Physics II and Chemistry II

List of courses where this course will be prerequisite

SEP4351-Energy Laboratory – I, SET4352-Renewable Energy Systems, SEP4352-Energy Laboratory-II, SET4353-Energy Conversion and Storage, SET4354-Materials for Energy Applications

Description of relevance of this course in the Int. M. Tech. Program

- To present an overview of energy generation, distribution, and control systems
- To impart understanding of sources of energy and its significance

	Course Contents (Topics and subtopics)	Hours
1	**Basics of energy:** Different forms of energy, energy conversion process, indirect and direct energy conversion; Different energy sources; Conventional energy systems: engines, power plants, various methods of power generation; **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	**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,	**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	**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	**6**
5	Natural Gas	**4**
6	Nuclear Energy	**4**
	Total	**30**

List of Textbooks / Reference Books

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

Course Outcomes (students will be able to….)		
CO1	List forms of energy, conversion processes	K1
CO2	Categorize renewable and non-renewable energy sources	K2
CO3	Apply knowledge to estimate calorific value and other characteristics of coal-based fuels	K2
CO4	Explain energy generation and distribution system	K2
CO5	Optimize process to minimize emissions	K2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K1	3	3	-	-	-
CO2	K2	3	2	-	-	-
CO3	K2	3	3	1	-	-
CO4	K2	3	3	-	-	-
CO5	K2	3	3	1	-	-
Course	K1, K2	3	3	-	-	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester IV

Course Code: SET4352	Course Title: Renewable Energy Systems	Credits = 2		
		L	T	P
Semester: IV	Total contact hours: 30	2	0	0

List of Prerequisite Courses

Material and Energy Balance Calculations, Chemical Engineering Thermodynamics II, Physics II and Chemistry II

List of Courses where this course will be prerequisite

SEP4351-Energy Laboratory-I, SEP4352-Energy Laboratory-II, SET4353-Energy Conversion and Storage, SET4354-Materials for Energy Applications, SET4355-Advanced Thermodynamics of Energy Systems

Description of relevance of this course in the Int. M. Tech. Program

- To examine the principles of sustainability and renewable energy
- To create an understanding of solar energy conversion including photovoltaic (PV) and solar thermal conversion systems.
- To examine the trade-offs with use of biomass-based energy

	Course Contents (Topics and subtopics)	Reqd Hours
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	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	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	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	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	5
6	**Solar thermal conversion:** Theory and Basics. Introduction to different solar thermal energy systems: Solar flat plate collector, Concentrating collector,	4

	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;	
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
	Total	**30**
List of Textbooks / Reference Books		
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	
Course Outcomes (students will be able to….)		
CO1	Apply principles of mathematics, science and engineering to the analysis of solar, wind and biomass power	K3
CO2	Design systems for harnessing biomass, solar, wind and hydrokinetic energy	K3
CO3	Integrate the considerations of economic, environmental, factors for analysis of renewable energy systems	K2
CO4	Analyze the sustainability, health and safety, social, and political impacts	K3
CO5	Resource assessment, power, and energy calculations	K2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K3	2	3	-	-	-
CO2	K3	2	3	1	-	-
CO3	K2	3	2	-	-	-
CO4	K3	3	3	1	-	-
CO5	K2	2	3	1	-	-
Course	K3	2	3	2	2	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Course Code: SEP4351	Course Title: Energy Laboratory-I	Credits = 2		
		L	T	P
Semester: IV	Total contact hours: 60	0	0	4

List of Prerequisite Courses

SET4351-Conventional Energy and Combustion Chemistry of Fuels

List of Courses where this course will be prerequisite

SEP4352-Energy Laboratory-II, SET4354-Materials for Energy Applications, SET4355-Advanced Thermodynamics of Energy Systems

Description of relevance of this course in the Int. M. Tech. Program

- To learn to characterization techniques of conventional energy sources
- To learn to collect, collate and interpret analytical results
- To Learn quality and quantitative determination of sample

	Course Contents (Topics and subtopics)	Rqd. hours
1	Determination of flash point and fire point using Cleve land open cup.	4
2	Determination of flash point using Abel's apparatus.	4
3	Determination of flash point using Pensky Martene apparatus.	4
4	Determination of diesel index of given petroleum sample.	4
5	Determination of drop point of given sample.	4
6	Determination of Saybolt's viscosity of given petroleum sample.	4
7	Determination of the smoke point.	4
8	Determination of calorific value of fuel by Bomb calorimeter.	6
9	Determination of carbon residue of given petroleum fraction using Ramsbottom method.	6
10	Determination of carbon residue of given petroleum fraction using Conradson Carbon method.	4
11	Determination of the penetration index of petroleum sample.	4
12	Detection of copper strip corrosion of petroleum product.	6
13	Determination of cloud point and pour point.	6
	Total	**60**

Course Outcomes (students will be able to….)

CO1	Describe the basic principles of different petroleum characterization techniques.	K2
CO2	Suggest possible characterization techniques for given petroleum sample.	K4
CO3	Strengthen the theoretical knowledge of petroleum products	K3
CO4	Analytical knowledge of different physicochemical parameters	K3
CO5	Utilization of characterization techniques development of different module	K2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K2	1	3	3	-	-
CO2	K4	1	3	3	-	-
CO3	K3	1	3	3	-	-
CO4	K3	3	3	1	-	-
CO5	K2	2	3	1	-	-
Course	K2, K3, K4	1	3	3	3	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester V

Course Code: SET4353	Course Title: Energy Conversion and Storage	Credits = 2		
		L	T	P
Semester: V	Total contact hours: 30	2	0	0

List of Prerequisite Courses

Chemical Engineering Thermodynamics II, SET4351-Conventional Energy and Combustion Chemistry of Fuels

List of Courses where this course will be prerequisite

SEP4351-Energy Laboratory-I, SEP4352-Energy Laboratory-II, SET4354-Materials for Energy Applications, SET4355-Advanced Thermodynamics of Energy Systems

Description of relevance of this course in the Int. M. Tech. Program

- To expose students to energy storage chemistry particularly for storage of electricity
- Provide fundamental knowledge of the energy storage devices and systems
- To review conversion of energy in form of fuels

	Course Contents (Topics and subtopics)	Hours
1	Different types of energy storage; Mechanical, Chemical, Electrical, Electrochemical, Biological, Magnetic, Electromagnetic, Thermal; Comparison of energy storage technologies.	4
2	Thermal energy storage: principles and applications, Sensible and Latent heat, Phase change materials; solar energy and thermal energy storage, case studies.	3
3	Flywheel and compressed air storage; Pumped hydro storage; Hydrogen energy storage	2
4	Capacitor and super capacitor, Electrochemical Double Layer Capacitor: Principles, performance and applications.	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.	6
6	Hydrogen as energy carrier and storage; Hydrogen resources and production; Basic principle of direct energy conversion using fuel cells	5
7	Fuel cell types: AFC, PEMFC, MCFC, SOFC, Microbial Fuel cell; Fuel cell performance, characterization and modelling; Fuel cell system design and technology, applications for power and transportation.	5
8	Application of Energy Storage: Food preservation, Waste heat recovery, Solar energy storage	2
	Total	**30**

List of Textbooks / Reference Books

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

Course Outcomes (students will be able to….)

CO1	Describe criteria used to determine performance, advantages, and disadvantages	K2

CO2	Perform efficiency analysis of energy storage systems	K4
CO3	Recommend optimal (appropriateness, cost and sustainability) solutions to any potential energy storage application	K5
CO4	Characterization and modelling of different fuel cells	K3
CO5	Applications in food preservation, waste heat recovery	K4

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K2	3	3	-	-	-
CO2	K4	2	2	3	3	-
CO3	K5	2	2	3	3	2
CO4	K4	3	3	1	1	2
CO5	K4	3	3	1	1	2
Course	K5	3	2	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Course Code: SEP4352	Course Title: Energy Laboratory-II	Credits = 2		
		L	T	P
Semester: V	Total contact hours: 60	0	0	4

List of Prerequisite Courses

SET4352-Renewable Energy Technology, SET4354-Materials for Energy Applications

List of Courses where this course will be prerequisite

SET4351-Conventional Energy and Combustion Chemistry of Fuels, SET4352-Renewable energy systems, SEP4351-Energy Laboratory – I, SET4353-Materials for Energy Applications, SET4355-Advanced Thermodynamics of Energy Systems

Description of relevance of this course in the Int. M. Tech. Program

- To learn to characterization techniques of renewable energy sources
- To learn to collect, collate and interpret analytical results
- To Learn quality and quantitative determination of sample

	Course Contents (Topics and subtopics)	Hours
1	Solar cell effectiveness	4
2	Solar Thermal Heater	4
3	Performance analysis of Solar PV Electricity Generator	4
4	PV system characterization under the influence of varying radiation and shadow	4
5	Production of biofuel	8
6	Characterization of biofuel	4
7	Fuel cell experiment	4
8	Wind turbine	4
9	Hydrogen production by splitting of water	8
10	Exergy calculation of heat exchanger	4
11	Exergy calculation of boiler	4
12	Exthalpy calculations (1-2 experiments)	8
	Total	**60**

Course Outcomes (students will be able to….)

CO1	Describe the basic principles of different renewable energy sources characterization techniques	K4
CO2	Suggest possible characterization techniques for given renewable energy source	K3
CO3	Strengthen the theoretical knowledge of renewable energy source	K4

CO4	Able to clearly communicate the results of experimental work in oral and written formats	K4
CO5	Able to design and develop biofuels, wind turbines	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K4	1	-	-	-	-
CO2	K3	1	3	3	-	-
CO3	K4	2	3	3	-	-
CO4	K4	3	3	3	-	-
CO5	K5	2	3	2	2	3
Course	K3, K5	2	3	3	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester VI

Course Code: SET4354	Course Title: Materials for Energy Applications	Credits = 2		
		L	T	P
Semester: VI	Total contact hours: 30	2	0	0

List of Prerequisite Courses

SET4352-Renewable Energy Systems, SET4351-Conventional Energy and Combustion Chemistry of Fuels

List of Courses where this course will be prerequisite

SEP4352-Energy Laboratory-II, SET4354-Materials for Energy Applications, SET4355-Advanced Thermodynamics of Energy Systems

Description of relevance of this course in the Int. M. Tech. Program

- To understanding the concepts of energy materials and their characterizations and applications in energy devices
- To analyze the material design and relate to photovoltaic device, fuel cell systems and energy storage devices
- To develop an attitude of innovation / creativity towards material design for various energy harvesting devices

	Course Contents (Topics and subtopics)	Hours
1	**Device fabrication technologies:** diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), plasma enhanced CVD (PECVD), hot wire CVD (HWCVD)	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	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;	6
4	**Materials and devices for energy storage:** Carbon Nano-Tubes (CNT), fabrication of CNTs, CNTs for hydrogen storage, CNT-polymer composites	4
	Total	**30**

List of Textbooks / Reference Books

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	
Course Outcomes (students will be able to….)		
CO1	Students will be able to understand and apply principles in solid state chemistry / physics, material science and engineering, adsorption, surface science, and catalysis in analyzing materials for energy applications	K4
CO2	Students will learn about the physical, chemical, thermal, electrical, and mechanical properties of materials relevant to energy applications	K5
CO3	Students will develop critical thinking skills to analyze complex issues related to energy materials and apply their knowledge to solve real-world problems in energy research and development.	K6
CO4	Apply characterization techniques for analysis of materials	K4
CO5	Develop materials and devices for energy storage	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K4	-	-	3	3	2
CO2	K5	1	3	3	3	3
CO3	K6	-	2	2	2	3
CO4	K5	3	3	3	2	-
CO5	K5	2	3	2	2	2
Course	K4, K5, K6	2	3	3	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester VII

Course Code: SET4355	Course Title: Advanced Thermodynamics of Energy Systems	Credits = 2		
		L	T	P
Semester: VII	Total contact hours: 30	2	0	0

List of Prerequisite Courses

SET4352-Renewable Energy Systems, SET4351-Conventional Energy and Combustion Chemistry of Fuels

List of Courses where this course will be prerequisite

SET4351-Conventional Energy and Combustion Chemistry of Fuels, SET4352-Renewable energy systems, SEP4351-Energy Laboratory – I, SEP4352-Energy Laboratory – II, SET4354-Materials for Energy Applications

Description of relevance of this course in the Int. M. Tech. Program

- To impart understanding of fundamentals of energy conversion, reversibility and irreversibility
- To study energy conversion and storage from molecular perspective

	Course Contents (Topics and subtopics)	Hours
1	Macroscopic and microscopic analysis of direct and indirect energy conversion in thermochemical, electrochemical, thermomechanical and other processes	8
2	Kinetic theory and transport phenomena in energy systems	8
3	Exergy analysis for energy conversion systems	8
4	Case studies: fossil fuels, electrochemical cells, fuel cells, photovoltaics, supercritical and combined power generation cycles	6
		30

List of Textbooks / Reference Books

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

Course Outcomes (students will be able to….)

CO1	Evaluate feasibility of a particular energy conversion process or storage	K5
CO2	Assess a process for energy efficiency using exergy analysis and recommend improvements	K4
CO3	Design efficient energy systems for recovery of waste heat, electrochemical storage, etc.	K6
CO4	Apply characterization techniques for analysis of materials	K4
CO5	Develop materials and devices for energy storage	K5

K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K5	-	-	2	3	3
CO2	K4	-	2	3	3	3
CO3	K6	1	3	3	3	3
CO4	K5	2	2	2	1	-
CO5	K5	2	2	2	2	3
Course	K4, K5, K6	2	2	2	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

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SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE

in

FOOD TECHNOLOGY

[Under the National Education Policy (NEP 2020)]

2023-2024

Offered by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra
BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

Preamble

The way the food system has changed over time has been complex and dynamic, reflecting larger shifts in society. A worldwide, industrialized food system has replaced small-scale, locally focused post-harvest processing techniques, and this transition has been driven by a number of reasons including population growth, ever increasing urbanization, technological improvements, and shifts in consumer preferences for foods. Food processing plays a crucial role in ensuring value addition, food safety, extended shelf life, convenience and accessibility to diversified food products and thus creating global economic impact. In recognition of the growing importance of food science and technology in addressing global challenges and ensuring the safety, quality, and sustainability of the world's food supply, Institute of Chemical Technology, Marathwada Campus, Jalna proudly offers a Minor Degree in Food Technology. This program is designed to provide students with a comprehensive understanding of the scientific principles of food processing, preservation, analysis of different food commodities, safety and toxicological aspects, packaging technologies, and innovations that shape the field of food processing.

This minor course is crafted to complement a major degree in chemical engineering, allowing students to broaden their knowledge base in food processing, and food analytical skills. As the food industry becomes increasingly complex and dynamic, this minor equips students with the necessary expertise to navigate and contribute to this vital sector. According to National Education Policy guidelines, the course has been designed for a total of 14 credits as per the requirements of a minor degree.

Programme Specific Outcomes (PSOs)
Multidisciplinary Minor Degree (Food Technology)

Students will be able to:

PSO1	**Understand** the basic constituents of foods and their role in processing, preservation and quality. (Factual Knowledge) (K1)
PSO2	**Select and categorize** appropriate food processing unit operations for processing and value-addition of different food commodities. (Conceptual Knowledge) (K2, K3)
PSO3	**Investigate** the compositions of foods, conduct experiments for analysis of different food commodities, evaluate food safety & quality. (Procedural Knowledge) (K4, K5)
PSO4	**Apply** knowledge of food additives, food packaging and preservation techniques for development of new food products and their safety evaluation. (Metacognitive Knowledge) (K6)
PSO5	**Cater** to the needs of food industries, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about Food Technology profession

1. **Recommended batch size: Minimum 10; Maximum 15**
2. **Duration: Three years**
3. **Eligibility criteria**

   Students enrolled in the Integrated Master of Technology in Chemical Engineering of Institute of Chemical Technology, Marathwada Campus, Jalna will be eligible. The allotment of minor degree programme will be as per the policy of the Institute.

4. **Pedagogy/ Teaching methods**

   - **Lecture/ Discussions:** These sessions will discuss the subject contents of the course.
   - **Experiential Learning:** The sessions will involve hands on training.
   - **Tutorials:** Problem solving / case studies / relevant real-life applications / student presentations / home assignments / individual or group projects

5. **Evaluation**

   Theory courses

   Continuous Assessment Tests (CATs): Continuous assessment will vary from course to course; the instructor will decide the evaluation mode. Two to three CATs will be conducted throughout the course, usually before and after the midsemester examination. These CATs will carry a total weightage of 20%. Depending on the instructor, class test, assignments, case studies, group discussions, report submission and seminar/presentation could also form part of the continuous assessment.

   Mid-semester: Total 30 Marks (Theory paper)

   End-semester: Total 50 Marks (Theory paper)

   Practical courses

   Continuous assessment: 50 Marks

   Performing given experiments as per the instructions, submission of lab journal on time, viva voce, group/ personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.

   End Semester: 50 Marks (Lab experiment performance followed by viva-voce examination)

6. Instructors: (Tentative)

Semester	Course Code	Subjects	Faculty
III	SFT4351	Food Chemistry	RFC
IV	SFT4352	Food Processing Technology – I	RFC/VF
IV	SFP4351	Food Analysis Laboratory	RFC
V	SFT4353	Food Processing Technology – II	SRS
V	SFP4352	Food Processing Laboratory	SRS
VI	SFT4354	Food Additives and Toxicology	SRS/VF
VII	SFT4355	Food Preservation and Packaging	RFC/SRS/VF

RFC: Dr. Ramesh F. Chavan, SRS: Dr. Sandhya R. Shewale, VF: Visiting Faculty

Minor Degree in Food Technology

Semester	Course Code	Subjects	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
III	SFT4351	Food Chemistry	2	1	1	0	20	30	50	100
IV	SFT4352	Food Processing Technology – I	2	1	1	0	20	30	50	100
IV	SFP4351	Food Analysis Laboratory	2	0	0	4	50	00	50	100
V	SFT4353	Food Processing Technology – II	2	1	1	0	20	30	50	100
V	SFP4352	Food Processing Laboratory	2	0	0	4	50	00	50	100
VI	SFT4354	Food Additives and Toxicology	2	1	1	0	20	30	50	100
VII	SFT4354	Food Preservation and Packaging	2	1	1	0	20	30	50	100
		TOTAL	**14**	5	5	8				

Mapping of All Courses of Food Technology with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Food Chemistry	K4	3	3	-	-	-
Food Processing Technology – I	K4	3	2	-	-	-
Food Analysis Laboratory	K4	1	3	3	-	-
Food Processing Technology – II	K4	2	3	3	-	-
Food Processing Laboratory	K4	1	1	2	2	2
Food Additives and Toxicology	K4	-	-	3	3	3
Food Preservation and Packaging	K4	-	2	3	3	3

Semester III

Course Code: SFT4351	Course Title: Food Chemistry	Credits = 2		
		L	T	P
Semester III	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Analytical chemistry (CHT4251), Basics of Organic and Inorganic Chemistry

List of Courses where this course will be prerequisite

Food Analysis Laboratory (SFP4351), Food Processing Technology – I (SFT4352), Food Processing Technology – II (SFT4353), Food Additives and Toxicology (SFT4354), Food Preservation and Packaging (SFT4355)

Description of relevance of this course in the Int. M. Tech. Program

- To understand basic physico-chemical properties and chemical structures of food components
- To understand the importance and mechanisms of the reactions of food components taking place during food processing
- To understand the significance and mechanisms of the reactions of food components taking place in storage and spoilage
- To think critically on the role of water and its various forms in food preservation
- To understand the role of food constituents responsible for nutritional, and aesthetic quality of foods (such as texture, flavor, and color)
- To apply course concepts in solving problems related to food constituents

Sr. No.	Course Contents	Required Hours
1	Introduction to the constituents of foods: Water in food systems: Chemistry, properties and food significance	3
2	Carbohydrates: Classification, Analysis, Physicochemical and functional properties of carbohydrates	7
3	Proteins: Classification, Analysis, Physicochemical and functional properties	6
4	Lipids: Classification, Analysis, Physicochemical and functional properties	6
5	Vitamins: Classification, Analysis, Physicochemical and functional properties	4
6	Minerals: Classification, Analysis, Physicochemical and functional properties	4
	Total	**30**

List of Textbooks / 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)
Course Outcomes (Students will be able to….)	
CO1	Understand the various constituents present in foods and their roles therein (K2)
CO2	Describe the mechanisms and significance of physicochemical reactions involved in food processing and subsequent storage (K2)
CO3	Describe the mechanisms and significance of physicochemical reactions involved in spoilage of foods (K2)
CO4	Explain the significance of water in food quality, preservation and storage (K3)
CO5	Describe and demonstrate the role of food constituents on nutritional/anti-nutritional and aesthetic quality of raw and processed foods (K4)
CO6	Extrapolate the knowledge gained on food composition to practical problems in food quality (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	3	1	-	-
CO2	K2	3	2	-	-	-
CO3	K2	3	3	1	-	-
CO4	K3	3	3	-	-	-
CO5	K4	3	2	1	-	-
CO6	K4	3	3	-	-	-
Course	K4	3	3	-	-	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester IV

Course Code: SFT4352	Course Title: Food Processing Technology-I	Credits = 2		
		L	T	P
Semester: V	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Food Chemistry (SFT4351), Food Analysis Laboratory (SFP4351) (Simultaneous)

List of Courses where this course will be prerequisite

Food Processing Technology – II (SFT4353), Food Additives and Toxicology (SFT4354), Food Preservation and Packaging (SFT4355)

Description of relevance of this course in the Int. M. Tech. Program

- To understand the principles of food processing and preservation
- To understand processing and preservation of fruits and vegetables, plantation crops, meat and meat products
- To analyse/ design/ modify new products/processes for processing and value-addition of post-harvest commodities, meat, and meat products
- To learn different commercial processing techniques for value addition
- To understand the application of processing and preservation for product development

Sr. No.	Course Contents	Required Hours
1	Principles of food processing and preservation; unit operations in food processing (mechanical separation processes, food conversion operations, material handling etc.)	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
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
4	Technology of meat, fish, poultry and egg processing: Meat processing operations; egg processing and preservation; processing of fish and marine products.	8
	Total	**30**

List of Textbooks / Reference Books	
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
Course Outcomes (Students will be able to…..)	
CO1	Understand the principles of food processing and preservation (K2)
CO2	Understand and apply the processing and preservation of different foods (K3)
CO3	Apply processing techniques for value-addition of post-harvest commodities, meat, and meat products (K3)
CO4	Analyse processes for preservation and value addition of different food commodities (K4)
CO5	Apply and analyse various techniques of by-product processing and waste utilization (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	2	3	-	-	-
CO2	K2	2	3	1	-	-
CO3	K2	3	2	-	-	-
CO4	K3	2	3	1	-	-
CO5	K4	2	3	-	-	-
CO6	K4	2	3	1	-	-
Course	K4	3	2	-	-	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester IV

Course Code: SFP4351	Course Title: Food Analysis Laboratory	Credits = 2		
		L	T	P
Semester: IV	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Food Chemistry (SFT4351), Introduction to Biological Sciences (BST4251)

List of Courses where this course will be Prerequisite

Food Processing Technology – I (SFT4352), Food Processing Technology – II (SFT4353), Food Additives and Toxicology (SFT4354), Food Processing Laboratory (SFP4352), Food Preservation and Packaging (SFT4355)

Description of relevance of this course in the Int. M. Tech. Program

- To give students hands on training on chemical analysis of specific food products
- To analyse and quantify the quality attributes of food
- To identify and analyse the food adulterants
- To train the students on different biochemical assay for food products

Sr. No.	Course Contents	Required Hours
1	Proximate composition in food	8
2	Analysis of milk and dairy products	4
3	Analysis of wheat flour	4
4	Analysis of tea and coffee	4
5	Estimation of phytochemicals	8
6	Analysis of Food adulteration	4
7	Discriminative and Descriptive Sensory analysis of Foods	8
8	Demo of colorimeter, texture analyzer, DSC, etc.	4
9	Demo of HPLC, GC-MS, etc.	4
10	Demo of spray drier, extruder, SCFE, Tray drier etc.	4
11	Microbial assay	4
12	Enzyme assay	4
	Total	**60**

List of Textbooks / Reference Books

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
Course Outcomes (Students will be able to….)	
CO1	Demonstrate the knowledge of redox chemical reactions to develop a protocol for analysing specific food attributes (K2)
CO2	Interpret different chemical and biochemical analysis specific to food (K2)
CO3	Compare protocols on different types of chemicals and sensory analysis in foods (K2)
CO4	Apply and infer about the principles of different enzyme and microbial assays (K3)
CO5	Perform microbial assay, enzyme assay, etc. (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	1	3	3	-	-
CO2	K4	1	3	3	-	-
CO3	K3	1	3	3	-	-
CO4	K2, K3	1	2	2	-	-
CO5	K4	1	2	3	-	-
Course	K4	1	3	3	-	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester V

Course Code: SFT4353	Course Title: Food Processing Technology-II	Credits = 2		
		L	T	P
Semester: V	Total contact hours: 30	1	1	0

List of Prerequisite Courses

Food Processing Technology-I (SFT4352), Food Chemistry (SFT4351)

List of Courses where this course will be prerequisite

Food Additives and Toxicology (SFT4354), Food Preservation and Packaging (SFT4355)

Description of relevance of this course in the Int. M. Tech. Program

- To understand the basics of various unit operations in food processing
- To understand the processing and milling of cereal, legume and oilseeds
- To differentiate various dairy products and the equipment's used for its processing
- To differentiate various bakery and confectionary products and the equipment's used for its processing
- To learn different commercial processing techniques for value addition

Sr. No.	Course Contents	Required Hours
1	Recent advances in product and process development; important aspects of process and equipment design for food processing; CGMP/HACCP.	**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**
3	Technology of milk and dairy processing: Dairy developments in India; sampling and quality testing of milk; processing technology of dairy products.	**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**
	Total	**30**

List of Textbooks / Reference Books	
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)
Course Outcomes (Students will be able to…..)	
CO1	Understand the basic knowledge of food processing and value addition (K2)
CO2	Develop an overall understanding of cereal, legume and oilseeds processing aspect (K2)
CO3	Design/ develop processing technology for bakery, confectionary, and dairy products (K3)
CO4	Understand and extrapolate importance of by-product processing and waste utilization (K3)
CO5	Analyse and apply the processing technology for value addition and new product development (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	-	-	-	-
CO2	K2	2	3	3	-	-
CO3	K2	2	3	3	-	1
CO4	K2, K3	2	3	3	1	1
CO5	K4	3	-	-	-	1
Course	K4	2	3	3	-	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester V

Course Code: SFP4352	Course Title: Food Processing Laboratory	Credits = 2		
		L	T	P
Semester: VI	Total contact hours: 60	0	0	4

List of Prerequisite Courses

Food Processing Technology-I (SFT4352), Food Processing Technology-II (SFT4352-) (Simultaneous), and Food Chemistry (SFT4351)

List of Courses where this course will be Prerequisite

Food Preservation and Packaging (SFT4355)

Description of relevance of this course in the Int. M. Tech. Program

- To analyze the integration of processing in food formulations
- To design and develop the process flow chart for any product development
- To design the product and process formulations in food industry
- To evaluate the processing cost of any developed product

Sr. No.	Course Contents	Required Hours
1	Preparation of tomatoes products (minimum three types)	**6**
2	Preparation of fruit preserves from selected fruits (minimum three types)	**6**
3	Preparation of selected bakery products (minimum three types)	**8**
4	Preparation of fermented food products (minimum three types)	**4**
5	Preparation of value-added poultry/meat/ egg products (minimum three types)	**8**
6	Preparation of fried products (minimum three types)	**4**
7	Preparation of milk based food products (minimum three types)	**4**
8	Preparation of sugar based sweets/traditional Indian confection products (minimum three types)	**4**
9	Preparation of extrudate snack products (minimum three types)	**4**
10	Preparation of non-alcoholic beverages (minimum three types)	**4**
11	Preparation of soy-based food products (minimum three types)	**4**
12	Demonstration and preparation of dehydrated food product using spray, cabinet or vacuum dryer	**4**
	Total	**60**

List of Textbooks / Reference Books

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, CRC Press,UK
4	Preservation of Fruits and Vegetables by Giridhari Lal, G.S. Siddappa, G.L.Tandon in 1998, ICAR,New Delhi.
Course Outcomes (Students will be able to…..)	
CO1	Apply the knowledge of material balance specific to different food processing operations (K3)
CO2	Explain the major processing steps applied for food preparations (K3)
CO3	Use different food processing equipment specific to the product (K3)
CO4	Develop and analyse protocol for different types of food preparations (K4)
CO5	Apply the engineering principles to design novel food product and process (K5)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	1	-	-	-	-
CO2	K2	1	3	3	-	-
CO3	K2	2	3	3	-	-
CO4	K2, K3	3	3	3	-	-
CO5	K5	2	3	3	-	2
Course	K4	1	1	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester VI

Course Code: SFT4354	Course Title: Food Additives and Toxicology	Credits = 2		
		L	T	P
Semester: VI	Total Contact Hours: 30	1	1	0

List of Prerequisite Courses

Food Chemistry (SFT4351), Food Processing Technology I (SFT4352), and Food Processing Technology II (SFT4353)

List of Courses where this course will be Prerequisite

Food Preservation and Packaging (SFT4355)

Description of relevance of this course in the Int. M. Tech. Program

- To understand the significance of different food additives in quality, preservation and storage of foods
- To understand the safety of use of different food additives
- To understand the effect of different process conditions on stability of food additives
- To understand the food hazards and food safety aspects

Sr. No.	Course Contents (Topics and subtopics)	Required Hours
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
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
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
4	Types of food hazards: biological, chemical and physical; Risk assessment; Existing and emerging pathogens due to globalisation of food trade.	6
	Total	30

List of Textbooks / Reference Books

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
Course Outcomes (Students will be able to…..)	
CO 1	Understand the importance and mechanisms of action of different food additives in processing, preservation and storage of food (K2)
CO 2	Understand and apply the toxicity and safety aspects of use of food additives (K3)
CO 3	Analyse the hazards to food products and importance of food safety evaluation system (K4)
CO 4	Extrapolate the knowledge gained on food additives in food industries (K3)
CO 5	Carry out application of food additives in new product development (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	-	-	3	2	3
CO2	K2	1	3	3	2	3
CO3	K2	-	2	2	3	3
CO4	K2, K3	2	3	3	3	3
CO5	K4	2	3	3	3	3
Course	K4	-	-	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester VII

Course Code: SFT4355	Course Title: Food Preservation and Packaging	Credits = 2		
		L	T	P
Semester: VI	Total Contact Hours: 30	1	1	0

List of Prerequisite Courses

Food Chemistry (SFT4351), Food Processing Technology-I (SFT4352), and Food Processing Technology-II (SFT4353)

List of Courses where this course will be Prerequisite

None

Description of relevance of this course in the Int. M. Tech. Program

- To understand the role of food packaging in food preservation
- To understand the various food packaging materials and their applications with respect to various food commodities
- To understand different types of package testing methods employed to evaluate quality, performance and safety of food packaging materials
- To understand various food-package interactions and environmental issues related to packaging.
- To understand newer food packaging application technologies

Sr. No.	Course Contents (Topics and subtopics)	Required Hours
1	Introduction to food preservation and packaging: causes of food spoilage; factors affecting food spoilage; packaging as a method for preservation of foods.	06
2	Food packaging materials and its interaction: Different materials used in food packaging such as paper, glass, metal containers, plastics, laminates/ composites; Food and Packaging material interactions including migration.	08
3	Newer packaging technologies: VP/CAP/MAP; aseptic processing and packaging; active and intelligent packaging; Non-thermal preservation technology	12
5	Quality evaluation of packaging materials: Testing of various packaging materials and packages for evaluation of quality; Shelf life analysis.	04
	Total	**30**

List of Textbooks / Reference Books

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
Course Outcomes (Students will be able to…..)	
CO1	Gain the ability to perform the root cause analysis of any food spoilage (K4)
CO2	Understand the role of food packaging in food preservation (K2)
CO3	Analyze different food packaging materials and their properties and application to various food commodities (K4)
CO4	Comprehend food and packaging material interactions (K3)
CO5	Ability to develop the strategies to preserve the food products (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	-	-	2	3	3
CO2	K2	-	2	3	3	3
CO3	K2	1	3	3	2	3
CO4	K2, K3	1	3	3	2	3
CO5	K4	-	-	2	3	3
Course	K4	-	2	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

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SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE (MDM)

in

PHARMACEUTICAL CHEMISTRY & TECHNOLOGY

Under the National Education Policy (NEP 2020)

Offered by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra
BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

Preamble

Welcome to the Multidisciplinary minor in Pharmaceutical Chemistry and Technology at the Institution of Chemical Technology Mumbai, Marathwada campus, Jalna. The pharmaceutical sector is a dynamic, intricate industry that continually evolves to satisfy the needs of patients around the globe. Recent years have seen a significant change in the use of technology in the healthcare industry, particularly in how drugs are discovered, developed and administered to patients. The pharmaceutical science and technology field has undergone dynamic and varied development, reflecting societal shifts on a larger scale. Pharmaceutical science and technology advancements have influenced how drug compounds and products are manufactured, formulated, discovered and delivered.

In light of this, a new minor degree course called "Pharmaceutical Science and Technology" has been designed to cover a range of topics related to pharmaceutical science and technology. The course is created to give students a fundamental understanding of these topics and help them develop their knowledge and skills in this field. The course has been developed in accordance with National Education policy guidelines, and it is worth 14 credits towards a minor degree. This specialised program is designed to provide students with a comprehensive understanding of the fundamental concepts in the pharmaceutical sciences and cutting-edge technologies that drive innovation in the pharmaceutical industry. This course aims to cultivate a deep understanding of the latest technological advancements in pharmaceutical manufacturing, quality control, regulatory affairs, drug discovery and drug delivery systems through hands-on experiences and practical training, including proficiency in state-of-the-art laboratory techniques and technologies. The particular course can encourage collaboration across various disciplines, fostering an environment where students can integrate knowledge from Pharmaceutical Technology, Chemical Engineering, and Chemical Technology. The broad goal is to nurture allied professionals who can contribute significantly to the evolution of pharmaceutical technologies to ensure the safe, economical and practical application of pharmaceutical products for the benefit of society.

Programme Specific Outcomes (PSOs) for MDM in Pharmaceutical Sciences and Technology

PSO1	Understand the theoretical and practical knowledge of pharmaceutical sciences and technology, which consists of dosage form design, routes of administration of various drugs, their mechanism of action, and the regulation of drugs and the fine chemical manufacturing etc. (Factual Knowledge) (K1)
PSO2	Able to choose appropriate equipment/s, or process/processes for manufacturing of active pharmaceutical ingredients, suitable dosage forms, and drug analysis, or choose an appropriate model/s for a drug discovery etc. (Conceptual Knowledge) (K2, K3)
PSO3	Investigate, conduct experiments, research, or model, analyse data to solve complex problems of pharmaceutical formulation technology and drug discovery and prepare the valid technical reports (Procedural knowledge) (K4, K5)
PSO4	Able to translate emerging science and technologies into innovative pharmaceutical products applying principles and knowledge gained throughout the program or to develop new methodologies through research (Metacognitive Knowledge) (K6)
PSO5	**Cater** to the needs of pharmaceutical industries, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about pharmaceutical profession

1. **Recommended batch size:** Minimum 10 Maximum 15
2. **Duration:** Three years
3. **Eligibility criteria:**
   Students enrolled in the Integrated M. Tech at the Institute of Chemical Technology, Marathwada Capus, Jalna, shall be eligible. The allotment to the minor degree programme will be as per the policy of the Institute.
4. **PEDAGOGY/TEACHING METHODS:**
   Lecture/Discussions: These sessions will discuss the subject matters of the course

   Experiential Learning: The sessions will involve hands-on training.

   Tutorials: Problem solving/case studies/relevant real-life applications/student presentations/home assignments/individual or group projects
5. **Evaluation**
   Theory courses
   Continuous Assessment Tests (CATs): Continuous assessment will vary from course to course; the instructor will decide the evaluation mode. Two to three CATs will be conducted throughout the course, usually before and after the midsemester examination. These CATs will carry a total weightage of 20%. Depending on the instructor, class test, assignments, case studies, group discussions, report submission and seminar/presentation could also form part of the continuous assessment.

   Mid-semester: Total 30 Marks (Theory paper)

End-semester: Total 50 Marks (Theory paper)

Practical courses

Continuous assessment: 50 Marks

Performing given experiments as per the instructions, submission of lab journal on time, viva voce, group/ personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.

End Semester: 50 Marks (Lab experiment performance followed by viva-voce examination)

6. Instructors (Tentative)

Semester	Course Code	Subjects	Faculty
III	SRT4351	Introduction to Pharmaceutical Technology	NTH
IV	SRT4352	Pharmaceutical Chemistry	NTH
IV	SRP4351	Pharmaceutical Analysis Laboratory	NTH
V	SRT4353	Formulation Technology and Drug Delivery	NTH
V	SRP4352	Pharmaceutical Chemistry and Formulation Technology Laboratory	NTH
VI	SRT4354	Pharmaceutical Technology and Drug Design	NTH
VII	SRT4355	Process Development for Fine Chemicals and API	NTH

Minor Degree in Pharmaceutical Chemistry and Technology

Course Code	Sem	Subjects	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
SRT4351	III	Introduction to Pharmaceutical Technology	2	2	0	0	20	30	50	100
SRT4352	IV	Pharmaceutical Chemistry	2	2	0	0	20	30	50	100
SRP4351	IV	Pharmaceutical Analysis Laboratory	2	0	0	4	50		50	100
SRT4353	V	Formulation Technology and Drug Delivery	2	2	0	0	20	30	50	100
SRP4352	V	Pharmaceutical Chemistry and Formulation Technology Laboratory	2	0	0	4	50		50	100
SRT4354	VI	Pharmaceutical Technology and Drug Design	2	2	0	0	20	30	50	100
SRT4355	VII	Process Development for Fine Chemicals and API	2	2	0	0	20	30	50	100
		TOTAL:	**14**	**10**	**0**	**8**				

Mapping of All Courses of Pharmaceutical Chemistry and Technology with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Introduction to Pharmaceutical Technology	K4	3	3	3	3	3
Pharmaceutical Chemistry	K4	3	3	2	2	2
Pharmaceutical Analysis Laboratory	K4	2	3	3	2	3
Formulation Technology and Drug Delivery	K4	2	3	2	2	3
Pharmaceutical Chemistry and Formulation Technology Laboratory	K4	2	3	2	2	3
Pharmaceutical Technology and Drug Design	K4	2	3	3	3	3
Process Development for Fine Chemicals and API	K4	3	2	2	2	3

Semester III

Course Code: SRT4351	Course Title: Introduction to Pharmaceutical Technology	Credits = 2		
		L	T	P
Semester: III	Total Contact Hours: 30	1	1	0

List of Pre-requisite Courses

OE: Biology

List of Courses where this course will be a pre-requisite

Pharmaceutical Chemistry (SRT4352), Formulation Technology and Drug Delivery (SRT4353), Process Development for Fine Chemicals and API (SRT4355)

Description of relevance of this course in the Int. M. Tech. Program

- Students are required to know various aspects of the Technology of Pharmaceuticals and Fine Chemicals.
- This subject will fulfil the need to build an additional professional career in the Pharmaceutical Sector.

Course Contents (Topics and Subtopics)		
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
2	Overview of Pharmaceutical Industry; Origin & development of the pharmacopoeia – IP/BP/USP, Introduction to Monograph and Biopharmaceutics	4
3	Dosage form: Definition and classification based on route of administration, physical form along with special emphasis on Monophasic (Oral and Topicals) (solution, syrups, elixirs, linctus, glycerites, nasal drops, ear drops, etc.), Biphasic, Ointments, Creams, Gels, Suppositories, Aerosols - Suspensions and Emulsions	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, Antifungal, Anti-tubercular, Anticancer agents, etc.	14
	Total	**30**

Suggested/ Reference books

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
Course Outcomes (Upon completion of the course)	
CO1	Students will be able to know the cultivation/control methods for the diversity of microorganisms and their physiology.
CO2	Know the different drug categories.
CO3	Students will be able to understand general principles of Pharmacology, including pharmacokinetics and Pharmacodynamics.
CO4	Students will be able to conceptualise and develop monophasic, biphasic and other products.
CO5	Students will be able to comprehend Anti-malarial, Antifungal, Anti-tubercular drugs

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	1	1	3	2	2
CO2	K2	3	2	2	3	3
CO3	K2	3	3	3	1	2
CO4	K3	3	3	3	3	3
CO5	K3	3	3	3	3	3
Course	K4	3	3	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester IV

Course Code: SRT4352	Course Title: Pharmaceutical Chemistry	Credits = 2		
		L	T	P
Semester: IV	Total Contact Hours: 30	1	1	0

List of Pre-requisite Courses

Introduction to Pharmaceutical Technology (SRT4351)

List of Courses where this course will be pre-requisite

Pharmaceutical Chemistry and Formulation Technology Laboratory (SRP4352), Pharmaceutical Technology and Drug Design (SRT4354), Process Development for Fine Chemicals and API (SRT4355)

Description of relevance of this course in the Int. M. Tech. Program

- This course is designed to acquaint students with nomenclature, classification, the molecular mechanism of action, synthesis and SAR of (a) Anti-infective agents, (b) Anti-histaminic agents, (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 with to train the students with the basics of Medicinal Natural Products and Phytochemistry

	Course Contents (Topics and Subtopics)	Hours
1	Classification of Drugs and their molecular targets: Enzymes, proteins and receptors as drug targets	4
2	Overview of Antibacterial agents; Antiparasitic agents; Antifungal agents; Antimycobacterial agents; Anticancer agents; Antiviral agents; Drugs Affecting the Central Nervous System; Cholinergic Drugs; Adrenergic Drugs; Analgesics	15
3	Introduction to Anti-inflammatory drugs; Cardiovascular Drugs; Drugs acting on hormonal systems; Other miscellaneous Classes of drugs	11
	Total	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
Course Outcomes (Upon completion of the course)	
CO1	Students will be able to classify drugs based on different methods. (K2)
CO2	Students will be able to explain the SAR and MOA of drugs at the molecular level of understanding. (K2)
CO3	Students will be able to apply principles of drug discovery from hit to lead to preclinical molecules. (K2)
CO4	Students will be able to theoretically predict the absorption distribution, metabolism and excretion of drugs and the related concepts of prodrugs. (K3)
CO5	Students will be able to evaluate the effect of functional groups on the bioactivity and the toxicity. (K4)

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	2	2	1	2	3
CO2	K2	3	3	3	3	3
CO3	K2	3	3	2	3	2
CO4	K3	3	3	2	2	2
CO5	K4	3	2	2	2	2
Course	K4	3	3	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester IV

Course Code: SRP4351	Course Title: Pharmaceutical Analysis Laboratory	Credits = 2		
		L	T	P
Semester: IV	Total Contact Hours: 60	0	0	4

List of Pre-requisite Courses

Chemistry Laboratory

List of Courses where this course will be pre-requisite

None

Description of relevance of this course in the Int. M. Tech. Program

- The course is designed to enable students to operate the instruments, understand their instrumentation, prepare solutions with accurate concentrations, measure the readings, calculate and interpret the results obtained, and familiarise themselves with accelerated stability testing for shelf life calculations.

Sr. No.	Course Contents (Topics and Subtopics)	Reqd. Hours
1	UV spectrophotometric estimation of two components formulation by simultaneous equation method and by absorbance ratio method, Eg Caffeine and Sodium benzoate injection	4
2	UV spectrophotometric estimation of formulation by Difference spectroscopy: Eg: Phenylephrine HCl ophthalmic solution	4
3	Assay of finished products by UV spectroscopy (any two), using A (1%, 1 cm), e.g. Paracetamol tablets, Propranolol tablets/Atenolol tablets/Hydrochlorothiazide tablets/Frusemide tablets/Albendazole tablet/Rifampicin capsules (two examples)	4
4	Solubility determination of any drug/formulation by using UV spectroscopy	4
5	Separation and identification of drug/Intermediate by TLC/Column chromatography	8
6	Experiments based on HPLC, e.g. quantification of impurities in APIs	8
7	Gas Chromatography (GC) handling and analyses of API intermediates	4
8	Detection of residual solvent in the formulation by using Gas Chromatography	4
9	Working on FTIR and Interpretation of IR spectra of any one drug.	4
10	Polarimetry: Different concentrations of sugar, determination of unknown concentration and specific rotation	4
11	Assay of streptomycin injection/Salicylic acid by using Colorimetry (Construction of calibration curve using linear regression analysis)	8

12	Accelerated stability testing of any suitable drug/ formulation, Problems based on Arrhenius equation for shelf life calculations	**8**
	Total	**60**
List of Textbooks/Reference Books		
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	
Course Outcomes (Upon completion of the course)		
CO1	Students will be able to record the absorbance and calculate the analyte concentration in formulation or as an API by using A (1%, 1cm) by UV spectrophotometer.	
CO2	Students will be able to develop and optimise mobile phase composition for qualitative analysis by TLC and interpret qualitative analysis data by TLC.	
CO3	Students will be able to outline the workings and applications of HPLC.	
CO4	Students will be able to outline the working and application of GC.	
CO5	Students will be able to understand the sample preparation technique for FTIR spectroscopy and interpret the IR spectra to identify the functional groups.	

Mapping of Course Outcomes (Cos) with Programme Specific Outcomes (PSOs						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	2	3	3	2	3
CO2	K2	2	3	3	2	2
CO3	K3	2	3	3	2	2
CO4	K3	2	3	3	2	2
CO5	K4	3	2	2	2	2
Course	K4	2	3	3	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester V

Course Code: SRT4353	Course Title: Formulation Technology and Drug Delivery	Credits = 2		
		L	T	P
Semester: V	Total Contact Hours: 30	1	1	0

List of Pre-requisite Courses

Introduction to Pharmaceutical Technology (SRT4351)

List of Courses where this course will be pre-requisite

Pharmaceutical Chemistry and Formulation Technology Laboratory (SRP4352)

Description of relevance of this course in the Int. M. Tech. Program

- This course is designed to train the students with respect to basics and application of technology of solid and sterile dosage forms and introduce novel drug delivery systems, validations and regulatory requirements of pharmaceuticals.

	Course Contents (Topics and Subtopics)	Hours
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	10
2	Introduction to capsules; Preformulation considerations for capsule dosage form; Hard and soft gelatin capsules: formulation considerations, capsule manufacture equipment, quality control tests, packaging, Large scale manufacture, layout design; Microencapsulation;	5
3	Facility design for parenteral manufacture with focus on air systems HEPA filters, environmental classes for manufacture of parenterals; Methods of sterilisation; 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.	10
4	Introduction to Quality by Design, Validation, Documentation and Regulatory bodies for pharmaceuticals.	5
	Total	**30**

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.
Course Outcomes (Upon completion of the course)	
CO1	Students will be able to describe preformulation, formulation, unit operation, large-scale manufacturing, and layout design of tablets.
CO2	Students will be able to explain the coating polymers, technology and equipments used for coating of tablets and describe microencapsulation techniques.
CO3	Students will be able to describe formulations for hard and soft gelatin capsules and machinery used for filling.
CO4	Students will be able to describe the preformulation, formulation, evaluation, packaging, large-scale manufacturing and facility design of parenteral products.
CO5	Students will be able to describe product and process validation and documentation required for the pharmaceuticals.

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	3	3	2	2
CO2	K2	2	2	2	2	2
CO3	K3	2	2	2	2	2
CO4	K3	3	2	2	3	3
CO5	K4	2	2	2	3	3
Course	K4	2	3	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester V

Course Code: SRP4352	Course Title: Pharmaceutical Chemistry and Formulation Technology Laboratory	Credits = 2		
		L	T	P
Semester: V	Total Contact Hours: 60	0	0	4

List of Pre-requisite Courses

Pharmaceutical Chemistry (SRT4352), Formulation Technology and Drug Delivery (SRT4353) (Simultaneous)

List of Courses where this course will be pre-requisite

None

Description of relevance of this course in the Int. M. Tech. Program

- The course is designed to train the students with respect to practical aspects of green chemistry while preparing the commonly used organic compounds as a drug. It also introduces the students to advanced formulation development technology.

	Course Contents (Topics and Subtopics)	Hours
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
2	Preparation and evaluation of Transdermal/ophthalmic gels	4
3	Preparation of Eye drops/ and Eye ointments	4
4	Preparation of Creams (cold/vanishing cream)	4
5	Preparation of Paracetamol paediatric elixir	4
6	Preparation and evaluation of microspheres of paracetamol	4
7	Preparation and evaluation of microspheres of losartan	4
8	Solubilisation of drugs by complexation with *β*-Cyclodextrin	4
9	Solubilisation of drugs *via* co-crystallization	4
10	Evaluation of Glass containers (as per IP)	8
11	Synthesise of Aspirin from the salicylic acid	4
12	Synthesis of Phenytoin from Benzil	4
13	Synthesis of Benzocaine from *p*-aminobenzoic acid	4
14	Synthesis of Paracetamol from *p*-aminophenol	4
	Total	**60**

List of Textbooks/Reference Books	
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)
6	Strategies for Organic Drug Synthesis and Design, 2nd Edition, Daniel Lednicer, Wiley (2008)
Course Outcomes (Upon completion of the course)	
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, purification and structural characterisation skills.

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	3	3	2	3
CO2	K2	2	2	2	2	2
CO3	K3	2	2	2	2	2
CO4	K4	3	2	2	2	3
CO5	K4	2	2	3	3	3
Course	K4	2	3	2	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester VI

Course Code: SRT4354	Course Title: Pharmaceutical Technology and Drug Design	Credits = 2		
		L	T	P
Semester: VI	Total Contact Hours: 30	1	1	0

List of Pre-requisite Courses

Introduction to Pharmaceutical Technology (SRT4351), Pharmaceutical Chemistry (SRT4352)

List of Courses where this course will be pre-requisite

None

Description of relevance of this course in the Int. M. Tech. Program

- This course is designed to teach the students how physicochemical properties / QSAR/ other computational techniques play a role in designing, developing and optimising the structure of leads.

	Course Contents (Topics and Subtopics)	Hours
1	Introduction to Historical and Modern Drug Discovery- Sources of drugs/leads, Serendipity, random screening, natural sources, analogue-based design, Rational drug design, Techniques and tools in modern drug discovery, Introduction to QSAR, SBDD and LBDD, Concepts of privileged structures and chemical diversity	4
2	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
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	8
4	Molecular Mechanics and Energy Minimization: General features of force fields, cross terms, force field parameterisation, Energy minimisation – non-derivative and derivative methods, applications of energy minimisation	5
5	Docking by different techniques	4
6	Role of Natural Products (NPs) in New Drug Discovery: A few selected NPs, with different pharmacophores, their sources, purification and drug-target interactions. Case studies of taxol, artemisinin, etc	5
	Total	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
Course Outcomes (Upon completion of the course)	
CO1	Students will be able to understand the basics of QSAR for applications in drug design.
CO2	Students will be able to understand the basics of the physicochemical properties of drugs and their implications.
CO3	Students will be able to design new potential therapeutic molecules using structure-based drug design.
CO4	Students will be able to design new potential therapeutic molecules using ligand-based drug design.
CO5	Students will be able to rationalise natural products' contribution to new drug discovery.

Mapping of Course Outcomes (Cos) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5+K6	K6
CO1	K2	2	3	2	3	3
CO2	K2	2	3	3	3	3
CO3	K3	2	3	3	3	3
CO4	K4	2	3	3	3	3
CO5	K4	2	3	3	3	3
Course	K4	2	3	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester VII

Course Code: SRT4355	Course Title: Process Development for Fine Chemicals and API	Credits = 2		
		L	T	P
Semester: VII	Total Contact Hours: 30	1	1	0

List of Pre-requisite Courses

Introduction to Pharmaceutical Technology (SRT4351), Pharmaceutical Chemistry (SRT4352)

List of Courses where this course will be pre-requisite

None

Description of relevance of this course in the Int. M. Tech. Program

- This course is designed to help students understand the principles of chemical process development for API and fine chemicals and acquire knowledge of green chemistry, process safety, and hazards.

	Course Contents (Topics and Subtopics)	Hours
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
2	Status of pharmaceutical industry: Status of bulk drugs, natural products and formulations in India vis-a-vis industrialised nations	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
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
5	Selected Fine Chemical Technologies with examples: Alkylation, Halogenation, Oxidation, Reduction, Esterification, Nitration, and Hydrogenation	4
6	Impurity Considerations: Introduction, Steps to optimising reactions, Minimising impurity formation by identifying impurities first, Method development for separation, Synthesis and Isolation of impurities and their characterisation	4
	Total	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)
Course Outcomes (Upon completion of the course)	
CO1	Students will be able to understand the principles of process design along with the selection of different routes. (K2)
CO2	Students will be able to get insights into underlying technologies in the manufacturing of various APIs (K2)
CO3	Students will be able to differentiate between bulk drugs and fine chemicals and state their various applications in industry and daily life. (K3)
CO4	Students will be able to explore the process of manufacturing a variety of fine chemicals. (K4)
CO5	Students will be able to apply steps to optimising reactions, and minimising impurities. (K4)

Mapping of Course Outcomes (Cos) with Programme Specific Outcomes (PSOs

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	2	2	2	3
CO2	K2	2	3	2	3	3
CO3	K3	2	3	3	2	2
CO4	K4	3	2	2	3	3
CO5	K4	3	2	3	3	3
Course	K4	3	2	2	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

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SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE

in

POLYMER AND MATERIALS ENGINEERING

[Under the National Education Policy (NEP 2020)]

2023-2024

Offered by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra
BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

Preamble

This field lies at the intersection of chemistry, physics, and engineering, focusing on the study and manipulation of materials to meet the demands of modern technological advancements. Throughout this program, students will study the fundamental principles governing the behavior, properties, and applications of materials, with a specific emphasis on polymers – versatile compounds with a wide range of applications. The Polymer and Materials Engineering Minor curriculum is designed to provide students with a comprehensive understanding of materials science and engineering principles, as well as specialized knowledge in polymer chemistry, processing, and characterization techniques. Students will gain hands-on experience through laboratory work, projects, and industry collaborations, preparing them for careers in diverse sectors such as aerospace, automotive, electronics, healthcare, and sustainable technologies. By exploring topics such as material synthesis, structure-property relationships, and polymer processing, students will develop the critical thinking skills and technical expertise necessary to address complex challenges in materials design, performance optimization, and sustainability.

Designed according to the National Education Policy guidelines, the minor degree course in Polymer and Materials Engineering offers students the chance to explore diverse domains within the field. With 14 credits, students will delve into fundamental principles and emerging scientific and technological advancements, preparing them for a rewarding career in polymer and materials engineering.

Programme Specific Outcomes (PSOs) for Multi-Disciplinary Minor in Polymer and Materials Engineering

PSO1	**Understand** different terminologies and fundamental concepts related to Polymer and Material Engineering (Factual Knowledge).
PSO2	**Comprehend** different theories and models, equipment, or processes to meet the specified needs considering feasibility, safety, health hazards, societal, economic, environmental or sustainability factors as well as critically analyse relationships between these factors (Conceptual Knowledge)
PSO3	**Demonstrate** the knowledge, skills, and practical experience necessary to pursue careers in industries such as manufacturing, automotive, aerospace, biomedical, and electronics, or to pursue further studies in graduate programs related to materials science and engineering (Procedural Knowledge).
PSO4	**Apply** the ability to analyze complex materials-related problems, identify innovative solutions, and make informed decisions based on scientific principles and engineering considerations (Metacognitive Knowledge).
PSO5	**Cater** to the needs of polymer industries, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about Polymer Engineering profession

1. **Recommended batch size: Minimum 10; Maximum 15**
2. **Duration: Three years**
3. **Eligibility criteria**

   Students enrolled in the Integrated Master of Technology in Chemical Engineering of Institute of Chemical Technology, Marathwada Campus, Jalna will be eligible. The allotment of minor degree programme will be as per the policy of the Institute.

4. **Pedagogy/ Teaching methods**

   - **Lecture/ Discussions:** These sessions will discuss the subject contents of the course.
   - **Experiential Learning:** The sessions will involve hands on training.
   - **Tutorials:** Problem solving / case studies / relevant real-life applications / student presentations / home assignments / individual or group projects

5. **Evaluation**

   Theory courses

   Continuous Assessment Tests (CATs): Continuous assessment will vary from course to course; the instructor will decide the evaluation mode. Two to three CATs will be conducted throughout the course, usually before and after the midsemester examination. These CATs will carry a total weightage of 20%. Depending on the instructor, class test, assignments, case studies, group discussions, report submission and seminar/presentation could also form part of the continuous assessment.

Mid-semester: Total 30 Marks (Theory paper)

End-semester: Total 50 Marks (Theory paper)

Practical courses

Continuous assessment: 50 Marks

Performing given experiments as per the instructions, submission of lab journal on time, viva voce, group/ personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.

End Semester: 50 Marks (Lab experiment performance followed by viva-voce examination) presentations / home assignments / individual or group projects

6. Instructors (Tentative)

Semester	Course Code	Subjects	Faculty
III	SMT4351	Introduction to Material Technology	AMS/NK
IV	SMT4352	Polymer Science and Technology- I	AMS/NK
IV	SMP4351	Synthesis and Characterization of Resins and Polymers	AMS/NK
V	SMT4353	Polymer Science and Technology- II	AMS/NK
V	SMP4352	Materials Processing Laboratory	AMS/NK
VI	SMT4354	Material Processing	GJ/NK
VII	SMT4355	Structure-Property Relationship	GJ/AMS/NK

MDM Course in Polymer and Materials Engineering

Semester	Course Code	Subjects	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
III	SMT4351	Introduction to Material Technology	2	2	0	0	20	30	50	100
IV	SMT4352	Polymer Science and Technology- I	2	2	0	0	20	30	50	100
IV	SMP4351	Synthesis and Characterization of Resins and Polymers	2	0	0	2	50	-	50	100
V	SMT4353	Polymer Science and Technology- II	2	1	1	0	20	30	50	100
V	SMP4352	Materials Processing Laboratory	2	0	0	2	50	-	50	100
VI	SMT4354	Material Processing	2	1	1	0	20	30	50	100
VII	SMT4355	Structure-Property Relationship	2	2	0	0	20	30	50	100
		TOTAL	**14**	**7**	**2**	**4**				

Mapping of All Courses of Polymer and Materials Engineering with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Introduction to Material Technology	K4	3	2	3	2	-
Polymer Science and Technology- I	K4	2	2	3	2	1
Synthesis and Characterization of Resins and Polymers	K4	3	3	3	3	2
Polymer Science and Technology- II	K4	3	3	3	3	2
Materials Processing Laboratory	K4	3	3	3	2	2
Material Processing	K4	3	3	3	3	3
Structure-Property Relationship	K5	3	3	3	3	3

Semester III

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.	
	List of Courses where this course will be prerequisite	
	Polymer Science and Technology- I (SMT4352), Material Processing (SMT4354), Structure-Property Relationship (SMT4355)	
Sr. No.	**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, fibre 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**
	Total	**30**
	List of Textbooks/ 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	Remember fundamental properties of materials, along with the fundamental aspects of phase diagrams and the concepts of degradation and failure.	K1
CO2	Define the basic concept of monomer, polymer and repeating units and their properties.	K1
CO3	Understand the various engineering materials knowledge.	K2
CO4	Understand the significance of material science in domestic and engineering applications.	K2
CO5	Understand structural composites, Composite interfaces, Bonding mechanisms	K3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	2	3	1	-
CO2	K2	2	3	3	1	-
CO3	K2	3	3	3	1	-
CO4	K3	3	2	2	2	-
CO5	K3	2	3	3	2	1
Course	K4	3	2	3	2	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester IV

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 (CHT4151), Applied Chemistry-II (CHT4152) and Introduction to Materials Technology (SMT4351)	
	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.	
	List of Courses where this course will be prerequisite	
	Polymer Science and Technology- II (SMT4353), Structure-Property Relationship (SMT4355), Synthesis and Characterization of Resins and Polymers (SMP4351)	
Sr. No.	**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.	**5**
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 Polyester 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,	**5**

	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	**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.	**3**
7	**Recycling and Waste Management:** Introduction to waste management: global policies and regulations, social and environmental challenges of plastic waste in India, sorting techniques and classification, classification of waste management: primary, secondary, tertiary, quaternary recycling with examples. Disposal and waste treatment techniques: Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification, on-site disposal methods, compacting and bailing.	**3**
	Total	**30**
	List of Textbooks/ Reference Books	
	1. Polymer Science by Gowarikar, John Wiley and Sons 1986. 2. Encyclopaedia 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. 6. Chandra R., Adab A., (2004) Rubber and Plastic Waste: Recycling, Reuse and Future Demand, CBS Publisher	
	Course Outcomes (Students will….)	
CO1	Remember the basic concept of polymers, their classifications, their chemical and physical structures.	K1
CO2	Understand various polymerization techniques and methods and their kinetics.	K2
CO3	Understand the basics of rheology in polymer materials & its effect on processing & application.	K2
CO4	Understand the importance of recycling and waste management of polymers.	K2
CO5	Be able to choose the raw materials and reactants for the synthesis and manufacturing of resins and polymers.	K3

Mapping of Course Outcomes (Cos) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	2	3	2	1
CO2	K2	2	3	3	2	1
CO3	K3	2	3	3	2	1
CO4	K3	3	2	2	2	1
CO5	K3	3	2	2	3	2
Course	K4	2	2	3	2	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester IV

Course Code: SMP4351	Course Title: Synthesis and Characterization of Resins and Polymers	Credits = 2		
Semester: IV	Total contact hours: 60	L	T	P
		0	0	2

	List of Prerequisite Courses	
	Applied Chemistry-I (CHT4151), Applied Chemistry-II (CHT4352) and Polymer Science and Technology- I (SMT4352)	
	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.	
	List of Courses where this course will be prerequisite	
	Structure-Property Relationship (SMT4355)	
Sr. No.	**Course Contents (Topics and subtopics)**	**Reqd. hours**
1	To synthesize polymer using bulk, solution, suspension or emulsion polymerization method.	**8**
2	To synthesize copolymer using bulk, solution, suspension or emulsion polymerization method.	**8**
3	Synthesis of Novolac and its analysis.	**4**
4	Synthesis of Resol and its analysis.	**4**
5	Synthesis of Epoxy resin and its analysis.	**4**
6	Synthesis of Unsaturated Polyester resin and its analysis.	**8**
7	Synthesis of UF resin and its analysis.	**4**
8	Synthesis of MF resin and its analysis.	**4**
9	Determination of molecular weight of polymer by viscometry	**4**
10	Determination of amine value	**4**
11	Determination of acid value	**4**
12	Determination of k-value of PVC	**4**
	Total	**60**
	List of Textbooks/ Reference Books	
	1. Polymer Chemistry: A Practical Approach (The Practical Approach in Chemistry Series)1st Edition Fred J. Davis Oxford University Press 2004. 2. A Practical Course in Polymer Chemistry. H. Pinner, Borough Polytechnic, London, Pergamon Press, he., New York, 1961	

	3. Phenolic Resins chemistry, Applications, Standardization, Safety and Ecology by L.Knop, Springer-Verlag Berlin Heidelberg 2000. 4. Chemistry and Technology of Epoxy Resins by Eliss Brayn, Springer Nethelands,1993	
	Course Outcomes (Students will ….)	
CO1	Able to choose different monomers, raw materials for polymer synthesis based on different techniques.	K5
CO2	Understand general concepts, principles, and method of polymerization.	K3
CO3	Able to learn synthesis of unsaturated Polyester resin and its analysis.	K3
CO4	Able to study amino Resin and its analysis.	K3
CO5	Apply analytical techniques for characterizations of polymers	K4

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5+K6	K6
CO1	K2	3	3	3	3	1
CO2	K2	3	2	3	2	2
CO3	K3	2	3	3	2	1
CO4	K3	2	2	2	2	1
CO5	K4	2	2	3	3	3
Course	K4	3	3	3	3	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester V

Course Code: SMT4353	Course Title: Polymer Science and Technology- II	Credits = 2		
Semester: V	Total contact hours: 30	L	T	P
		1	1	0

	List of Prerequisite Courses	
	Applied Chemistry-I (CHT4151), Applied Chemistry-II (CHT4352) and Polymer Science and Technology- I (SMT4352)	
	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.	
	List of Courses where this course will be prerequisite	
	Materials Processing Laboratory (SMP4352), Material Processing (SMT4354)	
Sr. No.	**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) Calendaring:** 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**
	Total	**30**
	List of Textbooks/ 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	Understand different moulding techniques and their applications.	K2
CO2	Solve the problems during processing by optimizing the processing parameters.	K3
CO3	Compare the different polymer processing techniques their design and problems associated	K4
CO4	Able to learn moulding cycle, moulding materials, bulk factor	K3
CO5	Able to understand process parameters and their effect on product quality	K4

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	2	2	3	2
CO2	K2	3	3	3	3	2
CO3	K3	3	3	3	3	2
CO4	K3	1	2	2	2	2
CO5	K4	2	2	3	3	3
Course	K4	2	3	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester V

Course Code: SMP4352	Course Title: Materials Processing Laboratory	Credits = 2		
Semester: V	Total contact hours: 60	L	T	P
		0	0	2

	List of Prerequisite Courses	
	Applied Chemistry-I (CHT4151), Applied Chemistry-II (CHT4352) and Polymer Science and Technology- II (SMT4353)	
	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.	
	List of Courses where this course will be prerequisite	
	Polymer Science and Technology- II (SMT4353), Material Processing (SMT4354)	
Sr. No.	**Course Contents (Topics and subtopics)**	**Reqd. hours**
1	To study injection moulding & batch mixer	**8**
2	To study extrusion moulding	**8**
3	Compounding of polymeric material using two roll mill	**4**
4	To produce an article from blow moulding machine	**4**
5	Compounding of polymeric material using compression moulding	**4**
6	Study of construction and working of thermoforming	**4**
7	Study of construction and working of rotational moulding for multilayered product	**4**
8	Study of construction and working of calendering	**4**
9	To prepare a fibre reinforced polymer composites	**4**
10	To prepare a binary blend with and without compatibilizer	**4**
11	To study mechanical testing of polymer samples	**4**
12	To study plastic welding, bonding process	**8**
	Total	**60**
	List of Textbooks/ Reference Books	
	1. Principles of polymer processing by Fenner R.T., Chemical publishing N.Y. (1979) 2. Polymer Processing: Principles and Design 1st Edition by Donald G. Baird (Author), Dimitris I. Collias 3. Extrusion of Polymers: Theory and Practice by C.Chung, Hanser Publications,2000 Handbook of Thermoplastics, Second Edition Olagoke Olabisi by CRC Press 2015	
	Course Outcomes (Students will able to ….)	

CO1	Handle processing techniques of given material sample.	K3
CO2	Discover the various processing techniques suitable for different resins and polymers	K4
CO3	Apply and understand the practical problems related to the experiment.	K4
CO4	Design the process parameters like temperature, pressure, curing time etc. of the respective experiments based on sample polymer.	K5
CO5	Develop different polymers for various applications	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5+K6	K6
CO1	K2	3	3	3	2	2
CO2	K2	3	3	3	2	2
CO3	K3	2	3	3	2	2
CO4	K3	2	2	2	2	3
CO5	K5	2	3	3	3	3
Course	K4	3	3	3	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester VI

Course Code: SMT4354	Course Title: Material Processing	Credits = 2		
Semester: VI	Total contact hours: 30	L	T	P
		1	1	0
	List of Prerequisite Courses			
	Polymer science and Technology I (SMT4352), Structural Property Relationship (SMT4355), Introduction to Material Technology (SMT4351)			
	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.			
	List of Courses where this course will be prerequisite			
	None			
Sr. No.	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 fibres, 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

	Total	**30**
	List of Textbooks/ Reference Books	
	1. Manufacturing Technology, Foundry, forming and welding, P N Rao, McGraw Hill Education, ISBN-13: 978-93-5316-051-7. 2. Material science and engineering, William D. Callister, JR.David G.Rethwisch, Wiley, ISBN-13: 9781119321590, 10th edition	
	Course Outcomes (Students will able to ….)	
CO1	Understand the different materials processing techniques	K2
CO2	Understand the basics of Microstructural aspects with the different processing of materials	K3
CO3	Interpret importance of mould during processing.	K3
CO4	Learn production of ceramic fibres, Electro-spinning; Drying, etc.	K4
CO5	Apply basic operation process, materials, etc.	K4

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	3	3	2	2
CO2	K2	3	2	3	3	3
CO3	K3	3	3	3	3	3
CO4	K3	1	1	2	2	2
CO5	K4	2	3	3	3	3
Course	K4	2	2	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester VII

Course Code: SMT4355	Course Title: Structure-Property Relationship	Credits: 2		
Semester: VII	Total contact hours: 30	L	T	P
		2	0	

	List of Prerequisite Courses	
	Applied Chemistry-I (CHT4151), Applied Chemistry-II (CHT4352) and Polymer Science and Technology- I (SMT4352)	
	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.	
	List of Courses where this course will be prerequisite	
	None	
Sr. No.	**Course Contents (Topics and subtopics)**	**Reqd. hours**
1	**General structural features of polymers:** Effects of atom 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-Huggin's theory.	**6**
3	**Polymer Chain Flexibility:** Concept of flexibility, many 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**
	Total	**30**
	List of Textbooks/ 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 able to ….)	
CO1	Understand the importance of structure-property correlation study of materials and its suitable applications.	K2
CO2	Classify different type of materials, and their structures.	K4
CO3	Understand the degradation/stabilization of polymers, effect of additives and analyse the respective case studies	K4
CO4	Analyze various stresses acting on polymers and their influence	K4
CO5	Apply concepts of degradation of plastics due to UV	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K2	3	2	2	2	3
CO2	K2	3	3	2	2	3
CO3	K3	3	3	3	3	3
CO4	K4	3	3	3	3	3
CO5	K5	2	2	3	3	3
Course	K5	3	3	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

*****

SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE

in

PETROLEUM AND PETROCHEMICALS TECHNOLOGY

[Under the National Education Policy (NEP 2020)]

2023-2024

Offered by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra
BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

Preamble

The petroleum refinery industry is an important sector that processes crude oil into various refined products, including gasoline, diesel, jet fuel, and petrochemical feedstock. On the other hand, the petrochemical industry transforms hydrocarbons derived from crude oil and natural gas into a diverse range of chemical products, such as plastics, solvents, and fertilizers, crucial for enhancing various aspects of modern life. Thus, petroleum refining and petrochemical industries plays a pivotal role in meeting global energy, providing fuel for transportation and manufacturing of products essential to daily life, thereby sustaining modern civilization's infrastructure and advancements.

The course structure of multidisciplinary minor in Petroleum and Petrochemical Technology at Marathwada campus Jalna and IOCL Campus Bhubaneshwar of Institute of Chemical Technology, Mumbai is designed to equip students with the knowledge, skills, and ethical values required to excel in the field of petroleum refining and petrochemical engineering. This course is designed in such a way that in theoretical subject's students can study the concepts of refining technology and principles of petrochemical processes based on their knowledge of fundamental chemical engineering subjects like heat transfer, mass transfer, fluid flow and chemical reaction engineering. This will cover refining processes like cracking, reforming, isomerization, alkylation and petrochemical processes, like polymerization, alkylation, hydrogenation etc. Also the practical courses give student an exposure to both experimental and process simulation in petroleum science and technology. This includes crude oil and its product characterization tests, simulation studies using various software gaining insights into the complexities of processes within the petroleum refining industry.

Thus, this comprehensive program integrates theoretical chemical engineering fundamentals with practical applications, preparing students to contribute significantly to the global petroleum and petrochemical sector. Upon successfully completing the courses of this multidisciplinary minor, students will be well-prepared to make meaningful contributions through a balance of theoretical knowledge, practical experience, and a commitment to continuous learning.

Programme Specific Outcomes (PSOs)

Multidisciplinary Minor Degree (Petroleum and Petrochemicals Technology)

Upon completion of this course, students will be able to:

PSO1	**Understand** the chemical composition and properties of various petroleum fractions, including crude oil, and their significance in refining and petrochemical processes. (Factual Knowledge) (K1)
PSO2	**Analyse and evaluate** the fundamental principles underlying petroleum refining and petrochemical technology, including thermodynamics, kinetics, and process optimization, to solve complex problems. (Conceptual Knowledge) (K2, K3)
PSO3	**Demonstrate** the operation and utilization of equipment and techniques employed in petroleum refining and petrochemical processes, including distillation, separation, catalysis, reforming and cracking ensuring safe and efficient production practices. (Procedural Knowledge) (K4, K5)
PSO4	**Apply** expertise in refining processes, operations, catalysts, and quality control to innovate and optimize manufacturing of petroleum products, meeting societal needs while upholding safety and environmental standards. (Metacognitive Knowledge) (K6)
PSO5	**Cater** to the needs of petroleum industries, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about Petroleum and Petrochemicals profession

2. **Recommended Batch Size**
   10; Maximum 15
3. **Duration**
   6 Semesters
4. **Eligibility Criteria**
   Students enrolled for the Integrated M.Tech programmess of the Institute of Chemical Technology at Marathwada/IOCL Bhubaneshwar campus and have passed the Sem-I and Sem-II examinations are eligible for the admission to minor degree Petroleum and Petrochemicals Technology.
5. **Prerequisites**
   The candidate must have passed the HSC/EQUIVALENT examination with Physics, Chemistry Mathematics.
6. **Instructors (Tentative)**
   Dr. Atul H. Bari (ICT Marathwada Campus, Jalna)

Multidisciplinary Minor Degree (Petroleum and Petrochemicals Technology)

Subject Code	Sem	Subject	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
SPT4351	III	Introduction to Petroleum Technology	2	2	0	0	20	30	50	100
SPT4352	IV	Petroleum refining processes	2	2	0	0	20	30	50	100
SPT4353	V	Reservoir Technology	2	2	0	0	20	30	50	100
SPP4351	V	Petroleum laboratory I	2	0	0	4	50	0	50	100
SPT4354	VI	Refinery engineering	2	2	0	0	20	30	50	100
SPP4352	VI	Petroleum laboratory-II	2	0	0	4	50	0	50	100
SPT4355	VII	Petrochemicals Technology	2	2	0	0	20	30	50	100
		Total	14							

Mapping of All Courses of Petroleum and Petrochemicals Technology with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Introduction to Petroleum Technology	K2	3	2	1	-	-
Petroleum refining processes	K2	3	3	2	1	1
Reservoir Technology	K3	3	1	2	2	1
Petroleum laboratory I	K2	3	3	2	1	1
Refinery Engineering	K4	3	3	2	1	1
Petroleum laboratory-II	K4	3	3	2	1	2
Petrochemicals Technology	K5	3	2	3	3	3

Semester: III

Course Code: SPT4351	Course Title: Introduction to Petroleum Technology	Credits = 2		
		L	T	P
Semester: III	Total contact hours: 30	2		

List of Prerequisite Courses

Applied Chemistry I (CHT4151) & Applied Chemistry II (CHT4151), Physics I, Material and energy balance calculations (CEP4151).

List of Courses where this course will be prerequisite

Petroleum refining processes (SPT4352), Reservoir Technology (SPT4353), Refinery engineering (SPT4354), Petrochemicals Technology (SPT4355), Petroleum laboratory-I (SPP4351).

Description of relevance of this course in the Int. M. Tech. Program

- This course gives students an overview of: Petroleum and petrochemical industry, their history, important petroleum product, their characterization and general refinery setup.

	Course Contents (Topics and subtopics)	Reqd. hours
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
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
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	Crude oil fractionation: Pipe still heaters, atmospheric distillation unit (ADU), vacuum distillation unit (VDU), different petroleum fractions.	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	Major petrochemical products, Feed stock for petrochemicals	6

List of Textbooks

Modern petroleum refining processes by B K Bhaskara Rao

Reference 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	
	Course Outcomes (students will be able to...)	
1	Effectively communicate the fundamentals of petroleum refining and petrochemical technology through oral and written means.	K1
2	Comprehend the history and origin of petroleum.	K1, K2
3	Understand the importance of petroleum refinery and petrochemical industry.	K1
4	Explain specifications of various petroleum products.	K1
5	Explain distillation of crude oil to give different petroleum fractions	K1, K2
6	Explain different types of refinery set ups.	K1, K2

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K1	3	1	1	1	-
CO2	K1, K2	3	2	1	1	-
CO3	K1	3	2	1	1	-
CO4	K1	3	3	1	-	-
CO5	K1, K2	3	3	1	-	-
CO6	K1, K2	3	2	2	-	-
Course	K2	3	2	1	-	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester: IV

Course Code: SPT4352	Course Title: Petroleum refining processes	Credits = 2		
		L	T	P
Semester: IV	Total contact hours: 30	2		

List of Prerequisite Courses

Applied Chemistry I (CHT4151) & Applied Chemistry II (CHT4151), Introduction to Petroleum Technology (SPT4351).

List of Courses where this course will be prerequisite

Refinery engineering (SPT4354), Petrochemicals Technology ((SPT4355), Petroleum laboratory-II (SPP4352)

Description of relevance of this course in the Int. M. Tech. Program

- The objective of this course is to understand the chemistry and processes involved in converting the crude oil into valuable products in the petroleum refinery.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Separation of oil and gas, pre-treatment methods, removal of moisture and salts, transportation and storage.	2
2	Thermal cracking, thermal processing like visbreaking, delayed coking, fluid coking, flexicoking.	4
3	Catalytic cracking: Cracking reactions, cracking catalysts, cracking units, fluidized bed catalytic cracking (FCC), new designs for FCC units.	4
4	Hydrocracking and hydro-processing: Hydrocracking reactions, hydrocracking catalysts, hydrocracker unit, hydro-processor, hydrogen production and purification.	4
5	Catalytic reforming: Reforming reactions, feed preparations, reforming catalyst, reactor design, catalytic reformer.	8
6	Light end processes: Isomerization, alkylation and polymerisation.	8

List of Textbooks

1. Modern petroleum refining processes by B K Bhaskara Rao.
2. Advanced Petroleum Refining by G. N. Sarkar.

List of Additional Reading Material / Reference 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

Course Outcomes (students will be able to..)

1	Explain the separation of oil and gas in the petroleum refining industry.	K1
2	Explain various refining processes in detail.	K1, K2
3	Explain the interconnections between various refining processes and their impact on the overall refining scheme.	K2, K3
4	Assess and optimize refining processes based on specific objectives and constraints.	K3, K4
5	Identify the process/technique to improve quality of given petroleum fraction.	K3, K4
6	Address the practical problems related to petroleum refining processes	K4

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K1	3	3	2	1	-
CO2	K1, K2	3	3	2	1	-
CO3	K2, K3	3	3	3	1	-
CO4	K3, K4	3	3	3	2	1
CO5	K3, K4	3	2	2	2	1
CO6	K4	3	2	2	2	1
Course	K3	3	3	2	1	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Semester: V

Course Code: SPT4353	Course Title: Reservoir Technology	Credits = 2		
		L	T	P
Semester: V	Total contact hours: 30	2		

List of Prerequisite Courses

	Introduction to petroleum technology (SPT4351), Fluid Flow (CET4251), Chemical Engineering Operations (CET4254).	

List of Courses where this course will be prerequisite

	None	

Description of relevance of this course in the Int. M. Tech. Program

- This course will provide a broad outline with respect to both basic and advanced topics in the field of petroleum reservoir technology like petroleum geology, drilling, exploration, enhanced oil recovery etc.

	Course Contents (Topics and subtopics)	Reqd. hours
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
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
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	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
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	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
List of Textbooks		
	1. Advanced Reservoir Engineering by T. Ahmed and P. McKinney. 2. Principles of Petroleum Reservoir Engineering by G.L. Chierici.	
List of Additional Reading Material / Reference Books		
	1. Applied Petroleum Reservoir Engineering by R.E, Terry, M. Hawkins and B.C. Craft. 2. Fundamentals of Reservoir Engineering by L.P. Dake.	
Course Outcomes (students will be able to..)		
1	Understand the key concepts of petroleum geology.	K1
2	Explain the concept of oil and gas traps in geological formations.	K1, K2
3	Explain the composition and functions of drilling rigs, drilling string, and drilling fluid.	K1, K2
4	Predict the reservoir performance using reserve estimation techniques.	K2, K3
5	Demonstrate understanding of well logging, well completion, well testing, primary, secondary, and enhanced oil recovery techniques.	K2, K4

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5, K6	K6
CO1	K1	3	3	3	1	1
CO2	K1,K2	3	1	2	2	1
CO3	K1,K2	3	1	3	1	1
CO4	K2, K3	3	1	3	2	1
CO5	K2, K4	3	1	2	3	1
Course	K2	3	1	2	2	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Course Code: SPT4354	Course Title: Refinery engineering	Credits = 2		
		L	T	P
Semester: VI	Total contact hours: 30	2		

List of Prerequisite Courses

	Introduction to Petroleum Technology (SPT4351), Petroleum refining processes (SPT4352), Chemical Engineering operations (CET4254), Separation processes (CET4356), Heat transfer (CET4252), Chemical Reaction Engineering (CET4351).	

List of Courses where this course will be prerequisite

	Petroleum laboratory-II (SPP4352)	

Description of relevance of this course in the Int. M. Tech. Program

- In this course student will apply their knowledge of mass transfer, heat transfer, equipment design and chemical reaction engineering to complex processes of petroleum refineries

	Course Contents (Topics and subtopics)	Reqd. Hours
1	Design aspects of pipe still heaters, radiant and convection sections, calculation of heat flux, radius and number of pipes. Furnace design: Heat load calculations for furnace heaters, typical heat flux values, basic constructional features, different furnace types, factors to be considered in the design of fired heaters.	3
2	Distillation curves: ASTM, TBP, EFV distillation curves; experimental details, their comparison and inter relations by Nelson and Edmister correlations. Multicomponent vapour liquid equilibrium, flash distillation, key components, dew point and bubble point calculations. Multicomponent distillation, calculation of number of stages in distillation, calculation of minimum reflux and number of plates, feed plate location.	6
3	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
4	Multicomponent liquid - liquid equilibrium relations, estimation of number of stages by triangular and rectangular diagrams for complex petroleum oils.	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	Adsorption, breakthrough phenomena, concept of adsorption zone height, unsteady state fixed bed operation, LUB concept, design of absorbers. Sorbex technologies and its concepts.	6
List of Textbooks		
List of Additional Reading Material / Reference 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.	
Course Outcomes (students will be able to..)		
1	Perform calculations for heat flux, radius, and the number of pipes in refinery heating systems.	K3
2	Interpret and use ASTM, TBP, and EFV distillation curves, including their experimental details for designing of crude distillation unit.	K3, K4
3	Perform calculations for multicomponent distillation, including the determination of the number of stages, minimum reflux, and feed plate location.	K4
4	Design multicomponent separation technique for separation any hydrocarbon stream.	K5
5	Analyze multi- component absorbers and strippers	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K3	3	3	3	1	1
CO2	K3, K4	3	3	2	1	1
CO3	K4	3	3	3	1	1
CO4	K5	3	3	3	1	1
CO5	K5	2	1	2	2	1
Course	K4	3	3	2	1	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Course Code: SPT4355	Course Title: Petrochemicals Technology	Credits = 2		
		L	T	P
Semester: VII	Total contact hours: 30	2		

List of Prerequisite Courses

	Chemistry I & II, Introduction to petroleum technology (SPT4351), Petroleum refining processes(SPT4352).	

List of Courses where this course will be prerequisite

	None.	

Description of relevance of this course in the Int. M. Tech. Program

- This course gives students a broad outline of manufacturing processes of important petrochemical products in terms of thermodynamics, kinetics, mechanism and process flow diagram.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Chemicals derived from C1-C2. Chemicals from natural gas, naphtha etc. Principal reactions of Methane, ethane, ethylene and acetylene. Naphtha and gas cracking to produce C2-C4 olefins, dienes and aromatics.	4
2	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
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	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
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
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
7	Lubricating oils, specifications, characteristics, production of lube specialities, additives, refining of lubricating oil: solvent chemicals & hydrogenation method,	6

	dewaxing, deasphalting etc. Manufacturing of grease, manufacture of specialty oils viz. insulating oil, transformer oil, white oil, etc.	
List of Textbooks		
	A Text Book on Petrochemicals, B.K.Bhaskara Rao.	
List of Additional Reading Material / Reference 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	
Course Outcomes (students will be able to..)		
1	Explain production of chemicals from various feedstock, including C1-C2, C3-C4, and high molecular weight n-paraffin	K2
2	Draw process flow diagrams/process block diagrams for the manufacture of various petrochemicals from process description.	K4
3	Develop the ability to analyze and select appropriate feedstocks based on their chemical compositions for various petrochemical processes	K5, K6
4	Critically evaluate the potential applications and impacts of emerging technologies in petrochemical industries.	K6
5	Develop lubricating oils, study their specifications, and characteristics	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5, K6	K6
CO1	K2	3	2	1	1	1
CO2	K4	3	2	2	1	1
CO3	K5, K6	3	2	3	1	1
CO4	K6	3	2	3	1	1
CO5	K6	3	2	2	1	1
Course	K4	3	2	2	1	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Course Code: SPP4351	Course Title: Petroleum laboratory I	Credits = 2		
		L	T	P
Semester: V	Total contact hours: 30	0		4

	List of Prerequisite Courses	
	Chemistry I, Introduction to petroleum technology (SPT4351)	
	List of Courses where this course will be prerequisite	
	Petroleum laboratory II (SPP4352)	
	Description of relevance of this course in the Int. M. Tech. Program	
•	To apply various testing methods for assessing various properties of petroleum products.	
	Course Contents (Topics and subtopics)	**Reqd. hours**
1	Determination of flash point and fire point using Cleve land open cup.	4
2	Determination of flash point using Abel's apparatus.	4
3	Determination of flash point using Pensky Martene apparatus.	4
4	Determination of diesel index of given petroleum sample.	4
5	Determination of drop point of given sample.	4
6	Determination of Saybolt's viscosity of given petroleum sample.	4
7	Determination of the smoke point.	4
8	Determination of calorific value of fuel by Bomb calorimeter.	6
9	Determination of carbon residue of given petroleum fraction using Ramsbottom method.	6
10	Determination of carbon residue of given petroleum fraction using Conradson Carbon method.	4
11	Determination of the penetration index of petroleum sample.	4
12	Detection of copper strip corrosion of petroleum product.	6
13	Determination of cloud point and pour point.	6
	Total	**60**
	List of Textbooks	
	Modern petroleum refining processes by B.K. Bhaskara Rao.	
	List of Additional Reading Material / Reference Books	
	1. ASTM Standard Manual 2. Handbook of Petroleum Analysis by G.G Speight.	
	Course Outcomes (students will be able to..)	
1	Conduct standard ASTM tests for petroleum products.	K1, K2
2	Assess the quality and performance characteristics of petroleum products.	K2

3	Apply quality assurance principles to ensure reliable and reproducible results in petroleum testing	K3, K4
4	Interpret the significance of results in the context of petroleum product quality and industry standards	K5
5	Designing of vacuum distillation unit (VDU) andatmospheric distillation unit (ADU)	

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5	K6
CO1	K1, K2	3	3	2	1	1
CO2	K2	3	3	2	1	1
CO3	K3, K4	3	3	2	1	1
CO4	K5	3	3	3	1	1
CO5	K5	2	2	2	1	1
Course	K4	3	3	2	1	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

Course Code: SPP4352	Course Title: Petroleum laboratory-II	Credits = 2		
		L	T	P
Semester: VI	Total contact hours: 30	2		

List of Prerequisite Courses

	Petroleum refining processes (SPT4352), Refinery engineering (SPT4354), Petroleum laboratory I (SPP4351), Process Simulation Lab – I.	

List of Courses where this course will be prerequisite

	None.	

Description of relevance of this course in the Int. M. Tech. Program

- To apply various testing methods for assessing various properties of petroleum products.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Determination of bromine number by colour indicator method.	4
2	Determination of water content by Dean and stark method.	4
3	Determination of saponification vale of a given sample.	4
4	Determination of bromine number of a given petroleum sample.	4
5	Determination the oxidation stability of the given fuel sample.	8
6	Determination of vaporization characteristics of given petroleum sample by ASTM distillation.	4
7	Determination vaporization characteristics of given petroleum sample by TBP distillation.	8
8	Generation of pseudo components in ASPEN from distillation profile (ASTM D86/TBP).	4
9	Designing of atmospheric distillation unit (ADU) using ASPEN.	4
10	Designing of vacuum distillation unit (VDU) using ASPEN.	4
11	Designing of debutanizer column using ASPEN.	4
12	Designing of naphtha reformer using ASPEN.	4
13	Designing of FCC unit using ASPEN.	4
	Total	**60**

List of Textbooks

List of Additional Reading Material / Reference 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.	
Course Outcomes (students will be able to..)		
1	Apply quality assurance principles to ensure reliable and reproducible results in petroleum testing	K3, K4
2	Interpret the significance of results in the context of petroleum product quality and industry standards	K5
3	Design and optimize key refining units (debutanizer column, ADU, VDU, naphtha reformer, FCC unit) using simulation software.	K5, K6
4	Apply simulation tools to analyse and improve petroleum refining processes	K6
5	Design debutanizer column using ASPEN, naphtha reformer, etc.	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2, K3	K4	K5, K6	K6
CO1	K3, K4	3	3	2	2	3
CO2	K5	3	3	2	2	3
CO3	K5, K6	3	1	3	3	3
CO4	K6	3	1	3	3	3
CO5	K6	2	2	2	1	1
Course	K5	3	2	3	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution
K, knowledge level from cognitive domain

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SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE

in

LIPID ENGINEERING

[Under the National Education Policy (NEP 2020)]

2023-2024

Offered by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence

Government of Maharashtra

BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

Preamble

In the pursuit of academic excellence and the advancement of knowledge, we, the faculty and administration of the Institute of Chemical Technology Mumbai, Marathwada Campus Jalna, are thrilled to introduce the Multi-Disciplinary Minor (MDM) degree programme where innovation meets industry demands.

The Lipids and oleochemical industry is an important sector that processes crude edible oil into various products, including refined edible oils and oleochemicals. On the other hand, lipids act as a much greener, sustainable feedstock alternative to petrochemicals and transforms crude edible oil into a diverse range of chemical products, such as surfactants, detergents, cosmetics, biodiesel, lubricants and greases, crucial for functioning and enhancing various aspects of modern life.

Our vision is to cultivate a learning environment that empowers students to become adept, forward-thinking professionals ready to contribute to the sustainable development of society. Through a dynamic curriculum and hands-on experiences, we aim to instil in our students a passion for discovery, problem-solving, and ethical leadership tailored to the diverse challenges posed by these industries.

The Mission of this programme is to

1. Provide students with a strong and holistic foundation in Lipids Engineering.
2. Offer specialised knowledge in lipid technology, focusing on the production, analysis, and application of lipids in diverse industrial settings, including cosmetics, detergents, and surfactants.
3. Equip students with the Industry-relevant skills and knowledge demanded by the lipids industry through real-world applications, industry collaborations, and cutting-edge research.
4. Emphasize global perspectives through international collaborations, ensuring that students are prepared for the interconnected nature of the field.

Over three enriching years spread across six dynamic semesters, students will delve deep into the core of lipid science and its applications. Through a meticulously crafted curriculum comprising five theory and two practical courses, participants will gain hands-on experience and theoretical knowledge essential for thriving in these pivotal industries.

From mastering the principles of lipid chemistry to understanding advanced refining techniques, this program enables students to explore the versatile applications of lipids in industries ranging from cosmetics and detergents to pharmaceuticals and nutraceuticals, preparing students for multifaceted roles in lipids and allied sectors. This programme is geared to foster a commitment to ethical practices, sustainability, and social responsibility in applying chemical engineering principles within the context of the lipids industry.

The Multi-Disciplinary Minor (MDM) degree programme in Lipids Technology stands at the forefront of education and research, ready to nurture the next generation of leaders in the complex and interconnected lipids and allied industries. We invite aspiring students to embark on this transformative academic journey, where they will be equipped to make meaningful contributions to industries shaping our everyday lives. Together, let us embark on a path of discovery and innovation that will propel us towards a sustainable and prosperous future in the chemical engineering and allied industries.

Programme Specific Outcomes (PSOs) for Multidisciplinary Minor Degree (Lipid Engineering)

Students will be able to;

PSO1	**Demonstrate** a comprehensive understanding of fundamental principles and chemistry for lipids and oleochemicals technology. (Factual Knowledge) (K1)
PSO2	**Interpret** emerging trends in lipids and developing innovative oleochemical products (Conceptual Knowledge) (K2, K3)
PSO3	**Develop** and carry out experiments using research-based knowledge and methodologies such as analysis, data interpretation, and valid conclusion. (Procedural Knowledge) (K4, K5)
PSO4	**Apply** the knowledge of science, chemical engineering, and fundamentals of oleochemicals to solve complex problems in core and allied industries. (Metacognitive Knowledge) (K6)
PSO5	**Cater** to the needs of oil and lipid industries, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about Lipids Technology profession

1. **Recommended Batch Size:** Recommended10; Maximum 15
2. **Duration:** 6 Semesters
3. **Eligibility Criteria:** Students enrolled for the Integrated M.Tech programmes of the Institute of Chemical Technology at Marathwada campus and have passed the Sem-I and Sem-II examinations are eligible for admission to minor degree in Lipids Technology
4. **Pedagogy/Teaching Method:**

   Lecture/Discussions: These sessions will discuss the subject matters of the course

   Experiential Learning: The sessions will involve hands-on training.

   Tutorials: Problem solving/case studies / relevant real-life applications/student presentations/home assignments / individual or group projects

6. **Evaluation**

   Theory courses

   Continuous Assessment Tests (CATs): Continuous assessment will vary from course to course; the instructor will decide the evaluation mode. Two to three CATs will be conducted throughout the course, usually before and after the midsemester examination. These CATs will carry a total weightage of 20%. Depending on the instructor, class test, assignments, case studies, group

discussions, report submission and seminar/presentation could also form part of the continuous assessment.

Mid-semester: Total 30 Marks (Theory paper)

End-semester: Total 50 Marks (Theory paper)

Practical courses
Continuous assessment: 50 Marks
Performing given experiments as per the instructions, submission of lab journal on time, viva voce, group/ personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.

End Semester: 50 Marks (Lab experiment performance followed by viva-voce examination)

5. **Instructors:**
   Dr. Parag R. Nemade
   Mr. Bhushan D. Patare

6. **Course Structure:**

MDM	Subject Code	Sem	Subject	Credits	Hrs/Week			Marks for various Exams			
					L	T	P	CA	MS	ES	Total
MDM1	SOT4351	III	Chemistry of Oils and Fatty Acids	2	2	0	0	20	30	50	100
MDM2	SOT4352	IV	Technology of Oleochemicals and Surfactant	2	2	0	0	20	30	50	100
MDM3	SOP4351	IV	Lipid Laboratory I	2	0	0	4	50	0	50	100
MDM4	SOT4353	V	Lipid Processing Technology I	2	2	0	0	20	30	50	100
MDM5	SOP4352	V	Lipid Laboratory II	2	0	0	4	50	0	50	100
MDM6	SOT4354	VI	Lipid Processing Technology II	2	2	0	0	20	30	50	100
MDM7	SOT4355	VII	Production and Applications of Soaps, Surfactants and Detergents	2	2	0	0	20	30	50	100
			Total	14							

Mapping of All Courses of Lipid Engineering with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Chemistry of Oils and Fatty Acids	K4	3	3	2	1	2
Technology of Oleochemicals and Surfactant	K4	3	3	2	1	1
Lipid Laboratory I	K3	1	1	3	2	2
Lipid Processing Technology I	K3	3	2	3	2	3
Lipid Laboratory II	K3	3	2	3	2	3
Lipid Processing Technology II	K3	1	2	3	2	3
Production and Applications of Soaps, Surfactants and Detergents	K3	1	2	3	2	3

Semester III

Course Code: SOT4351	Course Title: Chemistry of Oils and Fatty Acids	Credits =		
		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

SOT4352 - Technology of Oleochemicals and Surfactant, SOT4353- Lipid Processing Technology I, SOT4354 - Lipid Processing Technology II, SOT4355 - Production and Applications of Soaps, Surfactants and Detergents, SOP4351 -Lipids Laboratory I, SOP4352 -Lipids Laboratory II

Description of relevance of this course in the Int. M. Tech. Program

- This course will provide a comprehensive understanding of the industrial chemistry of oils and fatty acids, basic 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)	Reqd. 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, crystallisation, 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. Neutralisation, saponification, and formation of metallic soaps. Acylation, esterification, inter-esterification, trans-esterification.	4

7.	**Chemical reactions of oils/fats and fatty acids:** Estolide synthesis. Hydrogenation, halogenation, epoxidation, hydroxylation, ozonolysis, metathesis. Thermal and oxidative polymerisation, Diels-Alder reaction, Stereomutation, double bond migration and cyclisation.	10
	Total	**30**
	List of Textbooks	
1.	The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses, Frank D. Gunstone, Blackwell Publishing Ltd, UK (2004).	
2.	Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 1: Edible Oil and Fat Products: Chemistry, Properties, and Health Effects, Ed. Fereidoon Shahidi, John Wiley & Sons, Inc., Wiley Interscience Publication (2005).	
	List of additional reading material/Reference Books	
1.	Fatty Acids in Industry, R. W. Johnson, and E. Fritz, eds., Marcel Dekker, Inc., New York, (1989).	
2.	Oils and Fats Manual, Eds. A. Karleskind and J.-P. Wolff, Vols. I and II, Intercept Ltd., Andover, U.K. (1996).	
3.	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.	K1, K2
CO2	Analyse 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 derivatisation of oils/ fatty acids.	K3
CO5	Identify and interpret the tools for chemical analysis of oils and fats.	K3

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K2	3	2	1	1	2
CO2	K4	2	3	2	2	2
CO3	K2	3	2	1	1	1
CO4	K3	3	3	2	2	2
CO5	K3	3	3	2	2	2
Course	K4	3	3	2	1	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester IV

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

List of Prerequisite Courses

SOT4351 - Chemistry of Oils and Fatty Acids

List of Courses where this course will be prerequisite

SOT4353 - Lipid Processing Technology I, SOT4354 - Lipid Processing Technology II, SOT4355 - Production and Applications of Soaps, Surfactants and Detergents

Description of relevance of this course in the Int. M. Tech. Program

- This course will give an understanding of the industrial chemistry of Surfactants and Oleochemicals. The objective is to provide training and knowledge of synthesis techniques of oleochemicals and surfactants, colloidal behaviour, 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 and reverse micelles, vesicles, Microemulsions). Thermodynamics of Adsorption and Micellization, structure of micelles	03
5.	Different surface activity phenomena: Emulsification, de-emulsification, foaming & and 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 Non-ionic 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 Textbooks	
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).
List of additional reading material/Reference Books	
1.	Surfactants in Consumer Products: Theory, Technology and Applications, Ed. J. Falbe, Springer-Verlag, Berlin (1987).
2.	Industrial Applications of Surfactants-II, D. R. Karsa, Royal Society of Chemistry (1990).
3.	Richard M.; Marilyn E. K.; Pashley. Applied Colloid and Surface Chemistry, *John Wiley and Sons Ltd*, Chichester, UK (2004).

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

CO1	Understand the technical significance of Oleochemical and Surfactant Industries.	K2
CO2	Conceptualise and develop the different modes of derivatisation of oleochemical and surfactants and their applications.	K6
CO3	Analyse and illustrate the HLB, diverse interfacial phenomenon, molecular aggregations and phase behaviour of surfactants.	K4
CO4	Ability to identify and interpret the role of surfactants as specialty and high-performance chemicals.	K5
CO5	Synthesize and analyze cationic and amphoteric Surfactants: Alkoxylated amines, Amine oxide, etc.	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5+K6	K6
CO1	K2	3	2	1	1	2
CO2	K4	3	3	3	3	3
CO3	K2	3	3	2	2	2
CO4	K5	3	3	2	2	2
CO5	K5	2	3	2	2	3
Course	K4	2	3	2	1	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester IV

Course Code: SOT4353	Course Title: Lipid Laboratory I	Credits = 2		
		L	T	P
Semester: IV	Total contact hours: 60	0	0	4

List of Prerequisite Courses

HSC (Science), Organic Chemistry Lab, SOT4351 - Chemistry of Oils and Fatty Acids,

List of Courses where this course will be prerequisite

SOP4352 - Lipid Laboratory II

Description of relevance of this course in the Int. M. Tech. Program

- This course will introduce the student to analytical techniques for lipid characterization, common lipid transformations, soaps, detergent synthesis, etc.

Sr. No.	Course Contents (Topics and subtopics)	Reqd. Hours
1	Determination of Acid value, Iodine value, Saponification value of ols/fats	4
2	Determination of Hydroxyl Value	4
3	Determination of Peroxide value and Anisidine value	4
4	Analysis of Soap Stock	4
5	Determination of Unsaponifiable Matter and Ash Content	4
6	Physical and Chemical Characteristis of Ghee and Vanaspati Ghee	4
7	Physical and Chemical Characteristis of Margarine	4
8	Physical and Chemical Characteristis of Waxes	4
9	Identification of Oils/fats in a mixture using TLC	4
10	Detection of Adulterants in oils/fats	4
11	Analysis of Butter I	4
12	Analysis of Butter II	4
13	Acid Oils Analysis	4
14	GC analysis of FAME I	4
15	GC analysis of FAME II	4
	Total	**60**

List of Textbooks

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.	Manual of methods of analysis of foods (oils & fats) -FSSAI Handbook (2015)

List of additional reading material/Reference Books

1.	Fatty Acids by Robert Johnson
2.	Fats and Oils Handbook by Bockisch Michael
3.	The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses – Frank D. Gunstone, Blackwell Publishing Ltd,

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

CO1	Analyse and evaluate the physical characteristics of oils, like specific gravity, refractive index, colour, viscosity, etc.	K4
CO2	Evaluate properties of oils, fatty acids and oleochemicals like acid value, sap value, iodine value, oxidation, crystallisation, oxirane value, and amine value.	K4
CO3	Interpret the analytical numbers in the testing of oils and fatty acids, adulteration of oils	K3
CO4	Detect castor oil and soyabean oil mixture using TLC	K4
CO5	Analyze Butter, Salt content, TFM, MP	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K2	1	1	3	2	2
CO2	K4	2	1	3	2	2
CO3	K2	3	2	3	1	1
CO4	K5	3	3	2	2	2
CO5	K5	3	2	2	2	3
Course	K3	2	2	3	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester V

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

List of Prerequisite Courses

HSC (Science), Organic Chemistry Lab, SOT4351 - Chemistry of Oils and Fatty Acids,

List of Courses where this course will be prerequisite

SOT4354 - Lipid Processing Technology II, SOT4355 - Production and Applications of Soaps, Surfactants and Detergents, SOP4352 - Lipid Laboratory II

Description of relevance of this course in the Int. M. Tech. Program

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

Sr. No.	Course Contents (Topics and subtopics)	Reqd. 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, and synthetic fatty material.	02
5.	Anti-nutritional constituents of oilseeds. General methods of upgrading and utilisation of oils, oil cakes and other products, Protein concentrates and isolates from oil meal	02
6.	Processes and equipment employed for refining, bleaching, deodorisation, hydrogenation and winterisation of oils or edible purposes	02
7.	Newer techniques for refining 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 Textbooks

1.	M.M Chakrabarty. Chemistry and Technology of Oils and Fats. Allied Publishers Pvt. Ltd. New Delhi
2.	Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 6: Industrial and Nonedible Products from Oils and Fats, Ed. Fereidoon Shahidi, Wiley Interscience Publication (2005).

List of additional reading material/Reference Books

1.	Hydrogenation of Oil & Fat Edited by H.B.W. Patterson Applied Science Publishers (1983)
2.	Gupta, M. K., Practical guide to vegetable oil processing. AOCS Press, 2008 Urbana, Illinois.
3.	Fats and oils, Formulating and Processing for Applications, 3rd Edition, 2009, Richard D.O. Brien.
4.	Fats and Oils Handbook, Michael Bockisch, 1st Edition, 1998, AOCS Press

5.	Treatise on fats, fatty acids and oleochemicals by O. P. Narula, Industrial Consultants (India), Vo. I & II (1994)

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

CO1	Understand and explain the technology of oilseed processing and crude edible oil refining.	K2
CO2	Apply the knowledge of, science, chemical engineering and fundamentals, of lipid processing technology to solve complex problems in core as wells as allied industries.	K3
CO3	Identify and interpret the tools for chemical analysis required for and during the processing of edible oils.	K3
CO4	Learn newer techniques for refining oils and fats	K4
CO5	Understand spoilage during storage of fats and fat products	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5	K6
CO1	K2	3	2	2	2	2
CO2	K4	2	3	2	2	2
CO3	K2	3	1	3	2	2
CO4	K4	2	2	3	3	2
CO5	K5	2	2	2	3	3
Course	K3	2	2	3	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester V

Course Code: SOT4353	Course Title: Lipid Laboratory II	Credits = 2		
		L	T	P
Semester: V	Total contact hours: 60	0	0	4

List of Prerequisite Courses

SOP4351 - Lipid Lab I, SOT4353 - Lipid Processing Technology I

List of Courses where this course will be prerequisite

None

Description of relevance of this course in the Int. M. Tech. Program

- This course will introduce the student to techniques used for extracting oils from natural sources, processing byproducts of the lipid refining industry, and analysis of soaps, surfactants and detergents.

Sr. No.	Course Contents (Topics and subtopics)	Reqd. Hours
1	Solvent Extraction : oil extraction from oilseeds I	4
2	Solvent Extraction : oil extraction from oilseeds II	4
3	Aqueous Extraction: oil extraction from oil seeds	4
4	Hydraulic Expelling: oil extraction from oil seeds I	4
5	Hydraulic Expelling: oil extraction from oil seeds II	4
6	Physical Refining of Crude edible oil	4
7	Chemical Refining of Crude edible oil	4
8	Double Solvent Extraction: oil extraction from oil seeds	4
9	Wax processing and analysis: Crystallization process, oil content	4
10	Splitting of Purified Wax	4
11	Analysis of Detergents: Foaming, wetting test, surface tension, active matter	4
12	Analysis of Soap I	4
13	Analysis of Soap II	4
14	Vegetable oil splitting: MAG, DAG, FAs	4
15	HPLC analysis of MAG, DAG, FAs	4
	Total	**60**

List of Textbooks

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.	Handbook of Surfactants, Porter, M. R., Springer Science and Business Media (1993).

Reference Books

1.	Fatty Acids by Robert Johnson
2.	Fats and Oils Handbook by Bockisch Michael
3.	The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses – Frank D. Gunstone, Blackwell Publishing Ltd.

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

CO1	Understand the methods and chemical engineering principles of oil extraction from oilseeds and execute the same on laboratory scales.	K4
CO2	Apply the analytical information in sound reasoning to solve problems in lipid and allied industries.	K5
CO3	Interpret and utilise the analytical information in oils, surfactants, detergents, and cosmetics.	K4
CO4	Carry out analysis of Soap: TFM, Glycerol Content	K4
CO5	Perform splitting of vegetable oils to get MAG, DAG	K5

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5+K6	K6
CO1	K2	1	1	3	2	2
CO2	K4	2	1	3	2	2
CO3	K2	3	2	3	1	2
CO4	K4	3	3	3	3	2
CO5	K5	2	2	3	3	3
Course	K3	3	2	3	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester VI

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

List of Prerequisite Courses

SOT4351 - Chemistry of Oils and Fatty Acids, SOT4352 - Technology of Oleochemicals and Surfactant, SOT4353 - Lipid Processing Technology I

List of Courses where this course will be prerequisite

SOT4355 - Production and Applications of Soaps, Surfactants and Detergents

Description of relevance of this course in the Int. M. Tech. Program

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

Sr. No.	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, crystallisation, high purity fatty acid product blends, etc.	04
3	Hydrogenation of oils: Significance 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
4	Production of fatty alcohols	08
5	Production of biodiesel and green diesel	04
	Total	**30**

List of Textbooks

1.	M.M Chakrabarty. Chemistry and Technology of Oils and Fats. Allied Publishers Pvt. Ltd. New Delhi
2.	Bailey's Industrial Oil and Fat Products, Sixth Edition Vol. 6: Industrial and Nonedible Products from Oils and Fats, Ed. Fereidoon Shahidi, Wiley Interscience Publication (2005).

List of additional reading material/Reference Books

1.	Hydrogenation of Oil & Fat Edited by H.B.W. Patterson Applied Science Publishers (1983)
2.	Gupta, M. K., Practical guide to vegetable oil processing. AOCS Press, 2008 Urbana, Illinois.
3.	Fats and oils, Formulating and Processing for Applications, 3rd Edition, 2009, Richard D.O. Brien.
4.	Fats and Oils Handbook, Michael Bockisch, 1st Edition, 1998, AOCS Press

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

CO1	Understand and explain the technology of secondary and tertiary oleochemical production and derivatisation.	K2
CO2	Apply the knowledge of chemical engineering fundamentals and oleochemical technology to solve complex problems in core and allied industries.	K3
CO3	Identify and interpret the tools for the chemical analysis required for producing and derivating oleochemicals.	K3
CO4	Design and execute experiments to carry out research for the development of novel oleochemical production technology and applications	K6
CO5	Carry out production of biodiesel and green diesel	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5+K6	K6
CO1	K2	3	2	2	2	2
CO2	K4	2	3	2	2	2
CO3	K2	3	1	3	2	3
CO4	K6	2	3	3	3	3
CO5	K6	2	3	3	3	3
Course	K5	1	2	3	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

Semester VII

Course Code: SOT4355	Course Title: 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

SOT4351 – Chemistry of Oils and Fatty Acids, SOT4352 – Technology of Oleochemicals and Surfactant, SOT4354 – Lipid Processing Technology II, SOP4352 – Lipid Laboratory II

List of Courses where this course will be prerequisite

None

Description of relevance of this course in the Int. M. Tech. Program

- This course will provide a knowledge base about the mechanism, theory, and practice of the production of surfactants and detergents and their application in core and allied industries.

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 manufacture of detergents for domestic and industrial consumption, product evaluation, Indian Standard Institution Methods, essential oils, and other ingredients for detergents.	8
4	Plant and 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 Textbooks

1.	Handbook of Surfactants, Porter, M. R., Springer Science and Business Media (1993).

List of additional reading material/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).

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

CO1	Understand and explain the production technology and applications of surfactants.	K2
CO2	Apply the knowledge of chemical engineering fundamentals and lipid chemistry to solve complex problems in surfactants, cosmetics, and allied industries.	K3
CO3	Identify and interpret the tools for chemical analysis required for the production and applications of surfactants in cosmetics, detergents and allied industries.	K3
CO4	Able to interpret emerging trends in the surfactants industry and developing innovative products and newer applications by designing and carrying out research through experimentation	K4
CO5	Formulate soaps, surfactants and detergents in food, pharmaceuticals, etc.	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1	K2+K3	K4	K5+K6	K6
CO1	K2	3	2	2	2	2
CO2	K4	2	3	2	2	3
CO3	K2	3	1	3	2	3
CO4	K4	2	3	3	3	3
CO5	K6	2	3	3	3	3
Course	K3	1	2	3	2	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; − No Contribution

K, knowledge level from cognitive domain

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SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE

in

CHEMICAL SCIENCES

[Under the National Education Policy (NEP 2020)]

2023-2024

Offered by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra
BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

Preamble

Chemistry is known as the 'central science' – a sound understanding of the interactions between molecules is critical in all the technical applications. Understanding the fundamentals of Chemistry is the first step towards designing high throughput synthetic methodologies for fine and bulk chemicals, pharmaceutical components, plastics, etc. The principals of thermodynamics and kinetics are critical for designing energy efficient industrial processes. Applications based on the chemical sciences are bound play an indispensable role in achieving sustainable development goals at a global level. The present module of Multidisciplinary Minor (MDM) on Chemical Sciences is offered by the Institute of Chemical Technology, Mumbai Marathwada Campus, Jalna under the aegis of the National Education Policy (NEP 2020). The aim of the Chemical Sciences MDM is to equip Chemical Engineers with a thorough understanding of the concepts and applications of Chemistry. The salient features of the MDM in Chemical Sciences are as follows: Industry relevance: The bulk and fine manufacturing industries rely heavily on their trained experts to bridge the gap between concepts and technology. The MDM aims to equip students for diverse roles in numerous industries such as pharmaceuticals, polymers, dyes and textile industries Innovation and Entrepreneurship: The national objectives of self-reliance are driving the economy towards a setup where entrepreneurial ventures will be more important. With the growth in demand for 2 locally manufactured chemicals and in accordance with the Institute's legacy of producing industrialists and entrepreneurs, students will be able to successfully combine the expertise in Chemistry and technology to address this expanding market. Research and Development: The future of research in interdisciplinary with greater coordination between the scientists and technologists. The students will comprehend and combine both aspects through their training to be competent researchers on a global level. Interdisciplinary Collaboration: In addition to chemical industries, innovations in Chemistry can traverse into other domains such as biological sciences, electronics, automobiles, smart technologies, etc. The students with a thorough understanding of materials can develop solutions in diverse fields and contribute substantially. Sustainable development: The current challenges of pollution and non-renewable feedstocks can only be addressed through well-trained chemical experts. Development of clean technologies and energyefficient transportation can be achieved only through application of chemical knowledge. Chemistry can play a pivotal role in ensuring food security and access to health care – key factors in alleviating poverty.

A. List of the open electives (OE) and MDM offered by ICT MARJ:

Course Code	Semester	Subject	Credits	Hrs/Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
SCT4351	III	Organic Spectroscopy	02	2	0	0	20	30	50	100
SCT4352	IV	Organic Synthesis	02	2	0	0	20	30	50	100
SCP4351	IV	Organic Synthesis Laboratory	02	0	0	4	20	30	50	100
SCT4353	V	Chemical Kinetics	02	2	0	0	20	30	50	100
SCP4352	V	Physical Chemistry Laboratory	02	0	0	4	20	30	50	100
SCT4354	VII	Computational Chemistry	02	2	0	0	20	30	50	100
SCT4355	VIII	Organometallic Chemistry and Catalysis	02	2	0	0	20	30	50	100
Total			**14**							**800**

The students enrolled for Minor Degree in Chemical Science program will not be allowed to take the following Open Elective courses:

1. Organic Synthesis
2. Organic Spectroscopy
3. Computational Chemistry
4. Chemical Kinetics
5. Organometallic Chemistry and Catalysis

Students are also expected to confirm the **course pre-requisites for each course offered as an open elective** before enrolling.

MDM Courses – Faculty members:

1) Organic Spectroscopy – Dr. M M Jadhao
2) Organic Synthesis –Dr. M. B. Gawande
3) Organic Synthesis Laboratory – Dr. M B Gawande
4) Chemical Kinetics – Dr. S. Mondal
5) Physical Chemistry Laboratory – Dr. S Mondal
6) Computational Chemistry – Dr. M M Jadhao/ Visiting faculty
7) Organometallic Chemistry and Catalysis – Dr. M. B. Gawande / Visiting faculty

Programme Specific Outcomes (PSOs) for Chemical Sciences (MDM)

PSO1	Foundations of Chemistry: Gain a comprehensive understanding of organic and physical chemistry principles, including hydrocarbons, chemical kinetics, and computational methods, essential for problem-solving in industrial applications.
PSO2	Catalysis and Advanced Technologies: Explore the broad spectrum of catalysis applications and advancements, facilitating the implementation of cutting-edge chemical technologies at scale.
PSO3	Research and Problem Solving: Develop skills to investigate and resolve complex real-world challenges by leveraging chemical knowledge and research methodologies, from problem identification to data analysis and solution provision.
PSO4	Chemistry in Society: Apply reasoning informed by the existing knowledge pool to convert into a quantitative framework, collect relevant information and address various societal issues using chemical tools.
PSO5	Cater to the needs of chemical and allied industries, research organizations and academic institutes. set-up their own ventures and generate employment, promote awareness in society about Chemical Science profession

Mapping of All Courses of Chemical Sciences with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Organic Spectroscopy	K6	3	3	3	2	1
Organic Synthesis	K6	3	3	3	1	1
Organic Synthesis Laboratory	K6	3	3	3	2	2
Chemical Kinetics	K6	3	3	2	2	2
Physical Chemistry Laboratory	K6	3	3	2	3	3
Computational Chemistry	K6	3	2	2	2	2
Organometallic Chemistry and Catalysis	K6	3	2	2	2	2

Semester III

Course Code: SCT4351	Course Title: Organic Spectroscopy	Credits = 2		
		L	T	P
Semester: III	Total Contact Hours: 30	2	0	0

List of Prerequisite Courses

Applied Chemistry I (CHT4151)

List of Courses where this course will be Prerequisite

Organic Synthesis (SCT4352)

Description of relevance of this course in the Int. M. Tech. Program

- This course aims to introduce the students to the concepts of organic spectroscopy. The course content is designed to familiarize the students with various spectroscopic techniques used for the structural elucidation of organic molecules.

Sr. No.	Course Contents (Topics and subtopics)	Reqd. Hours
1	**Ultra Violet (U.V.) Spectroscopy**: Introduction, spectrophotometer, Beer-Lambert's law, Energy absorption and electronic transitions, Terms used in U.V. spectroscopy (Chromophore, auxochrome, bathochromic shift, hypsochromic shift, hyperchromic and hypochromic shift), Woodward – Fieser Rules for dienes, enones and aromatic compounds	6
2	**Infrared spectroscopy:** Vibrational transitions, Selection rule, Modes of stretching and bending, FT-IR spectrophotometer. Group frequencies, Factors affecting IR group frequency, NIR spectroscopy, Applications of vibrational spectroscopy in structural elucidation of organic compounds.	6
3	**NMR Spectroscopy** **A. ^{1}H NMR Spectroscopy:** Basic principle, Nuclear spin states and magnetic moments, Chemical shifts, Factors affecting the chemical shift, Shielding mechanism and anisotropic effects. **B. ^{13}C NMR Spectroscopy:** Elementary idea, Chemical shift, Calculation of approximate chemical shift values, Coupling constants, Interpretation of simple CMR spectra, Proton coupled and decoupled ^{13}C NMR spectra.	10
4	**Mass Spectrometry:** Introduction, Ion production, Fragmentation, Stevenson's rule, Radical site and Charge site initiated cleavage, Rearrangements, Cleavage associated with common functional groups, Molecular ion peak, Metastable ion peak, Nitrogen rule, LRMS and HRMS, Isotopic abundance and Interpretation of mass spectra.	8
	Total	**30**

List of Text Books/ Reference Books	
1	Introduction to Spectroscopy, D.L. Pavia, G.M. Lampman, G.S. Kriz, J.R. Vyvyan, Cengage Learning India Pvt Ltd
2	Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X. Webster, Wiley
3	Organic Spectroscopy: William Kemp, Palgrave
4	Principles of NMR in one and Two Dimensions: R.R. Ernst, G. Bodenhausen, A. Wokaun: Oxford Science Publication

Course Outcomes (Students will be able to….)		
CO1	Understand the general principles of various spectroscopic techniques used for characterization of organic molecules	K1, K2
CO2	Assign the spectroscopic data to particular structural features of molecules	K3
CO3	Understand the theory of Nuclear Magnetic Resonance spectroscopy and its applications to structural problems	K2, K3
CO4	Predict the fragmentation of alkanes, alkyl aromatics, alcohols, ketones using the principle of Mclafferty rearrangement, and mass spectrometry	K4, K5
CO5	Solve problems based on UV, IR, NMR & MS Spectroscopy for interpretation of the structure.	K5, K6
CO6	Choose the optimum spectroscopic technique/s for identification and structure elucidation of a given compound	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1 + K2	K3	K4 + K5	K5	K5
CO1	K1, K2	3	3	2	1	-
CO2	K3	3	3	2	1	-
CO3	K2, K3	3	3	3	1	-
CO4	K4, K5	3	3	2	1	-
CO5	K5, K6	3	3	2	1	1
CO6	K6	3	3	2	1	1
Course	K6	3	3	3	2	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester IV

Course Code: SCT4352	Course Title: Organic Synthesis	Credits = 2		
		L	T	P
Semester: IV	Total contact hours: 30	2	1	0

List of Prerequisite Courses

Applied Chemistry I (CHT4151)

List of Courses where this course will be prerequisite

Organic Chemistry Laboratory (CHP4151), Organometallic Chemistry and Catalysis (SCT4355)

Description of relevance of this course in the Int. M. Tech. Program

- This course will require for getting minors in Chemistry in for 4 years B. Tech (Chemical engineering) and 5 years Int.-M. Tech (Chemical engineering).
- This course will also useful for the firth year Int.-M. Tech students during their master's thesis to understand the organic transformations and chemical engineering reactions such as flow chemistry, batch reactions, photochemical reactions and others.
- Importantly, students will be familiar with concepts related to fundamentals of Organic Chemistry including reaction mechanism, organic transformations, types of reactions, selectivity of chemical transformations, stereochemical implications of organic reactions, functional group identification and reactions so thatthey are perfectly aligned to apply the same for future courses and in their professional career.

	Course Contents (Topics and subtopics)	Reqd. Hours
1	**Chemistry of Carbonyl Compounds** Concept of acidity and tautomerism of carbonyl compounds, General methods of preparation and Nucleophilic Addition reactions Enolate chemistry, Aldol and related condensation reactions, Michael reaction, Robinson annulation, Claisen condensation, Dieckmann condensation, Mannich reaction.	**5**
2	**Haloalkanes:** General reactions. Mechanisms of nucleophilic substitutions reactions (SN1 & SN2) and elimination reactions.	**5**
3	**Heteroaromatic compounds:** Basic structures and common names, comparison of electronic and structural properties to benzenoid compounds, Reactivity and synthetic routes Pyrrole, Furan, Thiophene, Pyridine.	**5**
4	**Named Organic Reactions** Perkin reaction (Mauvine synthesis-dyes), Fischer indole synthesis, (dyes), Jacobson Corey epoxide synthesis (Pharmaceutical), Ziegler Natta polymerisation (polymer), Multicomponent reactions, Mailard reaction (foods), Strecker amino acid synthesis (Pharmaceuticals & Food), Wittig reactions, Prilezhaev reaction	**5**
	Stereochemistry of Organic Compounds	

5	Containing one and two asymmetric carbon atoms, Stereo descriptors – R/S, E/Z, erythro and theory, Conformation – Ethane and butane. Enantiomers and Diastereomers, meso compounds, different representations of stereoisomers – Saw-horse, Newmann, Wedge and dash and Fischer and their interconversions	**6**
6	**Chemistry of important natural products:** Terpenes, steroids, carotenoids/prostaglandins	**4**
	Total	**30**

List of Textbooks / Reference Books

1. Smith, M. B.; March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure;7th ed.; Wiley, India (2015)
2. Carey F. A., Sundberg, R. J. Advanced Organic Chemistry: Part A: Structure andMechanisms; 5th ed.; Springer (2005)
3. Carey F. A., Sundberg, R. J.; Advanced Organic Chemistry: Part B: Reaction andSynthesis; 5th ed.; Springer (2007)
4. Wade, L. G.; Simek, J. W.; Singh, M. S. Organic Chemistry; 9th Ed.; Pearson Education(2019)
5. Eliel, E. L. Stereochemistry of Carbon Compounds; Mcgraw-Hill (2001)
6. Bruice, Paula, Y. Organic Chemistry; 8th Ed.; Pearson Education (2020)
7. Bhat, S. V., Nagasampagi, B. A., Meenakshi, S. Natural Products Chemistry and Applications.Narosa publishing house (2009)

CO1	Identify structures of organic compounds and write their IUPAC names correctly	K1, K2
CO2	Understand organic chemistry reactions related to aliphatic as well as aromatic compounds as well as decipher the outcome of a given organic transformation	K1, K3
CO3	List the properties and synthetic routes, and decipher outcomes of various transformations involving heterocycles	K3
CO4	Apply the knowledge obtained through the course to predict the outcome of reactions and devise solutions to unknown problems	K3, K4
CO5	Appreciate the stereochemical implications of organic compounds and visualize and appreciate the chirality concept	K4
CO6	Interpret and analyze reactions having different functionalities to predictproducts and design synthetic protocols	K5, K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1 + K2	K3	K4 + K5	K5 + K6	K5
CO1	K1, K2	3	2	3	-	-
CO2	K1, K3	2	3	3	-	-
CO3	K3	2	3	3	-	1
CO4	K3, K4	3	2	2	-	1
CO5	K4	3	2	2	1	1
CO6	K5, K6	3	2	3	1	1
Course	K6	3	3	3	1	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester IV

Course Code: SCP4351	Course Title: Organic Synthesis Laboratory	Credits = 2		
			T	P
Semester: IV	**Total contact hours: 60**			**2**

List of Prerequisite Courses

Applied Chemistry I (CHT4151)

List of Courses where this course will be prerequisite

Computational Chemistry (SCT4354), Organometallic Chemistry and Catalysis (SCT4355), Research thesis (CEP4473) and IPT (CEP4473)

Description of relevance of this course in the Int. M. Tech. Program

- This course will give a clear idea about different organic synthesis protocol by using cost effective catalysts. The prepared organic compounds will be isolated by several techniques such as crystallization method, preparative TLC, and column chromatography.
- The isolated pure compounds will be characterized by analytical and spectroscopic techniques. These techniques include melting point/boiling point, FT-IR spectroscopy, GC and GC-MS. Moreover, the student will be able to learn design of cost-effective routes for the organic compounds synthesis and its characterized working knowledge of terminology and tools used during the physical chemistry lab.

	Course Contents (Topics and subtopics)	Reqd. Hours
1.	Identification of unknown organic compounds based on physicochemical properties: Organic compounds/molecules contain different advanced functional groups which undergo characteristic reactions.	
2.	Identification of unknown mixture of organic compounds based on physicochemical properties and chemical properties.	
3.	Physical properties such as solubility and chemical reactivity in known reactions will also be used in the identification.	
4.	One-pot synthesis of organic compounds	
5.	In-situ two-step synthesis of organic compounds.	
6.	Hydrogenation of nitro compounds to corresponding amines under ambient conditions	
7.	One-pot multicomponent approach for the organic synthesis	
8.	Common synthetic methods using in reactions for the synthesis of pharmaceutical and biological importance molecules and optimization of reaction conditions.	
9.	Progress of the reactions monitoring by thin layer chromatography (TLC) and IR analysis.	
10.	Identification of organic molecules using FTIR spectroscopy.	

11.	To analyze the obtained reaction mixture by Gas Chromatography	
12.	To determine the pure organic compounds by Gas chromatography/mass spectrometry (GC/MS)	
	Total	**60**

List of Textbooks / Reference Books

1. Advanced Organic Synthesis a Laboratory Manual, By Dmitry V. Liskin, Penny Chaloner, 2016.
2. Advanced Practical Organic Chemistry, NK Vishnoi
3. Practical Synthetic Organic Chemistry: Reactions, Principles, and Techniques
4. Editor(s): Stéphane Caron, Wiley publication

CO1	Identify and understand structures of organic compounds and their physical properties based on their physicochemical properties	K2, K3
CO2	Apply the knowledge of organic chemistry basics for the one-pot, two-step and hydrogenation reactions	K3, K4
CO3	Use the appropriate isolation method or analysis for the prepared organic compounds	K2, K5
CO4	Interpret and analyse synthesized organic compounds by FT-IR, GC and GC-MS	K6
CO5	Determine the pure organic compounds	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1 + K2	K3	K4 + K5	K5	K5
CO1	K2, K3	3	2	1	1	1
CO2	K3, K4	3	3	2	2	1
CO3	K2, K5	3	3	1	3	1
CO4	K6	3	3	2	3	1
CO5	K6	3	2	2	1	1
Course	K6	3	3	3	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution
K, Knowledge-level from cognitive domain; A, Affective domain, S, Psychomotor domain

Semester V

Course Code: SCT4353	Course Title: Chemical Kinetics	Credits = 2		
Semester: V	Total contact hours: 30	L	T	P
		2	0	0

List of Prerequisite Courses

Std XII Chemistry, Applied Chemistry-II (CHT4152)

List of Courses where this course will be prerequisite

Physical Chemistry Laboratory (SCP4352)

Description of relevance of this course in the Int. M. Tech. Program

- Chemical reactions are involved in the production of almost everything in the modern world. Why do some reactions take years to complete whilst others are so fast that can be completed in pico/femto seconds? The course covers the key concepts of three of the principal topics in chemical kinetics.
- This will help to understand how fast a reaction can go. Relevance of reaction rates and parameters affecting the same are required in many situations which are faced by Chemical Engineers I their professional career.

	Course Contents (Topics and subtopics)	Rqd. Hours
1	Chemical kinetics – Introduction, concept of reaction rates and order, experimental methods in kinetic studies, differential and integral methods to formulate rate equations of zero, first and second order	03
2	Complex reactions- parallel, consecutive and reversible reactions, order and molecularity	03
3	Kinetics and reaction mechanism- steady state and rate determining step Mechanism of thermal photochemical chain reactions, polymerization reactions, branched chain reactions and kinetics of enzyme catalysis	04
4	Surface reactions – Adsorption, kinetics of surface reactions- Hishelwood and Rideal models of surface reactions	02
5	Theories of reaction rates and temperature effects- collision theory and TST Theory of unimolecular reactions	04
6	Kinetics of reactions in solutions- solvent effects and effects of ionic strength	04
7	Fast reactions and reactions in molecular beams – experimental techniques	03
8	Kinetics of solid-state reactions	02
9	Applications – food, pharmaceutical industry, kinetic isotope effect	03
	List of Text Books/ Reference Books	

1. Introduction to colloid and surface chemistry – D.J. shaw, Butterworth publications
2. Surfaces interfaces and colloids- Drew Myers- Wiley VCH

3. Surfactants and interfacial phenomena- Milton J Rosen – Wiley Interscience
4. Industrial utilization of surfactants principles and applications – M.J. Rosen and M Dahanayake, AOCS Press
5. Foundations of Colloid science – Robert J Hunter – Oxford university Press

Course Outcomes (Students will be able to…..)	
CO1: Understand the concept of rate of change associated with chemical change and its measurements.	K2, K3
CO2: Be able to identify the reaction order for a chemical change.	
CO3: Understand the concept of pseudo-first order kinetics and when they apply.	K2, K3
CO4: To obtain the concentration of chemical species during a reaction of different orders by applying integrated rate equations.	K3, K4
CO5: Understand the concept of mechanism and factors, such as concentration, temperature, medium and the presence of a catalyst, affect the reaction rate.	K2, K3
CO6: Interpret a reaction coordinate diagram/potential energy diagram and determine a single or multistep mechanism.	K3, K4
CO7: Understand the concept of activation energy in the context of the transition state and calculate the activation from some real experiments.	K2, K5
CO8: Apply the concept of kinetic isotope effect in the applications of food, pharmaceutical industry.	K4, K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1 + K2	K3	K4 + K5	K5	K5
CO1	K2, K3	3	2	1	1	1
CO2	K3, K4	3	3	1	2	2
CO3	K2, K3	3	2	1	1	1
CO4	K3, K4	3	3	2	1	1
CO5	K2, K3	3	2	1	1	1
CO6	K3, K4	3	3	3	3	3
CO7	K2, K5	3	3	3	3	3
CO8	K4, K6	3	3	3	3	3
Course	K6	3	3	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge-level from cognitive domain; A, Affective domain, S, Psychomotor domain

Semester V

Course Code: SCP4352	Course Title: Physical Chemistry Laboratory	Credits = 2		
Semester: V	Total contact hours: 60	L	T	P
		0	0	2

	List of Prerequisite Courses	
	Applied Chemistry I (CHT4151)	
	List of Courses where this course will be prerequisite	
	Chemical Engineering Electives (CETxxxx)	
	Description of relevance of this course in the Int. M. Tech. Program	
	This course will give a clear idea about different analytical techniques, solution preparation, concentration measurements, different kinds of spectroscopy. Graph and diagram of the experiment will give a statistical description of experimental methods. Moreover, the student will be able to develop working knowledge of terminology and tools used during the physical chemistry lab.	**4hr/ lab**
1	Study of viscosity of unknown liquid (glycerol, sugar) with respect to water.	**60**
2	Determination of surface tension by drop count method	
3	Study of the kinetics of Hydrolysis of Methyl Acetate 8hrs	
4	Determination of Critical Micelle Concentration (CMC) of a Surfactant.	
5	Study of the Adsorption of acetic acid on Charcoal-verification of Freundlich's adsorption isotherm	
6	Study the kinetics of decomposition of H_2O_2. 8hrs	
7	To verify Beer – Lambert's Law of a colored solution	
8	Determination of the pKIn Value of an Acid-Base Indicator by Spectrophotometric Method	
9	Determination of Iso-Electric Point of an Amino acid.	
10	To determine the dissociation constants of a polybasic acid using pH meter	
11	Study of kinetics of reactions by using spectrophotometric method	
12	Introduction of excitation and emission spectra, Mirror-image relation and Stokes shift 8hrs	

List of Text Books/ Reference Books

Advanced Physical Chemistry Experiments: by Gurtu & Gurtu
Selected experiments in Physical Chemistry by N. G. Mukherjee
An Advanced Course in Practical Chemistry by Ghoshal, Mahapatra, and Nad

Course Outcomes (Students will be able to…..)	
CO1: To learn basic analytical techniques useful for engineering applications.	K2, K3
CO2: Estimation of solution concentration and kinetics using advanced spectroscopic techniques.	K3, K4
CO3: To learn different physical parameters and understanding of Graph and diagram of the experiment.	K2, K5

CO4: Applications of spectroscopic measurements.	K6
CO5: Determine the dissociation constants of a polybasic acid.	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1 + K2	K3	K4 + K5	K5 + K6	K5
CO1	K2, K3	3	2	2	2	2
CO2	K3, K4	3	3	2	2	3
CO3	K2, K5	3	3	3	3	3
CO4	K6	3	3	3	3	3
CO5	K6	3	3	3	3	3
Course	K6	3	3	2	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge-level from cognitive domain; A, Affective domain, S, Psychomotor domain

Semester VI

Course Code: SCT4354	Course Title: Computational Chemistry	Credits 2		
Semester: VI	Total contact hours: 30	L	T	P
		2	0	0

List of Prerequisite Courses

Standard XIIth Mathematics (Calculus and Matrix Algebra), Chemistry I, II, Organic Synthesis (SCT4352)

List of Courses where this course will be prerequisite

This course will require for getting minors in Chemistry in for 4 years B. Tech (Chemical engineering) and 5 years Int.-M. Tech (Chemical engineering). This course will also useful for the fifth year Int.-M. Tech students during their master's thesis for running quantum chemical calculations.

Description of relevance of this course in the Int. M. Tech. Program

- The quantum chemistry gives the molecular level understanding of the chemical reactions and the properties of moderated sized isolated molecules. While the molecular mechanics can be used for the studying the supramolecular and ensembles. The course will provide the molecular level understanding of various processes/reactions.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Introduction to Computational Chemistry, Basic concepts	2
2	**Historical background of quantum mechanics**- failure of classical theory, wave particle duality, uncertainty principle, Postulates of Quantum mechanics, probabilistic interpretation of wave function, Schrodinger wave equation, Eigen values and operators.	4
3	**Applications of Schrodinger equation**– particle in a box, harmonic oscillator **H and H like atoms**- two particle problem, Schrodinger equation in spherical coordinates, representation of orbitals, radial and angular plots, probability functions	4
4	**Chemical bonding**- Born-Oppenheimer approximation, LCAO and MO theory	4
5	**Electronic structure - methods:** SCF Theory, Energy of Slater Determinant, Basis Set Approximation, Basis Sets, Hartree-Fock Approximation	6
6	Semi empirical Methods, Huckel Theory	4
7	**Force fields**, potential energy functions, inter and intramolecular interactions, empirical parameters. **Molecular mechanics** calculations, energy minimization, conformational analysis	4

8	Applications in Drug Designing, QSAR, and Catalysis.	**2**
List of Text Books/ Reference Books		
1.	Alan Hinchliffe, Molecular Modelling for Beginners, 2nd Ed. Wiley & Sons, 2008.	
2.	Frank Jensen, Introduction to Computational Chemistry, Wiley & Sons,1999.	
3.	Christopher J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Ed. Wiley & Sons, New York.	
4.	Daan Frenkel & Berend Smit, Understanding Molecular Simulation, AP, NY, 2002.	
5.	Andrew R. Leach, Molecular Modelling: Principles and Applications, 2nd Ed., Prentice Hall, 2001.	
6.	James E. House, Fundamental of Quantum Chemistry, 2nd Ed. Academic Press, 2004.	
Course Outcomes (Students will be able to…..)		
CO1	Define the computational techniques currently used to predict the structure and properties of molecules	K1, K2
CO2	Apply semi-empirical / ab initio techniques to model structure and properties of molecules	K3
CO3	Apply molecular dynamics techniques for modelling larger systems and elucidate their properties	K3, K4
CO4	Compare the output of the various computational methods to explain the experimental observations	K5
CO5	Choose the optimum level of theory for computing properties of the systems	K5, K6
CO6	Design the computational protocol for predicting the outputs of chemical reactions and processes	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K1, K2	3	0	2	1	1
CO2	K3	3	1	2	1	2
CO3	K3, K4	3	1	2	2	2
CO4	K5	3	1	2	2	2
CO5	K5, K6	3	2	2	2	2
CO6	K6	3	2	2	2	2
Course	K6	3	2	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester VII

Course Code: SCT4355	Course Title: Organometallic Chemistry and Catalysis	Credits = 2		
		L	T	P
Semester: VII	Total contact hours: 30	2	0	0

List of Prerequisite Courses

Applied Chemistry-I (CHT4151) Applied Chemistry-II (CHT4152)

List of Courses where this course will be prerequisite

This course will require for getting minors in Chemical Sciences in for 4 years B. Tech (Chemical engineering) and 5 years Int.-M. Tech (Chemical engineering). This course will also useful for the fifth year Int.-M. Tech students during their master's thesis and IPT.

Description of relevance of this course in the Int. M. Tech. Program

- This course will require for getting minors in Chemistry in for 4 years B. Tech (Chemical engineering) and 5 years Int.-M. Tech (Chemical engineering). This course will also useful for the firth year Int.-M. Tech students during their master's thesis to understand the advanced catalytic organic transformations and chemical engineering reactions such as Environment remediation for CO_2 utilization and depolymerization.
- Importantly, to acquaint the students the concepts of organometallic chemistry which is the basis of all the catalyticprocesses either known in academia or industries. The course will allow students to appreciate the science behind how catalytic processes help expedite synthesis.

	Course Contents (Topics and subtopics)	Hours
1	General Properties of Organometallic Complexes: 18- electron rule and its limitation, Electron counting in reactions, Bridged complexes, Metal-metal bond. Associative-Dissociative mechanisms	6
2	Complexes of π-Bound Ligands: Backbonding concept for explaining metal-alkene and alkyne interactions. Alkene and Alkyne complexes allyl complexes, Diene complexes. Ziegler-Natta Polymerization, SHOP (Shell Higher OlefinProcess), Catalytic Hydrogenation	10
3	Carbonyls Complexes: Backbonding concept for explaining metal-carbonyl interactions. Metal complexes of CO ligands, Dissociative substitution, Associative mechanism. Substitution reactions of Metal-CO complexes. Formylation (Monsanto Acetic Acid Synthesis), Hydroformylation (Otto Roelen Process)	10
4	Organometallic chemistry for meeting future challenges: Environment remediation for CO_2 utilization and depolymerization	4
		30

List of Textbooks / Reference Books

1	The organometallic chemistry of the transition metals, Robert H. Crabtree, John Wiley & Sons	
2	Organometallic Chemistry of Transition elements: F. P. Pruchnik: Springer	
3	Organometallic reagents in Organic Synthesis: Paul R. Jenkins: Oxford Science Publication	
Course Outcomes (students will be able to….)		
CO1	Learn the basic concepts of how catalysis works	K1, K2
CO2	Understand the basic properties for organometallic compounds	K1, K2
CO3	Explain the observed properties on the basis of structure and bonding in organometallics	K3, K4
CO4	Explain the experimental observations by proposing plausible mechanisms for catalytic reactions	K3, K4
CO5	Select the suitable organometallic compounds for applications as catalysts in organic transformations	K5
CO6	Develop synthesis and characterization protocols for organometallics based on the desired structure and applications	K6

Mapping of Course Outcomes (COs) with Programme Specific Outcomes (PSOs)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K1, K2	3	3	2	1	1
CO2	K1, K2	3	2	2	1	2
CO3	K3, K4	2	1	3	2	2
CO4	K3, K4	2	3	2	2	2
CO5	K5	3	3	2	1	1
CO6	K6	3	2	3	2	2
Course	K6	3	2	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution
K, Knowledge level from cognitive domain; A, Affective domain; S, Psychomotor domain

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SYLLABUS OF THE CURRICULUM

for

MULTIDISCIPLINARY MINOR DEGREE

in

MATERIALS PHYSICS

[Under the National Education Policy (NEP 2020)]

2023-2024

Offer by

Institute of Chemical Technology Mumbai

Marathwada Campus, Jalna

(University Under Section-3 of UGC Act, 1956)
Elite Status and Center for Excellence
Government of Maharashtra
BT-5/6, Biotechnology Park, Additional MIDC Area,
Chhatrapati Sambhajinagar (Aurangabad) Road, Jalna – 431 203.

Preamble

The interdisciplinary field of materials science has become crucial to many emerging areas for advancing technology and their applications. For example, materials science is extensively used in the semiconductor industry, Polymer industry, renewable energy, automotive and aerospace industry to name a few.

The courses offered in this Minor program in materials science will allow interested students to gain an understanding of the fundamental processes that govern materials behaviour and their pivotal role in modern technology. The students shall understand various materials properties, materials processing techniques, characterization methods and selection criterion in implementing engineering solutions, and thereby enhance their core competence as an engineer/technologist.

To summarize, the students will have the opportunity of combining knowledge of their major with the knowledge of materials, improve their marketability to employers, and consider higher studies in materials related fields.

Program specific Outcomes (PSOs) for Minor degree in Materials Science

Students will be able to;

PSO1	**Understand** the fundamentals of materials science required in addressing complex real-world problems related to use of materials in technological applications. Develop a sound understanding of materials properties from the Physico-chemical perspective and their dependence on various parameters. (Factual Knowledge) (K1)
PSO2	**Comprehend** knowledge and familiarity with optimization of experimental conditions required for a desired performance. Acquaintance about materials economy and geographical distribution of minerals/resources. (Conceptual Knowledge) (K2, K3)
PSO3	**Select, design, synthesize**, process, characterize, and thoroughly investigate materials from a functional viewpoint. Expertise in techniques of advanced experimental measurement, and analysis of results to determine physical quantities. (Procedural Knowledge) (K4, K5)
PSO4	**Apply the skills** for combining knowledge of their major with the knowledge of materials to improve their marketability, aware of the importance of sustainability and environmental impact in the context of using materials for technological applications, strictly adhere and commit to follow ethical principles and norms of the practice of physical and material sciences in all verticals of industry and society. (Metacognitive Knowledge) (K6)
PSO5	**Cater** to the needs of research organizations and academic institutes. Set-up their own ventures and generate employment, promote awareness in society

Intake capacity of the program:

To run the program, the minimum number of students enrolled should be 10, and the maximum limit enrollment is restricted to 25. In the event the number is less than the minimum capacity, the candidate shall be offered a seat in the next available minor degree programme.

Eligibility criteria for minor in Materials science:

Should have cleared (i) Applied Physics and (ii) Physics laboratory courses in First year Int M Tech.

Structure of Minor in Materials Science

Structure of Minor in Materials Science											
Sr No	**Course Code**	**Course**	**Semester**	**Credits**	**Hours/week**			**Marks distribution**			
					L	**T**	**P**	**CA**	**MS**	**ES**	**Total**
1.	SYT4351	Solid State Physics	III	2	2	-	-	20	30	50	100
2.	SYT4352	Engineering Properties of Materials	IV	2	2	-	-	20	30	50	100
3.	SYP4351	Basics Materials Laboratory	IV	2	-	-	4	25	-	25	50
4.	SYT4353	Electrical properties of polymers	V	2	3	-		20	30	50	100
5.	SYT4354	Polymer Nanocomposite	V	2	2	-	-	20	30	50	100
6.	SYP4352	Materials Characterization Laboratory	VI	2	-	-	4	25	-	25	50
7.	SYT4355	Introduction to Nanophysics and Applications	VII	2	2	-	-	20	30	50	100

L= lecture; T= tutorial; P= Practical; CA = continuous assessment; MS: Mid-semester exam; ES= End-semester exam.

Pedagogy/Teaching methods:

I) Lecture/discussion:

These sessions will discuss the subject matters of the course

II) Experimental/Practical learning:

The sessions will involve practical exercises.

Evaluation:

Evaluation for the courses will be according to revised document of R.9 credit system and mode of evaluation; the link is provided below or visit the website (ictmumbai.edu.in) for the details.
Link: https://www.ictmumbai.edu.in/uploaded_files/R_9(Revised)_Credit_system.pdf

A general evaluation process for theory and lab courses is given below

A. Theory Courses

a. **Continuous Assessment Test (CAT):** Continuous assessment will vary from course to course; the instructor will decide the evaluation mode. Two to three CATs (Continuous Assessment Tests) will be conducted throughout the course, usually before and after the midsemester examination. These CATs will carry a total weightage of 20%. Depending on the instructor, assignments, case studies, group discussions, and seminars could also form part of the continuous assessment, additional creative assignment, and technical charts.

b. **Mid-semester exam:** Total 30 Marks (theory paper)

c. **End-semester exam:** Total 50 Marks (theory paper)

B. Practical Courses (Laboratory)

a. Continuous assessment: 50 Marks

Performing given experiments as per the instructions, submission of lab journal on time, viva voce, group/personal discussions, and quizzes can be part of continuous assessment. The course instructor will discuss the composition of marks for these at the beginning of the course.

b. End Semester: 50 Marks (Lab experiment performance followed by viva-voce examination)

Instructors (Tentative)

Semester	Course Code	Subjects	Faculty
III	SYT4351	Solid State Physics	GMJ
IV	SYP4351	Basics Materials Laboratory	NPM
IV	SYT4352	Engineering Properties of Materials	GMJ/NPM
V	SYT4353	Electrical properties of polymers	GMJ
V	SYP4352	Materials Characterisation Laboratory	NPM
VI	SYT4354	Polymer nanocomposite	GMJ
VII	SYT4355	Introduction to Nanophysics and Applications	GMJ/NPM

GJ: Prof. Girish Joshi, NM: Dr. Nagsen Meshram

Mapping of All Courses of Materials Physics with PSOs

Courses	K-Level	PSO1	PSO2	PSO3	PSO4	PSO5
Solid State Physics	K4	3	2	2	3	3
Basics Materials Laboratory	K4	3	2	1	1	1
Engineering Properties of Materials	K4	3	2	1	-	2
Electrical properties of polymers	K3	3	2	1	-	-
Materials Characterisation Laboratory	K4	1	1	2	3	3
Polymer nanocomposite	K4	3	2	1	-	2
Introduction to Nanophysics and Applications	K4	-	1	2	3	3

Semester III

Course Code: SYT4351	Course Title: Solid State Physics	Credits = 2		
		L	T	P
Semester: III	Total contact hours: 30	2	-	-

List of Prerequisite Courses

Applied Physics-I (BST 4102), Engineering Physics (PST 4251), Mathematics-I (BST 4103), Mathematics-II (BST 4104)

Courses where this course will be Prerequisite

Engineering Properties of Materials (SYT4352), Basics of Materials, Laboratory (SYP4351), Materials Characterization Laboratory (SYP4352), Introduction to Nanophysics and Applications (SYT4355)

Description of relevance of this course in the Int. M. Tech. Program

- The Solid State Physics course in a Master of Technology program is crucial for understanding the fundamental properties of materials, which underpins advancements in electronics, nanotechnology, and materials science.
- It provides in-depth knowledge of crystal structures, electronic band theory, and semiconductors, essential for developing innovative technologies.

	Course Contents (Topics and subtopics)	Reqd. hours
1	**Binding in solids** Materials in the solid state, origin of attractive and repulsive interactions, types of bonding in solids, derivation of Madelung constant for solids.	4
2	**Crystal structure of solids: diffraction from periodic structures** Brief revision of crystal structures, introduction to reciprocal space and elastic scattering, Laue conditions, atomic form factor, structure factor, experimental techniques for diffraction.	10
3	**Electronic structure of solids: band theory of solids** Free electron models of a metal: Drude's and Sommerfeld's models, inadequacies of free electron models, Electrons in a periodic potential: Schrodinger's equation and Bloch waves, Kronig-Penny model, conduction in semiconductors.	10
4	**Elastic and Thermal properties of solids** Einstein and Debye Models of specific heat, Introduction to lattice vibrations and quantization of elastic waves in a solid, Introduction to the concept of phonons, scattering and thermal conductivity in solids.	06
	Total	**30**

List of Reference Books

1 Elementary Solid-State Physics: Principles and Applications, M. Ali Omar.

2	The Oxford Solid State Basics, Steven H. Simon, Oxford Publishers
3	Principles of Solid-state Physics, R.A. Levy, Academic Publishers
4	Solid State Physics, N. Ashcroft and D. Mermin, Cengage, 1st edition
5	Solid State Physics, A. J. Dekker, Prentice Hall.
6	Electronic Properties of Materials, Rolf Hummel, 3rd Ed. Springer.
7	Introductory Solid-State Physics, H. P. Myers, Viva Publishers

Course Outcomes (students will be able to….)		
CO1	Understand bonding in solids in the context of interaction potentials.	K2, K3
CO2	Map periodic crystal structures in real space onto reciprocal space, and thereby understand the phenomenon diffraction in crystals.	K3, K4
CO3	Describe the behavior of electrons based on the band theory of solids, and thereby understand conduction in metals and semiconductors.	K3, K4
CO4	Correlate the elastic and thermal properties of solids to the concept of phonons	K4
CO5	Understand the terminology encountered in research publications, presentations and advanced courses on solid state and material science topics	K2, K3, K4

Mapping of course outcome (CO) to the program-specific outcome (PSO)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K2	3	3	-	-	-
CO2	K2	2	2	-	-	-
CO3	K2	2	2	2	-	-
CO4	K2	2	3	2	-	-
CO5	K3	3	2	2	-	3
Course	K4	3	2	2	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester IV

Course Code: SYP 4351	Course Title: Basic Materials Lab	Credits = 2		
		L	T	P
Semester: III	Total contact hours: 30	-	-	04

List of Prerequisite Courses

	Applied Physics-I (BST 4102), Engineering Physics (PST 4251), Solid state Physics (SYT4351), Engineering Properties of Materials (SYT4352)	

Courses where this course will be Prerequisite

	Electrical properties of polymers (SYT4353), Materials Characterization Laboratory (SYP4352), Introduction to Nanophysics and Applications (SYT4355), Engineering Properties of Materials (SYT4352)	

Description of relevance of this course in the Int. M. Tech. Program

The Basic Materials Lab course is crucial in a Master of Technology program as it provides hands-on experience with material characterization techniques, essential for understanding material properties.

	Course Contents (Topics and subtopics)	Reqd. hours
1	**Young's Modulus** –to determine the young's modulus of given metal wire as a function different load.	4
2	**Dielectric Constant measurement-** to determine the dielectric constant of materials as a function of thickness	6
3	**Four probe method** - determination temperature dependent resistivity of given semiconductor materials using four probe method	4
4	**Band gap Measurement**- Study the characteristics of PN junction diode with respect to temperature.	6
5	**Contact angle measurement**- determine the contact angle by sessile drop method,	4
6	**Hysteresis analysis**- determine the energy loss of ferromagnetic materials by BH curve analysis	6
7	**Thermal conductivity**- to determine the thermal conductivity of given materials using Lee's disc method	4
8	**Solar cell measurement**- study the solar cell characteristics	4
9	**LDR study** - study the characteristics of LDR	4
10	**Quincke's Tube-** Determine magnetic susceptibility of given materials paramagnetic materials Using Quincke's method	6
11	To find the specific rotation of sugar solution by using a polarimeter	4
12	Determination of the thickness of film by obtaining fringes in wedge shaped air film	4
13	Measurement of transmission and reflectance coefficient by using vector analyser	4
	Total	**60**

List of Reference Books

1.	Elementary Solid-State Physics: Principles and Applications, M. Ali Omar. publisher, 2017	
2.	The Oxford Solid State Basics, Steven H. Simon, Oxford Publishers, 2013	
3.	Materials Science and Engineering: An Introduction by William Callister & David Rethwisch., Wiley, 2013	
4.	Solid State Physics, N. Ashcroft and D. Mermin, Cengage Publishers, 2013	
5.	Solid State Physics, A. J. Dekker, Prentice Hall, 2000	
6.	Electronic Properties of Materials, Rolf Hummel, 3rd Ed. Springer, 2013	
7.	Introductory Solid-State Physics, H. P. Myers, CRC press, 1997	
Course Outcomes (students will be able to….)		
CO1	Elastic, plastic, stress stain properties of materials explore practically to deploy for engineering application	K2, K3
CO2	Identify the dielectric materials to deploy for capacitor	K3
CO3	Distinguish between hydrophilic and hydrophobic nature of materials which are useful for various coating. Able to measure thermal conductivity of given solid materials.	K2, K3
CO4	Understood soft and hard magnetic properties of materials, useful for various domestic and industrial application	K2, K3, K4
CO5	Determine the photo-resistance of materials for sensor application. Student able to measure band gap of semiconductor also able to Evaluate the solar cell materials useful energy application	K2, K3, K4

Mapping of course outcome (CO) to the program-specific outcome (PSO)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K2	3	2	-	-	-
CO2	K2	2	2	-	-	-
CO3	K2	2	2	2	-	-
CO4	K2	2	3	2	-	-
CO5	K3	2	2	-	-	1
Course	K4	3	2	1	1	1

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester IV

Course Code: SYT4352	Course Title: Engineering Properties of Materials	Credits = 2		
		L	T	P
Semester: IV	Total contact hours: 30	02		

List of Prerequisite Courses

Applied Physics-I (BST 4102), Engineering Physics (PST 4251), Solid state Physics (SYT4351)

Courses where this course will be Prerequisite

Basics of Materials Laboratory (SYP4351), Materials Characterization Laboratory (SYP4352), Electrical properties of polymers (SYT4353), Introduction to Nanophysics and Applications (SYT4355)

Description of relevance of this course in the Int. M. Tech. Program

- The course "Engineering Properties of Materials" is crucial in a Master of Technology program as it equips students with an in-depth understanding of the mechanical, thermal, electrical, and magnetic properties of materials, essential for advanced engineering applications.

	Course Contents (Topics and subtopics)	Reqd. hours
1	Introduction, mechanics of time dependent properties of materials, Mechanical and Electrical Properties of Materials: stress-strain behavior, Tensile, Flexural and Impact properties, true stress and true strain, brittle and ductile materials, stress-strain curve of single crystal, hardness, creep, fatigue, mechanism to improve the mechanical properties and fracture properties. Wear measurements.	7
2	Electrical properties, conductivity, dielectric properties, Impedance technique, Electromagnetic wave absorption, transmission, and reflection –Vector analyzer, Electro kinetics and zeta potential.	6
3	Thermal properties of materials, glass transition temperature, melting, crystallization of materials, heat distortion temperature, thermal conductivity of materials, sample preparation standardization, softening temperature, dilatometer, study of thermochemical analysis and differential calorimeter.	7
4	Surface properties of materials: Young' surface energy equation, affinity of liquids to different surfaces, different techniques to calculate contact angle, goniometer, sessile drop, dynamic mode. Surface characterization XPS, microscopy, AFM, etc.	6
5.	Optical properties of materials Exactions and defects, Refractive index , Dispersion, Transmittance and Fluorescence, Phosphorescence, Photoluminescence, Optical bistability, Photosensitivity	4
	Total	**30**

List of Reference Books

	1) Engineering physics by V Rajendran, TMH	
	2) Materials science by V Rajendran TMH	
	3) Materials science by V Rangarajan, TMH	
	4) Surface Energy by M Aliokahazraei, Intech open	
	5) Surface wetting by KYeelaw and Hong Zhao, Springer	
	6) Materials Science and Engineering: An Introduction by William Callister & David Rethwisch., Wiley, 2013	
Course Outcomes (students will be able to….)		
CO1	Understand the various mechanical and electrical properties of materials	K2
CO2	Students understand surface properties and characterization of materials.	K2
CO3	Students understand and apply logic of optical properties of materials and devices	K3
CO4	Students understand and apply thermal properties of materials for engineering applications.	K3, K4
CO5	Students apply logic of mechanics of time dependent materials for various engineering properties.	K2

Mapping of course outcome (CO) to the program-specific outcome (PSO)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K2	3	2	-	-	-
CO2	K2	2	2	-	-	-
CO3	K2	2	2	2	-	-
CO4	K2	2	3	2	-	-
CO5	K3	2	2	-	-	2
Course	K4	3	2	2	2	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester V

Course Code: SYT4353	Course Title: Electrical properties of polymers	Credits = 02		
		L	T	P
Semester: V	Total contact hours: 60	3	-	-

List of Prerequisite Courses

Applied Physics-I (BST 4102), Engineering Physics (PST 4251), Engineering Properties of Materials (SYT4352), Chemistry-I (BST4101)

Courses where this course will be useful

Polymer synthesis and Polymer Nanocomposite (SYT4354)

Description of relevance of this course in the Int. M. Tech. Program

This course is designed to provide students with a comprehensive understanding of the electrical properties of polymers, focusing on fundamental concepts, characterization methods, and practical applications of polymers

	Course Contents (Topics and subtopics)	Hours
	(Statistical theory of Design of Experiments)	
1	**Introduction to polymers and electrical properties:** Overview of polymers and their classifications, Influence of polymer structure on electrical properties, Factors affecting electrical properties of polymers, Introduction to dielectric materials, dielectric polarization mechanism, electrical conductivity of polymers, charge carriers in polymers	15
2	**Strategies to improve electrical properties of polymers:** Blending strategies for tailored electrical behavior, Impact of fillers on electrical properties, Role of nanoparticles in enhancing electrical properties of polymers, Case studies and applications	15
3	**Electronic conduction in polymers:** Band theory of conduction, properties of semiconductors, hopping conduction, band theory applied to polymers, measurement of electrical properties: Impedance spectroscopy, electrochemical workstation, Vector network analyzer, Molecular Structure and Electrical Behavior: Relationship between polymer structure and electrical properties, Influence of side groups, chain length, and branching	15
4	**Applications of polymers based on electrical properties:** Polymer-based electronic devices, Flexible electronics and organic semiconductors, Emerging trends in polymer electronics, Conductive polymer applications as capacitors	15
	Total	**60**
	List of Textbooks/ Reference Books	
1	"Electrical Properties of Polymers" by John A. Manson and Leslie H. Sperling	
2	Electrical properties of polymers edited by Donald A. Seanor	
3	Electrical properties of polymers by Tony Blethy and David bloor	

4	Physical properties of polymers prediction and control by Andrey A. Askadskill	
5	Dielectric polymer nanocomposites by J keith Nelson	
6	Electrical properties of polymers by Evaristo Riande, Ricardo Diaz-Calleja	
Course Outcomes (students will be able to….)		
CO1	Students understand the basic electrical properties of polymers and plastics	K1
CO2	Student understood the various strategies for the improvement of electrical properties of polymers	K2-K3
CO3	Students select actual techniques and model for the measurement of electrical properties and its significances	K4
CO4	Students identify the device properties of capacitor, electrodes, sensor	K3-K4
CO5	Student able to apply the knowledge for various characterization of electrical properties of polymers and plastics	K5-K6

Mapping of course outcome (CO) to the program-specific outcome (PSO)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K2	3	2	2	1	1
CO2	K2	2	2	2	1	1
CO3	K2	2	2	2	-	1
CO4	K2	2	3	2	-	-
CO5	K3	2	2	-	-	-
Course	K4	3	2	1	-	-

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester VI

Course Code: SYP 4352	Course Title: Materials Characterization Laboratory	Credits 02		
Semester: VII	Total contact hours: 60	L	T	P
		-	-	4

List of Prerequisite Courses

Applied Physics-I (BST 4102), Engineering Physics (PST 4251), Solid state Physics (SYT4351), Engineering Properties of Materials (SYT4352)

Courses where this course shall be useful

Science and technology for deployment of materials, Introduction to material characterization theory

Description of relevance of this course in the Int. M. Tech. Program

This course is crucial for developing innovative materials and improving existing ones in various engineering fields. Mastery of these techniques ensures graduates are prepared for research and industry challenges.

	Course Contents (List of Experiments)	Reqd. hours
1	**Structural properties**: Exploring the crystal structure of materials using X-ray diffraction techniques	6
2	**Optical Properties**: Measurement and analysis of absorbance and transmittance of materials using UV-Visible spectrophotometer.	6
3	Raman Analysis of two different grades of Carbon samples	4
4	**Impedance analyser-** AC conductivity measurement	4
5	**Ultrasonic Interferometer**- Determine the frequency of given mixture of liquid at different fraction.	4
6	**Chemical composition studies**: Identification of functional group, analysis molecular vibrations and chemical bonding using Fourier transform infra-red spectroscopy (FTIR)	4
7	**Tribometer-** Measurement of tribological quantities of given sample	4
8	To determine the strain by applying load-stain gauge method	4
9	Surface analysis by Goniometer techniques	4
10	Phase analysis of a materials by optical polarizing microscopy	4
11	Crystal growth of materials using simple techniques.	4
12	Rheometer test of a given samples.	4
13	**Mechanical properties:** Measurement and analysis of mechanical properties of materials using a Universal testing machine UTM (Tensiometer), Measurement of viscoelastic properties of fluids using Rheometer	4

14	Study of thermal properties of materials using differential scanning colorimetry (DSC)	4
	Total	**60**

List of Reference Books		
1.	Elementary Solid-State Physics: Principles and Applications, M. Ali Omar. publisher, 2017	
2.	The Oxford Solid State Basics, Steven H. Simon, Oxford Publishers, 2013	
3.	Solid State Physics, N. Ashcroft and D. Mermin, Cengage Publishers, 2013	
4.	Solid State Physics, A. J. Dekker, Prentice Hall, 2000	
5.	Electronic Properties of Materials, Rolf Hummel, 3rd Ed. Springer, 2013	
6.	Introductory Solid-State Physics, H. P. Myers, CRC press, 1997	
7.	Materials Science and Engineering: An Introduction by William Callister & David Rethwisch., Wiley, 2013	
Course Outcomes (students will be able to….)		
CO1	Configure, handle, and use advanced, research-grade experimental setups used in the characterization of various properties of materials.	K1-K2
CO2	Choose appropriate analytical techniques needed to investigate different properties of the materials.	K3
CO3	Understand how various advanced characterization instruments are fully controlled and operated using computers	K3, K4
CO4	Use data analysis techniques to obtain relevant quantities using raw experimental data.	K4, K5
CO5	Understand the infrastructural requirements and the safety protocols required to house advanced characterization facilities in a research lab/industry.	K3, K4

Mapping of course outcome (CO) to the program-specific outcome (PSO)						
		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K2	-	-	2	3	3
CO2	K2	-	-	2	3	3
CO3	K2	-	-	2	3	3
CO4	K2	-	1	2	3	3
CO5	K3	-	1	2	2	3
Course	K4	1	1	2	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain

Semester V

Course Code: SYT4354	Course Title: Polymer Nanocomposite	Credits 02		
		L	T	P
Semester: VI	Total contact hours: 30	2		

List of Prerequisite Courses

Applied Physics-I (BST 4102), Engineering Physics (PST 4251), Solid state Physics (SYT4351), Engineering Properties of Materials (SYT4352), Chemistry-I (BST4101), Electrical properties of polymer (SYT4353)

List of Courses where this course will be prerequisite

This course may be useful for the students who aim to explore in the material domain

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

This is an elective course which will give the interested students an exposure to gain insights into the unique properties and behaviors of polymer nanocomposites, exploring the influence of nanofillers on polymer matrices. Processing of nano composites. Application of nanocomposites in real life.

	Course Contents (Topics and subtopics)	Hours
1	**Introduction to polymer nanocomposites:** What is Nanotechnology, meaning of nano, uniqueness of nano structured materials, classification of nanomaterials, Types of nanocomposites, Polymer Matrix Nanocomposites, Ceramic Matrix Nanocomposites, Metal Matrix Nanocomposites fillers and their properties, present scenario of nanocomposites, Challenges, and opportunities in polymer nanocomposite research	7
2	**Polymer nanocomposite processing techniques:** aggregation, agglomeration, dispersion, sonication techniques used in nanocomposites, Solution Intercalation, Melt Intercalation: Thermoplastic nanocomposites, Elastomer Nanocomposites, Roll Milling, Emulsion polymerization, In-Situ polymerization, Melt blending, Electrospinning, Sol-gel methods Intercalation method, Direct Mixing of polymer and Nanofillers	8
3	**Characterization of polymer nanomaterials:** Mechanical properties, dynamic mechanical analysis, tensile properties, flexural properties, heat distortion temperature, thermal stability, fire retardant properties, gas barrier properties, conductivity, optical transparency, biodegradability of biodegradable polymers-based nanocomposites. Crystallization behavior and morphology of nanocomposites, Rheology, melt rheology and structure–property relationship). Interfacial interaction in polymer nanocomposite	7
4	**Applications of polymer nanocomposites:** High temperature applications: fire-retardant, flame-retardant nanocomposite applications, Thermoset nanocomposites for rocket ablative materials, carbon-carbon composites, Nanocomposites for carbon fiber reinforced polymer matrix composites, Engineering applications of polymer	8

	nanocomposites, Current Trends and Future Prospects: Emerging research areas, Future directions in polymer nanocomposite research	
	Total	**30**
List of Textbooks/ Reference books		
1	POLYMER NANOCOMPOSITES ": Processing, Characterization, and applications by Joseph H. Koo [publisher: Mcgraw Hill]	
2	Polymer Science - V. R Gowarikar, Wiley Eastern Ltd. New Delhi. John Wiley &sons. +1986	
3	Polymer nanocomposite towards multi-functionality by Arvind Dasral, Zhoog Zhen Yu	
4	Fundaments of Polymer Science and Engineering - Anil Kumar & S.K. Gupta, Tata Mc Graw Hill, New Delhi. 1978.	
5	Recent Advances in Polymer Nanocomposites; Editors: S. Thomas, G.E. Zaikov and S.V. Valsaraj, CRC Press, 2009	
6	Progress in Polymers Nanocomposites Research Editors: Sabu Thomas, Gennady E. Zaikov Seeweb site address: Novapublishers, 2009	
Course Outcomes (students will be able to….)		
CO1	Students will learn the basic concept of polymer nanocomposites.	K1-K2
CO2	Students will be able to know the possible routes for the preparation of polymer nanocomposites.	K3
CO3	Students understand the actual confirmation of polymer nanocomposites by various techniques	K4
CO4	Students apply polymer NANO composites for real life deployable emerging applications.	K4, K5
CO5	Understand the study of methods of polymerization reaction and their properties, advantages, disadvantages, modifications, and applications	K2, K3, K4

Mapping of course outcome (CO) to the program-specific outcome (PSO)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K2	1	-	2	3	3
CO2	K2	1	2	2	3	3
CO3	K2	-	2	2	2	2
CO4	K2	-	2	2	2	2
CO5	K3	-	2	2	2	2
Course	K4	3	2	1	-	2

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain.

Semester VII

Course Code: SYT4355	Course Title: Introduction to Nanophysics and Applications	Credits 02		
		L	T	P
Semester: VII	Total contact hours: 30	02	-	-

List of Prerequisite Courses

	Applied Physics-I (BST 4102), Engineering Physics (PST 4251), Solid state Physics (SYT4351), Engineering Properties of Materials (SYT4352)	

Courses where this course will be useful

	Materials Characterization Laboratory (SYP 4352), Thin film and nanomaterials synthesis processes	

Description of relevance of this course in the Int. M. Tech. Program

- It bridges theoretical concepts with practical applications in various industries, fostering innovation and interdisciplinary skills. This course is essential for those aiming to contribute to advanced technological developments and research in nanotechnology.

	Course Contents (Topics and subtopics)	Hrs./Week
1	**Introduction:** Metal Nanoclusters, magic Numbers, modeling of nanoparticles, bulk to nano transitions; the effect of size reduction on the physical and chemical properties of materials; properties of nanomaterials. Quantum Nature of Nanoworld: dots, wires, well.	6
2	**Physics based experimental approaches to Nanofabrication:** Lithography: Patterning, Masks and Photolithography; High energy mechanical milling, melt mixing; Evaporation-condensation method, ionized cluster beam deposition, sputter deposition, ALD, PVD, Chemical Vapor Deposition, pulse laser methods, Chemical Reduction Method, microemulsion, sol-gel method,	6
3	**Characterization of Nanomaterials:** Structural and chemical characterization: XRD, UV-visible, near-infrared, SEM (Scanning Electron Microscope), TEM, STM and AFM microscopy, photoluminescence, XPS, EXAFS, ESR, NMR (Nuclear Magnetic Resonance).	6
4	**Special Nanomaterials:** One-, two- and three-dimensional Nanomaterials, Band structure, property variation, Carbon nanostructures: fullerenes, carbon nanotubes. Bulk nanostructured materials, solid disordered nanostructures, nanostructured multilayers, metal nanoclusters, composite glasses, porous silicon.	6
5	**Application of Nanomaterials:** Nanofabrication, Nanoelectronics, quantum dots and quantum well devices, plasmon waveguides (optical devices), Energy sector, automobiles, space, defense, sports, and cosmetics. Commercial Status of Nanomaterials	6
	Total	**30**

List of Reference Books

1.	Introduction to Nanotechnology – C. P. Poole, Jr., and F.J. Owens, Wiley, 2003
2.	Nanotechnology: Principles and Practices – S. K. Kulkarni, Springer, 2015
3.	Nanostructures and Nanomaterials – G. Cao, Imperial College Press, 2004
4.	Nanomaterials – A. S. Edelstein, R. C. Cammaratra, Institute of Physics, 1998
5.	Nanostructures: Theory and Modelling – C. J. Delerue and M. Lannoo, Springer, 2010
6.	Nanophysics and Nanotechnology- Edward L. Wolf, Wiley, 2006
7.	Materials Science and Engineering: An Introduction by William Callister & David Rethwisch., Wiley, 2013

Course Outcomes (students will be able to….)

1.	Understand the importance of nanoscience and property variation with size.	K2
2.	Know the different methods of synthesis based on requirements.	K3
3.	Characterize the materials by understand the Working Principle and utilization of characterization techniques	K4, K5
4.	Know the properties of Special Nanomaterials and reason behind them	K3
5.	Understand the Applicability of Nanomaterials for commercial usage	K2

Mapping of course outcome (CO) to the program-specific outcome (PSO)

		PSO1	PSO2	PSO3	PSO4	PSO5
		K1+K2	K3	K3+K4	K5	K5
CO1	K2	-	-	2	3	3
CO2	K2	-	-	2	3	3
CO3	K2	-	-	2	3	3
CO4	K2	-	1	2	3	3
CO5	K3	-	1	2	2	3
Course	K4	-	1	2	3	3

3, Strong Contribution; 2, Moderate Contribution; 1, Low Contribution; 0, No Contribution K, Knowledge level from cognitive domain; A, Affective domain; P, Psychomotor domain

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