SYLLABUS

DR. VISHWANATH KARAD
MIT - WORLD PEACE UNIVERSITY

FACULTY OF ENGINEERING

SECOND YEAR B.TECH. (SYBTech)

POLYMER ENGINEERING

***Preamble**:*

Polymer Engineering Department was established in 1983 due to the visionary foresight of our Director, Prof. (Dr.) Vishwanath D. Karad. Polymer Engineering was unheard of at that time and there were very few institutes in the country offering an undergraduate Polymer Engineering course in the country. India was a backyard for manufacturing of plastic and rubber products and Mechanical Engineers were filling the gap due to shortage of trained professionals in Polymer Engineering. Thus, the mission back then was to fill in this gap. The department had a head-start over other institutes in this regard. During those times, emphasis was laid on building the very basic infrastructure in the department. The curriculum was designed by Late Prof. M. V. Joshi, the first Head of the Department, in consultation with eminent personalities like Dr. R. A. Mashelkar, Dr. V. M. Nadkarni.

The Polymer industry has grown in leaps and bounds in the past twenty years. Over the years, number of institutes offering this course has increased. Now, there is no dearth of trained professionals. The Polymer industry as a whole has undergone radical change. The manufacturing industry is well established now and the focus has shifted to new material and product development. Thus, need exists to train professionals who will be capable of carrying out research in niche areas of Polymer Science and Engineering hence our mission and vision now focus on excellence in education to create professionals competent to take up research.

Dr. Hemant V. Joshi
Chairman, Board of Studies, Polymer Engineering
Professor and Head, Department of Polymer Engineering

Vision and Mission of the Program

Vision and mission of the Department is in line with the Institute. It captures the basic philosophy and essence of the Institute's vision and mission which is confluence of science and technology with awareness of social responsibility and ethical values. To imbibe the spirit of value based universal education system, a confluence of ethical, moral values together with specified knowledge or professional knowledge or skill sets is required to be imparted to the students.

VISION
To be recognized as a centre of excellence in the field of Polymer Engineering education and research.

MISSION
To create an ambience nurturing sound technical knowledge, ethical values and research culture to produce good quality Polymer Engineers.

Program Educational Objectives

1. **Key Positions in Industry**: Graduates will demonstrate the ability to occupy key positions in the industries in India and Abroad in the areas of Polymer Processing, Polymer Material Manufacturing and Development, Process, Product and Tool Design. They will demonstrate ability to continue professional development through self-learning and higher education.
2. **Research:** The graduates will demonstrate the ability to pursue research in the frontier areas of Polymer Science and Engineering.
3. **Entrepreneurship:** The graduate will demonstrate the entrepreneurship abilities.
4. **Practicing Profession in Ethical Manner:** The graduate will demonstrate sensitivity in practicing the profession in an ethical, socially and environmentally responsible manner.
5. **Communication Skills and Working in Multidisciplinary Teams:** The graduate will demonstrate effective communication skill, and will be able to dexterously work in multi-disciplinary as well as multicultural teams.

Program Specific Outcomes

1. **Engineering Knowledge:** Apply the knowledge of Mathematics, Science and Engineering fundamentals to solve complex problems in broad areas of Polymer Engineering
2. **Problem Analysis :** Identify, formulate and analyze complex engineering problems in broad areas of Polymer Engineering and reach logical conclusions using 1st principles of mathematics, natural sciences and engineering sciences.
3. **Design/Development of solutions:** The student will be able to design methodology for understanding development of new materials and their applications by applying their knowledge of polymer synthesis, reaction kinetics, structure-property relationship, testing and characterization techniques along with core principles of polymer rheology, processing, tool and product design with appropriate consideration for safety and environmental issues.
4. **Conduct Investigation of Complex Problems:** The student will be able to carry out design of experiments by analyzing and interpreting research data. They will be able to synthesize the available information and data to reach logical conclusions.
5. **Modern Tool Usage:** (a) The students will be able to understand the application of modern instrumental characterization and testing techniques related to development of existing as well as new materials; (b) The students will be able use simulation software for polymer process design, tool and product design, designing of composite materials with an understanding of fundamentals of development of the software which can create awareness regarding limitations of the software tools; (c) Also, the students will be familiar with data analyzing and interpretation software
6. **The Engineer and Safety:** Understand responsibility, duties and obligations of a Polymer Engineer and practice the profession in a responsible manner by taking into consideration societal safety, health and legal issues.
7. **Environment and Sustainability:** Understand the impact on environment during various stages of polymeric materials life cycle such as manufacturing, conversion into product, application and its disposal, thereafter, providing feasible and sustainable solutions.
8. **Ethics:** Take professional decisions with sense of ethical responsibility
9. **Individual and Team Work:** Function effectively as an individual, and as a member or a leader in multidisciplinary and cross-cultural teams.
10. **Communication:** Develop verbal as well as non-verbal communication skills in order to effectively write technical report and other documents as well as deliver presentations.
11. **Project Management and Finance:** Understand various concepts related to project management and finance and apply them while working on various projects and assignments as a part of multidisciplinary teams.
12. **Life-long learning:** Understand the need for engaging in life-ling learning process and be prepared to take-up technological challenges in broad areas of polymer engineering.

Foundation / Orientation Program

The students admitted to the Polymer Engineering program belong to variety backgrounds and possess different levels of technical awareness. A one day orientation program is conducted for the students to get acquainted with the overall program, extra- and co-curricular activities alongwith employment avenues. Students are briefed about the contemporary scenario in the industry, academics and research. The orientation program helps the students to make a choice about the tracks by selecting the relevant electives which will help them in their career.

Program Structure :

(a) Program duration:

4-years full-time

(b) System followed:

Trimester pattern with total 12-trimesters

(c) Credits System :

Sr. No.	Year	Total
1	FYBTech	43
2	SYBTech	43
3	TYBTech	47
4	Final-BTech	34
	Total Credits	**168 + 6 from MOOCs**

(d) Credits for activities other than academics

Immersion programs are an important part of WPU method. They are designed to give student an exposure to real life problems at societal and professional level. They are included in the structure as follows.

Sr. No.	**Type of Immersion**	**Year**
1	Social Immersion	First Year
2	National Study Tour	Second Year
3	International Study Tour	Third Year

(e) Internship:

The Department has more than 25 years' legacy of students undergoing internship after the third year of program. This exposes students to the real world, thereby, facilitating them to widen the knowledge horizon.

(f) Assessment Criteria:

For a typical subject having 2 Credits for Theory Class and 1 Credit for Laboratory Practice, assessment of the course will have three components:

1. Class Continuous Assessment (CCA) : 50 Marks
2. Laboratory Continuous Assessment (LCA) : 50 Marks
3. End of the Term Test (ETT) : 50Marks

Student will be considered eligible for appearing in ETT if and only if he/she has scored above 20 independently in LCA and CCA each.

The final grade for the course will be derived from the total score in the above three components normalized on 10 point scale.

That is, Grade Point in a Subject = [(Total of CCA+ LCA +ETT) / 150] * 10

Typically, CCA will have Attendance/Initiative, Assignments, Mid-term Test and Group Activity as components; but they may vary as per the requirement of the course.

There will be continuous assessment of a student's performance throughout the trimester and grades will be awarded by the Subject Teacher / Coordination Committee formed for this purpose. The following should be taken as a guideline to ensure uniformity of grading among all courses.

1. For arriving at a grade obtained by a student for a particular subject, initially a numeric marks obtained by the student out of 150 is to be determined and then, the same is to be converted to letter grade.

2. For assigning marks in Teacher's Assessment (T.A.), performance in home assignments, class tests, tutorials, viva-voce, attendance etc. are to be considered. It is recommended that at least two class tests for 4 credit theory courses and 1 test for 3 credit theory courses are to be conducted for a subject.

   The weights of different subcomponents of T.A. may be announced to the students by the teacher at the beginning of the trimester.

3. For assignment of marks in the laboratory component, the relevant subcomponents that are to be considered are: day-to-day work, regularity, assignments and viva-voce etc. Percentage weights of the different subcomponents in deciding the final marks are to be announced at the beginning of the trimester. The evaluation process must be completed before the beginning of end trimester examination.

4. To the extent possible, laboratory work should be completed and evaluated every class thus ensuring continuous evaluation. Final examination and/or viva voce, if any, may not carry more than 20% marks.

(g) Branches or Specializations / Tracks :

I	Fundamentals
II	Polymer Materials Science and Forms
III	Polymer Manufacturing and Processing Operations
IV	Polymer Applications
V	Tool/Product Design and Process Simulation

(h) Mandatory Attendance to appear for examination:

It is expected on the part of student to attend each and every lecture, tutorial and laboratory session in order to achieve academic excellence. However, due to any contingencies, the attendance requirement will be minimum 90% of the scheduled/held classes.

(j) Medium of Instruction and Examination:

English

(k) Eligibility criteria for admission to the program :

1. Passed HSC or its equivalent examination with Physics and Mathematics as compulsory subjects along with either Chemistry or Biotechnology or Technical Vocational Subjects, and obtained at least 50% marks (at least 45% marks in case of backward class categories and persons with disabilities) for Maharashtra state only in above subjects taken together.
   AND
   Obtained score in MH-CET conducted by competent authority
   OR
   Obtained score in JEE-Mains conducted by competent authority

2. Lateral Admissions
   Awarded Diploma in Engineering and Technology, and obtained at least 50% marks (at least 45% marks in case of backward class categories and persons with disabilities) for Maharashtra state only.

B. Tech. Course in Polymer Engineering
2018-19

A. Definition of Credit:-

3 Hours Lectures / Tutorial per week	2 credit
2 Hours Practical (Laboratory session) per week	1 credit

B. Credits:-

Total number of credits for four year undergraduate ***B.Tech. program*** would be 168 + 6 = 174.

C. Structure of Credits for Undergraduate B.Tech. program:-

S. No.	Category	Break-up of Credits (Total 168)
1	*Humanities and Social Sciences and Peace Programs including Management courses*	*20*
2	*Basic Science courses*	*30*
3	*Engineering Science courses including workshop, drawing,*	*37*
4	*Professional core courses*	*30*
5	*Professional Elective courses relevant to chosen specialization/branch*	*18*
6	*Open subjects–Electives from other technical and/or emerging*	*18*
7	*Project work, seminar and internship in industry or elsewhere*	*15*
	Total	***168 + 6 credits of MOOCs***

D. Course Code and Definition :

Course code	Definitions
Th	*Lecture / Theory classes*
Tut	*Tutorial*
Lab	*Practicals / Laboratory sessions*
BS	*Basic Sciences*
ES	*Engineering Science Courses*
HSS	*Humanities and Social Sciences including Management courses*
WP	*Peace Programs*
ME	*Mechanical Engineering*
EC	*Electronics and Communication*
EE	*Electrical Engineering*
CH	*Chemical Engineering*
CS	*Computer Science and Engineering*
PO	*Polymer Engineering*
CE	*Civil Engineering*
PE	*Petroleum Engineering*

E. Grading Scheme:

(According to Para 12.1 of Academic Ordinances 2017)

B. Tech. Polymer Engineering (First Year) (Batch 2018-19)

Trimester – I

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment, Marks			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	ES111	Mathematics –I	BS	3	1	--	3	--	100	-	50	150
2	ES112	Physics	BS	3	1	2	3	1	100	50	50	200
3	CE111	Applied Mechanics	ES	3	1	2	3	1	100	50	50	200
4	ME111	Workshop Practices	ES	-	-	2	-	1	-	50	-	50
5		Effective Communication	HSS	2	-	2	1	1	50	50	-	100
6		Practicing Yoga and Meditation	WP	-		1	-	-	-	-	-	-
	-	**Total**		**11**	**03**	**09**	**10**	**04**	**350**	**200**	**150**	**700**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **23**

Total Credits: First Year B. Tech Trimester I : **14**

B. Tech. Polymer Engineering (First Year) (Batch 2018-19)

Trimester – II

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks **			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	ES121	Mathematics II	BS	3	1	-	3	-	100	-	50	150
2	ES122	Chemistry	BS	3	-	-	2	-	50	-	50	100
3	ME121	Material Science For Engineers	BS	3	-	2	2	1	50	50	50	150
4	ME122	Engineering Graphics	ES	2	-	2	1	1	-	50	50	100
5	CS121	Computer Programming	ES	3	-	2	2	1	50	50	50	150
6	WPC 1	Indian Culture and Heritage	WP	3	-	-	2	-	50	-	50	100
7		Rural Immersion Program	WP	-	-	-	-	-	-	-	-	-
8		Practicing Yoga and Meditation	WP	-	-	1	-	-	-	-	-	-
		Total		**17**	**1**	**07**	**12**	**03**	**300**	**150**	**300**	**750**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **25**

Total Credits: First Year B. Tech Trimester II : **15**

B. Tech. Polymer Engineering (First Year) (Batch 2018-19)

Trimester – III

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	ES131	Biology	BS	3	-	2	2	1	50	50	50	150
2	ME131	Introduction to Engineering Design Principles	ES	3	-	2	2	1	50	50	50	150
3	EL1	Engineering Science Elective Course I*	ES	3	-	2	2	1	50	50	50	150
4	EL2	Engineering Science Elective Course II*	ES	3	-	2	2	1	50	50	50	150
5	WPC 2	Philosophers, Great Kings & Dynasties	WP	3	-	-	2	-	50	-	50	100
6		Practicing Yoga and Meditation	WP	-	-	1	-	-	-	-	-	-
		Total		**15**	**0**	**09**	**10**	**04**	**250**	**200**	**250**	**700**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **24**

Total Credits: First Year B. Tech. Trimester III: **14**

Total First Year B. Tech Credits: 14+15+14 = 43

*** Any two courses other than parent/ home discipline can be chosen from the list given below.**

Sr. No.	Course Code	Name of Course
1		Introduction to Civil Engineering
2		Introduction to Mechanical Engineering
3		Introduction to Computer Science and Engineering
4		Introduction to Electrical Engineering
5		Introduction to Electronics Engineering
6	PO131	Introduction to Polymer Engineering
7		Introduction to Petroleum Engineering
8		Introduction to Chemical Engineering

B. Tech. Polymer Engineering (Second Year) (Batch 2018-19)

Trimester – IV

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	ES212	Physical and Inorganic Chemistry	BS	3	-	2	2	1	50	50	50	150
2	PO211	Strength of Materials	ES	3	-	2	2	1	50	50	50	150
3	PO212	Fluid Mechanics	ES	3	-	2	2	1	50	50	50	150
4	PO213	Process Calculations	ES	3	-	2	2	1	50	50	50	150
5	PO214	Thermodynamics	ES	3	1	-	3	-	100	-	50	150
6	ES	Environmental Science	HSS	2	-	-	1	-	50	-	-	50
		Total		**17**	**1**	**8**	**12**	**4**	**350**	**200**	**250**	**800**

Note : Subject to Minor revision

Type: (Refer Para 11 of Academic Ord. 2017) **Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours : **26**

Total Credits: Second Year B. Tech. Trimester I : **16**

B. Tech. Polymer Engineering (Second Year) (Batch 2018-19)

Trimester – V

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	ES224	Organic Chemistry	BS	3	-	2	2	1	50	50	50	150
2	PO221	Heat Transfer	ES	3	-	2	2	1	50	50	50	150
3	PO222	Polymer Chemistry	PC	3	-	2	2	1	50	50	50	150
4	PO223	Polymer Materials – I	PC	3	-	2	2	1	50	50	50	150
5		Science and Spirituality	WP	3	-	-	2	-	50	-	50	100
6		National Study Tour	WP	-	-	-	-	-	-	-	-	-
		Total		**15**	**-**	**08**	**10**	**04**	**250**	**200**	**250**	**700**

Note : Subject to Minor revision

Type: (Refer Para 11 of Academic Ord. 2017) **Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **23**

Total Credits: Second Year B. Tech. Trimester II: **14**

B. Tech. Polymer Engineering (Second Year) (Batch 2018-19)
Trimester – VI

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	ES231	Mathematics –III	BS	3	1	--	3	--	100	-	50	150
2	PO231	Polymer Materials – II	PC	3	-	2	2	1	50	50	50	150
3	PO232	Polymer Structure Property Relations	PC	3	-	2	2	1	50	50	50	150
4	PO233	Polymer Rheology	PC	3	-	2	2	1	50	50	50	150
5	IC	Indian Constitution	HSS	2	-	-	1	-	50	-	-	50
		Total		**14**	**1**	**06**	**10**	**03**	**300**	**150**	**250**	**650**

Note : Subject to Minor revision

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **21**

Total Credits: Second Year B. Tech. Trimester III: **13**

Total Second Year B. Tech Credits: 16+14+13 = 43

B. Tech. Polymer Engineering (Third Year) (Batch 2018-19)
Trimester – VII

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	ES311	Numerical and Statistical Methods	BS	3	1	-	3	-	100	-	50	150
2	PO311	Process Instrumentation and Control	ES	3	-	2	2	1	50	50	50	150
3	PO312	Polymer Processing Operations – I	PC	3	-	2	2	1	50	50	50	150
4	PO313	Professional Elective I	PE	3	1	-	3	-	100	-	50	150
5	PO314	Open Elective I	OE	3	1	-	3	-	100	-	50	150
6		Human Values and Professional Ethics	WP	3	-	-	2	-	50	-	50	100
		Total		**15**	**3**	**4**	**15**	**2**	**450**	**100**	**300**	**850**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **22**

Total Credits: Third Year B. Tech. Trimester I: **17**

B. Tech. Polymer Engineering (Third Year) (Batch 2018-19)
Trimester – VIII

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	PO321	Polymer Processing-II	PC	3	-	2	2	1	50	50	50	150
2	PO322	Polymer Multiphase Systems	PC	3	-	2	2	1	50	50	50	150
3	PO323	Professional Elective II	PE	3	1	-	2	1	100	-	50	150
4	PO324	Open Elective II	OE	3	1	-	2	1	100	-	50	150
5		Finance and Accounting	HSS	3	-	-	2	-	50	-	50	100
6		Spirit and Mind	WP	3	-	-	2	-	50	-	50	100
		Total		**18**	**2**	**4**	**12**	**04**	**400**	**100**	**300**	**800**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **24**

Total Credits: Third Year B. Tech. Trimester II: **16**

B. Tech. Polymer Engineering (Third Year) (Batch 2018-19)

Trimester – IX

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	PO331	Polymer Testing and Product Design	PC	3	-	2	2	1	50	50	50	150
2	PO332	Tool Design	PC	3	-	2	2	1	50	50	50	150
3	PO333	Professional Elective III	PE	3	1	-	3	-	100	-	50	150
4	PO334	Open Elective III	OE	3	1	-	3	-	100	-	50	150
5	PO335	Seminar/ Mini Project	PR	-	-	2	-	1	-	50	-	50
6		Gandhian Philosophy	WP	3	-	-	2	-	50	-	50	100
7		International Study Tour	-	-	-	-	-	-	-	-	-	-
		Total		**15**	**2**	**6**	**12**	**3**	**350**	**150**	**250**	**750**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **23**

Total Credits: Third Year B. Tech. Trimester III: **15**

Total Third Year B. Tech Credits: 17+16+15 = 47

B. Tech. Polymer Engineering (Final Year) (Batch 2018-19)

Trimester – X

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	PO411	Professional Elective IV	PE	3	1	-	3	-	100	-	50	150
2	PO412	Professional Elective V	PE	3	1	-	3	-	100	-	50	150
3	PO413	Open Elective IV	OE	3	1	-	3	-	100	-	50	150
4	PO414	Mini Project/ Interdisciplinary Project	PR	-	-	4	-	2	--	100	-	100
5		Strategic Planning and Leadership	LPC	3	-	-	2	-	50	-	50	100
		Total		**12**	**3**	**4**	**11**	**3**	**350**	**100**	**200**	**650**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **19**

Total Credits: Final Year B. Tech. Trimester I: **13**

B. Tech. Polymer Engineering (Final Year) (Batch 2018-19)

Trimester – XI

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Th	Tut	Lab	Th	Lab	CCA	LCA	ETT	Total
1	PO421	Professional Elective VI	PE	3	1	-	3	-	100	-	50	150
2	PO422	Open Elective V	OE	3	1	-	3	-	100	-	50	150
3	PO423	Open Elective VI	OE	3	1	-	3	-	100	-	50	150
4	PO424	Capstone Project: Stage I	PR	-	-	6	-	2	-	100	-	100
		Total		**9**	**3**	**6**	**9**	**2**	**300**	**100**	**150**	**550**

Type: (Refer Para 11 of Academic Ord. 2017)

**Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **18**

Total Credits: Final Year B. Tech. Trimester II: **11**

B. Tech. Polymer Engineering (Final Year) (Batch 2018-19)
Trimester – XII

Sr. No.	Course Code	Name of Course	Category	Weekly Workload, Hrs			Credits		Assessment Marks**			
				Theory	Tutorial	Lab	Th	Lab	CCA	LCA	ETT	Total
1	PO431	Capstone Project with/ without Internship : Stage II	PR	-	-	24	-	10	-	300	-	300
		Total		**-**	**-**	**24**	**-**	**10**	**-**	**300**	**-**	**300**

Type: (Refer Para 11 of Academic Ord. 2017) **Assessment Marks are valid only if Attendance criteria are met

Weekly Teaching Hours: **24**

Total Credits: Third Year B. Tech. Trimester III : **10**

Total Final Year B. Tech Credits: 13+11+10 = 34

Total B. Tech Credits: 43+43+48+34 = 168 Credits + 6 credits earned through MOOCs

List of Electives

Professional Electives	A	B	C	D	E
PE I (PO313)	Advanced Polymer Rheology	Elastomer Technology	Liquid Crystalline Polymers	Polymer Additives and Compounding	Design of Equipments and Machine Elements
PE II (PO323)	Additives Science and Technology	Adhesives and Sealants	Polymers in Automotives and Aerospace application	Composite Technology	Polymer Processing Operations Simulation
PE III (PO333)	Advanced Polymer Synthesis	Membrane Technology	Polymers in Electronic Applications	Additive manufacturing	Mechanics of Composites
PE IV (PO411)	Polymer Degradation and Stabilization	Fiber Technology	Polymers in Construction, Geotextiles and Geosynthetics	Polymer Processing – III	Tool and Product Design
PE V (PO412)	Polymer Physics	Packaging Technology	High Performance Polymers	Polymer Recycling and Waste Management	Manufacturing techniques for moulds and dies
PE VI (PO421)	Polymer Characterization	Surface Coating Technology	Polymers in Energy and Environment	Polymer Reaction Engineering	Computational Tools in Polymer Engineering

Open Electives	OE I (PO314)	OE II (PO324)	OE III (PO334)	OE IV (PO413)	OE V (PO422)	OE VI (PO423)
	Biopolymers (Polymers from renewable resources)	Biocompatible polymers	Polymers in Medical applications	Stimuli-responsive polymers	Nanotechnology	Polymers in Petroleum Engineering

- Every candidate will register for at least three MOOC courses. Students to submit the credits earned in MOOCs courses for inclusion in their grade sheet.
- World Peace programs like rural immersion, national study tour are mandatory for graduation.

SYLLABUS

SYBTech (Polymer Engineering)

Trimester - IV

COURSE STRUCTURE

Course Code	**ES212**			
Course Category	Basic Sciences			
Course Title	**Physical and Inorganic Chemistry**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites :
HSC Chemistry, FYBTech/Diploma Chemistry

Course Objectives :

1. To inculcate fundamentals of Physical and Inorganic chemistry.
2. To impart knowledge of atomic structure and bonding, transition elements and their complexes, catalysis and surface chemistry.

Course Outcomes :

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

1. Explain atomic structure and bonding.(CL-II)
2. Recall concept of interfaces and surfaces.(CL-I)
3. Summarize transition metals and their complexes.(CL-II)
4. Explain concept and need of catalysis.(CL-II)
5. Correlate colligative properties with molecular weight.(CL-IV)

Course Contents :

Atomic Structure and Bonding - Electronic configuration, energy levels, orbitals, quantum numbers. Lewis dot symbols, ionic bond, lattice energy for ionic compounds. Octet rule and exceptions to octet rule. Electronegativity, Valence shell electron pair repulsion theory. Dipole moment. Chemical bonding – Covalent bond, VBT, Hybridization, Hybridizational shapes of molecules with examples (up to C. N. 6), Molecular Orbital Theory, LCAO, M.O. diagrams for diatomic Molecules like H_2, CO_2, O_2, N_2, etc. Comparison of properties of ionic and covalent compounds. Secondary bonds.

Transition elements and their complexes - Transition elements, study of 1^{st} transition series w.r.t. oxidation states, magnetic behavior, colour, ability to form complexes and catalytic behavior. Coordination compounds –different terms- C.N., ligand, EAN etc. Nature of metal ligand bonding- VBT and CFT Formation and above properties of tetrahedral square planer and octahedral complexes of first transition series on the basis of VBT and CFT.

Catalysis - Definition, role and classification of catalyst, Role of transition metal compounds in homogeneous and heterogeneous catalysis, steps involved, and examples. Promoter and its examples, Catalytic poisons. Autocatalysis, negative catalysis. Theories of catalysis. Acid Base catalysis. Importance of catalysis by giving some industrial examples. Biocatalysts- Enzymes, mechanism of enzyme action, enzyme catalysis, examples. Examples of the reactions involving catalysis.

Surface Chemistry - Adhesion and cohesion, Surface tension, surface energy, methods of determining surface tension, interfacial tension, surfactants, Micellization and CMC emulsions, micro-emulsions, numerical.

Colligative Properties - Gels, Colloids, Colligative properties of dilute solution, lowering of vapour pressure, Elevation of boiling point, Depression in freezing point and use of these properties in determining molecular weight. Abnormal behavior of solutions of electrolytes, numerical.

Laboratory Work :

List of Experiments (any 7 experiments)

1. To find surface tension of liquid by stalagmometer.
2. To find CMC of surfactant.
3. To determine the molecular weight of a non volatile solute by the depression in freezing point method.
4. To find out effect of catalyst on reaction rate for the reaction between iodide and
5. hydrogen peroxide in an acidic environment.
6. Preparation of Tetra-ammine copper (II) sulfate, monohydrate.
7. Determination of concentration of the given unknown solution of titanium by colorimetric method.
8. Synthesis of potassium tris-oxolato chromate (III) trihydrate
9. To determine the molecular weight of a substance by Elevation of Boiling point method.
10. The comparison of rate of reaction between iron(III) nitrate and sodium thiosulfate using different transition metal ions as catalysts (Cu or Co).
11. Determine the influence of salt on the CMC of an anionic soap.

Learning Resources:

Reference Books -

1. Glasstone S., "Textbook of Physical chemistry", McMillan and Co. Ltd., 1981
2. Rosen M.J., "Surfactants and Interfacial Phenomenon", 4th edition, Wiley Interscience, 2012
3. Chang, R., "Chemistry", 9th edition, Tata McGraw Hill Education Pvt. Ltd., 2010

Supplementary Reading -

1. Atkins P and Paula J., "Physical Chemistry", 10th edition, Oxford University Press, 2014
2. Lee J.D., "Concise Inorganic Chemistry", 5th edition, Wiley Oxford University Press, 2013

Web Resources -

Web-links -

1. Atomic structure and bonding-
   http://nptel.ac.in/courses/104103069/5
   http://nptel.ac.in/courses/104103069/13
   http://nptel.ac.in/courses/104103069/15

2. Transition metals- http://nptel.ac.in/courses/104105033/
3. Catalysis- http://nptel.ac.in/downloads/103103026/
4. Surface tension- http://nptel.ac.in/courses/112104118/lecture-2/2-7- surface-tension-liquids.htm
5. Surfactants – http://nptel.ac.in/courses/116102016/10
6. Colloids – http://nptel.ac.in/courses/103104045/pdf_version/lecture1.pdf http://nptel.ac.in/courses/103104045/pdf_version/lecture2.pdf

MOOCs *(Online courses for self-learning)*

1. Atomic Structure: https://www.coursera.org/learn/chemistry-1.
2. Inorganic Chemistry: https://www.coursebuffet.com/course/75/saylor/inorganic-chemistry
3. Advanced Chemistry: https://www.coursera.org/learn/advanced-chemistry
4. Colligative properties : https://www.udemy.com/chemistry-colligative-properties-of-solutions/

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning.

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance and Initiatives
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Regularity and Punctuality	Understanding the objective	Understanding of Procedure	Experiment Skills	Ethics
10	10	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Atomic Structure and Bonding:** Electronic configuration, energy levels, orbitals, quantum numbers. Lewis dot symbols, ionic bond, lattice energy for ionic compounds. Octet rule and exceptions to octet rule. Electronegativity, Valence shell electron pair repulsion theory. Dipole moment. Chemical bonding – Covalent bond, VBT, Hybridization, Hybridizational shapes of molecules with examples (up to C. N. 6), Molecular Orbital Theory, LCAO, M.O. diagrams for diatomic Molecules like H_2, CO_2, O_2, N_2 etc. Comparison of properties of ionic and covalent compounds. Secondary bonds**.**	**9**	**--**	
2	**Transition elements and their complexes:** Transition elements, study of 1st transition series w.r.t. oxidation states, magnetic behavior, colour, ability to form complexes and catalytic behavior. Coordination compounds –different terms- C.N., ligand, EAN etc. Nature of metal ligand bonding-VBT and CFT Formation and above properties of tetrahedral square planer and octahedral complexes of first transition series on the basis of VBT and CFT.	**8**	**8**	
3	**Catalysis:** Definition, role and classification of catalyst, Role of transition metal compounds in homogeneous and heterogeneous catalysis, steps involved, and examples. Promoter and its examples, Catalytic poisons. Autocatalysis, negative catalysis. Theories of catalysis. Acid Base catalysis. Importance of catalysis by giving some industrial examples. Biocatalysts- Enzymes, mechanism of enzyme action, enzyme catalysis, examples. Examples of the reactions involving catalysis.	**6**	**2**	
4	**Surface Chemistry:** Adhesion and cohesion, Surface tension, surface energy, methods of determining surface tension, interfacial tension, surfactants, Micellization and CMC emulsions, micro emulsions, numericals.	**5**	**6**	
5	**Colligative Properties**: Gels, Colloids, Colligative properties of dilute solution, lowering of vapour pressure, Elevation of boiling point, Depression in freezing point and use of these properties in determining molecular weight. Abnormal behavior of solutions of electrolytes, numericals.	**4**	**4**	

COURSE STRUCTURE

Course Code	**PO211**			
Course Category	*Polymer Engineering*			
Course Title	**Strength of Materials**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites:
Applied Mechanics, Engineering Material Science, and FYBTech/Diploma Mathematics

Course Objectives

1. To understand basic concepts of strength of materials.
2. To develop foundation for studying design courses.

Course Outcomes:
After completion of this course students will be able to;

1. Demonstrate the ability to calculate strength of materials and deformation produced when subjected to different types of loads.
2. Demonstrate the ability to calculate bending and shear stresses in beams.
3. Demonstrate the ability to calculate stresses induced in columns and struts.

Course Contents:

Simple stresses and strains : Concept of stress, strain, modulus of elasticity, stress-strain curve for ductile materials, calculation of stress and strain produced in axially loaded members of uniform cross-section and composite/compound sections, lateral strain, Poisson's ratio, biaxial, tri-axial/volumetric stress system, relation between elastic constants of material (E,G,K, and μ), thermal stress and strain produced in simple bars.

Principal planes and stresses : Principle of complimentary shear, normal and tangential stresses developed on oblique sections in members subjected to biaxial stress system along with complimentary shear stress, concept of principal planes and stresses, calculation of principal planes and stresses, maximum shear stress using analytical and graphical methods (Mohr's circle method), theories of failure, stress tensors.

Stresses in Beams : Types of beams and supports, concept of shear force and bending moment at any section of the beam, moment of inertia of standard beam sections about neutral axis, theory of pure or simple bending, calculation of bending and shear stresses in beams, Slope and deflection of beams (using standard formulae).

Torsion of shafts : Theory of pure torsion, torsion formula for circular shafts, calculation of torsional shear stress and angle of twist in shaft, power transmitted by shaft, shafts subjected to compound stresses (direct + bending + torsion), equivalent bending moment and twisting moment, shaft design

based on strength and stiffness criteria.

Columns and struts : Axially loaded compression members, crushing load, buckling or crippling load for columns with different end conditions, calculation of crippling load using Euler's theory and Rankine theory, direct and bending stresses- stress distribution for an eccentrically loaded circular/circular section, the middle third rule, core or kernel of a section

Laboratory Work

List of Experiments

1. To determine Tensile properties
2. To determine Impact properties
3. To determine Bending properties
4. To determine Shear properties
5. To determine Torsion properties
6. To determine Hardness properties
7. To apply graphical methods of calculation of principal planes and stresses.

Learning Resources:

Reference books -

1. Khurmi R.S., Strength of Materials, Chand (s) & Co. Ltd., 2005
2. Ramamurtham S. and Narayanan N., Strength of Materials, Danpat Rai Publishing House, 2013

Supplementary Reading -

1. Timeshenko S., Strength of Materials : Elementary theory and problems, vol.1, Van Nostrand Reinhold Inc., US, 1969

Web Resources -

Web-links -

1. https://ocw.mit.edu
2. http://www1.rmit.edu.au
3. http://mit.espe.edu.ec/courses

MOOCs (*Online courses for self-learning)*

1. https://www.mooc-list.com/course/applications-engineering-mechanics-coursera
2. https://www.edx.org/course/mechanical-behavior-materials-part-1-mitx-3-032-1x-1
3. https://www.coursera.org/learn/mechanics-1

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos
3. Problem based learning
4. Technical quizzes / MCQs

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Regularity and Punctuality	Oral/MCQ	Experiment Skills	Problem based learning	Ethics
10	10	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Simple stresses and strains** : Concept of stress, strain, modulus of elasticity, stress-strain curve for ductile materials, calculation of stress and strain produced in axially loaded members of uniform cross-section and composite/compound sections, lateral strain, Poisson's ratio, biaxial, tri-axial/volumetric stress system, relation between elastic constants of material (E,G,K, and μ), thermal stress and strain produced in simple bars.	**6**	**8**	
2	**Principal planes and stresses :** Principle of complimentary shear, normal and tangential stresses developed on oblique sections in members subjected to biaxial stress system along with complimentary shear stress, concept of principal planes and stresses, calculation of principal planes and stresses, maximum shear stress using analytical and graphical methods (Mohr's circle method), theories of failure, stress tensors.	**6**	**2**	

3	**Stresses in Beams:** Types of beams and supports, concept of shear force and bending moment at any section of the beam, moment of inertia of standard beam sections about neutral axis, theory of pure or simple bending, calculation of bending and shear stresses in beams, Slope and deflection of beams (using standard formulae).	**6**	**2**	
4	**Torsion of shafts:** Theory of pure torsion, torsion formula for circular shafts, calculation of torsional shear stress and angle of twist in shaft, power transmitted by shaft, shafts subjected to compound stresses (direct + bending + torsion), equivalent bending moment and twisting moment, shaft design based on strength and stiffness criteria.	**6**	**2**	
5	**Columns and struts:** Axially loaded compression members, crushing load, buckling or crippling load for columns with different end conditions, calculation of crippling load using Euler's theory and Rankine theory, direct and bending stresses- stress distribution for an eccentrically loaded circular/circular section, the middle third rule, core or kernel of a section.	**6**	**0**	

COURSE STRUCTURE

Course Code	**PO212**			
Course Category	*Polymer Engineering*			
Course Title	**Fluid Mechanics**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites :
Basic HSC Physics and Mathematics, FYBTech/Diploma Physics and Mathematics

Course Objectives :
1. To understand basic concepts of fluid flow and its applications in polymer process industry.

Course Outcomes :
On completion of the course, the students will be able to
1. Develop an ability to write governing equations for a given flow systems based on fundamental principles
2. Develop an ability to perform pressure drop calculations and line sizing for single phase and Multiphase flows
3. Develop the ability to evaluate the performance based on fundamental working principles of the Fluid flow Machinery

Course Contents :

Fluid Properties and Dimensional Analysis - Properties of fluids: viscosity, density, specific gravity, vapor pressure, surface tension , capillary effect, coefficient of compressibility and volume expansion. Newtonian, Non-Newtonian fluid classification, Type of flows, Dimensional homogeneity and methods of dimensional analysis, Dimensional numbers.

Fluid Statics and Fluid Kinematics - Fluid Statics: Concept of pressure; types of manometers – simple and differential, pressure forces on surfaces; Fluid flow descriptions, Deformation of fluid elements, Forces acting on a control volume. Boundary layer theory

Basic Equations of Fluid Flow - Continuity Equation. Bernoulli equation. Forms of Bernoulli equation, Limitations on use of Bernoulli equation and correction terms involved in different cases, Application of Bernoulli equation. Momentum equation and its applications, Introduction to Navier Stokes Equation.

Flow Through Pipes and Flow past immersed bodies - Hagen-Poiseuille equation and its applications, Friction factor and its variations Darcy-Weisbach equations. Moody's diagrams. Major and Minor losses in piping system. Flow through porous media, fixed and fluidized beds, Ergun Equation, Gas-Liquid Flow regimes.

Fluid Flow Machinery - Comparison between fans, blowers, compressors. Pump's principle, construction and working of centrifugal pumps. Characteristic curves. NPSH concepts. Fundamental relationships, formulae and Numerical Calculations.

Laboratory Work :

List of Experiments (any 7 experiments)

1. Fluid property measurements such as viscosity, density, etc.
2. Reynolds's experiment for laminar, transition and turbulent flow identification
3. Verification of Bernoulli's Equation
4. Flow measurements using venturimeter and orificemeter
5. Single phase pressure drop measurements in flow through pipe
6. Pressure drop measurements in flow through packed bed
7. Verification of Darcy' law
8. Estimation of gas-liquid multiphase flow regimes in flow through pipe
9. Centrifugal pump characteristics

Learning Resources:

Reference books :

1. Noel de Nevers, Fluid Mechanics for Chemical Engineers, 3rd edition, McGraw Hill, 2005
2. Cengel Y.A. and Cimbala J.M., Fluid Mechanics, Tata-McGraw-Hill, 2013
3. McCabe W.L., Smith J.C. and Harriot P., Unit Operations in Chemical Engineering, 5th edition, McGraw-Hill Inc., 1993
4. Evett J.B. and Cheng L., Fundamentals of Fluid Mechanics, McGraw Hill, 1987
5. Darby R., Chemical Engineering Fluid Mechanics, 2nd edition, Marcel Dekker, 2001

Web Resources :

Weblinks -

1. mit.espe.edu.ec/courses
2. www.ipieca.org/Resources
3. ocw.mit.edu

MOOCs *(Online courses for self-learning)*

1. https://ocw.mit.edu/courses/chemical-engineering/10-52-mechanics-of-fluids-spring-2006/
2. http://nptel.ac.in/courses/103104044/1

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos
3. Problem based learning
4. Technical quizzes / MCQs

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Regularity and Punctuality	Oral based on practical	Understanding of Procedure	Experimental Skills	Ethics
10	10	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Fluid Properties and Dimensional Analysis -** Properties of fluids: viscosity, density, specific gravity, vapor pressure, surface tension , capillary effect, coefficient of compressibility and volume expansion. Newtonian, Non-Newtonian fluid classification, Type of flows, Dimensional homogeneity and methods of dimensional analysis, Dimensional numbers.	**6**	**4**	
2	**Fluid Statics and Fluid Kinematics -** Fluid Statics: Concept of pressure; types of manometers – simple and differential, pressure forces on surfaces; Fluid flow descriptions, Deformation of fluid elements, Forces acting on a control volume. Boundary layer theory	**6**	**2**	
3	**Basic Equations of Fluid Flow -** Continuity Equation. Bernoulli equation. Forms of Bernoulli equation, Limitations on use of Bernoulli equation and correction terms involved in different cases, Application of Bernoulli equation. The Momentum equation and its applications, Introduction to Navier Stokes Equation.	**6**	**6**	
4	**Flow Through Pipes and Flow past immersed bodies -** Hagen-Poiseuille equation and its applications, Friction factor and its variations Darcy-Weisbach equations. Moody's diagrams. Major and Minor losses in piping system. Flow through porous media, fixed and fluidized beds, Ergun Equation, Gas-Liquid Flow regimes.	**6**	**2**	
5	**Fluid Flow Machinery -** Comparison between fans, blowers, compressors. Pump's principle, construction and working of centrifugal pumps. Characteristic curves. NPSH concepts.	**6**	**0**	

	Fundamental relationships, formulae and Numerical Calculations.			

COURSE STRUCTURE

Course Code	**PO213**			
Course Category	*Polymer Engineering*			
Course Title	**Process Calculations**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites :
HSC Mathematics, Chemistry, Physics; FYBTech/Diploma Mathematics, Chemistry, Physics

Course Objectives :
1. To provide knowledge on the application of the laws of mass and energy conservation in various process industries

Course Outcomes :
On completion of the course, learner will be able to
1. Calculate quantities, compositions, energy usages in various processes
2. Calculate utility requirements of a process
3. Use modern software tools to solve material and energy balance problems

Course Contents :

Stoichiometric and Composition Relations - Units and Dimensions, Conversion of units. Basic process variables – Mass, Volume, Flow rate. Chemical composition - Volume, Mass and mole fractions. Wet basis and dry basis, Average molecular weight calculation for different polymers, Behavior of gases - Ideal and Van der Waal gases. Specific volume of gas mixtures, Dalton's law, Amagat's law, Raoult's law.

Material Balance without reactions - Steady state and unsteady state Processes. Overall and component material balance on non-reacting systems for Distillation, Evaporation, Extraction. Absorption, Drying. Analysis of systems with bypass, recycles and purge.

Material Balance with reactions - Molar table for converter, Balances on reacting systems. Limiting and excess reactants. Fractional conversion. Extent of reaction. Multiple reactions. Yield and selectivity. Analysis of systems with bypass, recycles and purge.

Energy Balance without reactions - Energy balance for open systems, enthalpy calculations, heat capacities of solid, liquid and gases, sensible and latent heats, enthalpy change for gaseous and liquid streams, energy balance for phase change processes.

Energy Balance with reactions - Heat effects accompanying chemical reactions, Hess's law, Standard heat of reaction, combustion and formation, Effect of temperature on standard heat of

reaction, Adiabatic reaction temperature

Laboratory Work :

Practical assignments will cover manual calculations, spread sheets and process simulation using process design software such as ASPEN, etc.

1. Composition analysis of solution
2. Average Molecular weight, Density, Specific/Molar volume of a Hydrocarbon mixture
3. Simple process plant based material balance
4. Molar table for convertor
5. Recycle/Purge calculation
6. Pxy, Txy and equilibrium diagram construction
7. Simple process plant based energy balance
8. Introduction and Application of ASPEN

Learning Resources :

Reference books :

1. Bhat B. I. and Vora, Stoichiometry, 2nd edition, Tata McGraw Hill, 2000
2. Himmelblau D. M., Basic Principles and Calculations in Chemical Engineering, 6th edition, Prentice-Hall, India, 1996
3. Narayanan K.V. and Lakshmikutty B., Stoichiometry and Process Calculations, 1st edition, Prentice-Hall, India, 2006
4. Felder R.M. and Rousseau R.W., Elementary Principles of Chemical Processes, 3rd edition, John Wiley and Sons, 2000

Web Resources :

Web-links -

1. mit.espe.edu.ec/courses
2. www.ipieca.org/Resources
3. ocw.mit.edu

MOOCs (*Online courses for self-learning)*

1. http://nptel.ac.in/syllabus/103106076/

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos
3. Problem based learning
4. Technical quizzes

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Regularity and Punctuality	Oral/MCQ	Experiment Skills	Problem based learning	Ethics
10	10	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	*Lab*	*Assess*
1	**Stoichiometric and Composition Relations -** Units and Dimensions, Conversion of units. Basic process variables – Mass, Volume, Flow rate. Chemical composition - Volume, Mass and mole fractions. Wet basis and dry basis, Average molecular weight calculation for different polymers, Behavior of gases - Ideal and Van der Waal gases. Specific volume of gas mixtures, Dalton's law, Amagat's law, Raoult's law.	**6**	**4**	
2	**Material Balance without reactions -** Steady state and unsteady state Processes. Overall and component material balance on non-reacting systems for Distillation, Evaporation, Extraction. Absorption, Drying. Analysis of systems with bypass, recycles and purge.	**6**	**2**	
3	**Material Balance with reactions -** Molar table for converter, Balances on reacting systems. Limiting and excess reactants. Fractional conversion. Extent of reaction. Multiple reactions. Yield and selectivity. Analysis of systems with bypass, recycles and purge.	**6**	**2**	
4	**Energy Balance without reactions -** Energy balance for open systems, enthalpy calculations, heat capacities of solid, liquid and gases, sensible and latent heats, enthalpy change for gaseous and liquid streams, energy balance for phase change processes.	**6**	**2**	
5	**Energy Balance with reactions** - Heat effects accompanying chemical reactions, Hess's law, Standard heat of reaction, combustion and formation, Effect of temperature on standard heat of reaction, Adiabatic reaction temperature	**6**	**4**	

COURSE STRUCTURE

Course Code	**PO214**			
Course Category	*Polymer Engineering*			
Course Title	**Thermodynamics**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	0	1	2 + 0 + 1 = 3

Pre-requisites:
FYBTech Mathematics, Basic Engineering Fundamentals

Course Objectives:

1. To study laws of thermodynamics and its various applications.
2. To study basic principles of various cycles and thermodynamic properties of fluids.
3. To use Thermodynamic fundamentals for commercial applications.
4. To predict feasibility of process and apply the thermodynamic principles to various engineering problems.
5. To identify real plant opportunities in energy saving and optimization.

Course Outcomes:

After completion of this course students will be able to;

1. Apply the laws of thermodynamics to solve problems
2. Determine the various thermodynamic properties of the fluids.
3. Apply the knowledge of various thermodynamic cycles.

Course Contents:

First Law - Scope of thermodynamics, fundamental and derived quantities, 1st law of thermodynamics: Formulation of 1st law of thermodynamics, state and path functions, thermodynamic systems, steady state flow system, phase rule, reversible process, heat capacity.

Volumetric Properties of Pure Fluids - PVT behavior of pure substance, the virial equation, constant volume, constant pressure, adiabatic, polytrophic processes, real gas, applications of virial equation, critical properties, Van der Waal equation, Limitations of 1st Law, Statements of 2nd law, ideal and actual engine efficiencies, Concept of entropy and derivation from second law, mathematical statement of 2nd law, statement of 3rd law.

Thermodynamic Cycles - Various thermodynamic cycles – Carnot cycle, Refrigeration cycle (p-v, t-s, h-s, and h-x diagrams), liquefaction.

Thermodynamic Properties of Fluids - Fundamental property relations for closed systems, Maxwell relationships, residual properties, residual properties by equations of state, two-phase systems, Clausius- Clapeyron equation, thermodynamic diagrams, Concept of Availability.

Solution Thermodynamics : Fundamental Property Relation, Partial Molar functions, Ideal-Gas Mixtures, Fugacity and Fugacity Coefficient - Pure species and species in solution, Ideal and Non-ideal solutions, Thermodynamic quality of a solvent, Thermodynamics of polymer solution and blends - Flory-Huggins theory, free energy of mixing, Phase equilibria, Phase stability, Phase diagrams, Solubility parameter, Effect of molecular weight on phase diagram, bimodal, spinodal and critical point, Criteria of LCST & UCST.

Tutorial Work :

Exercises / Assignments

1. Problems related to internal energy, heat supplied, change in enthalpy and work done for various processes.
2. Applications of Van der Waal equation and entropy calculations.
3. Problems based on power cycles with external and internal combustion.
4. Problems related to refrigeration cycle (Vapor compression and Absorption).
5. Fugacity and fugacity coefficient calculations.
6. Determination of solvents for given polymers using solubility parameter criteria.

Learning Resources:

Reference books:

1. Smith J.M. and van Ness H.C., Introduction to Chemical Engineering Thermodynamics, McGraw-Hill, 1996
2. Narayanan K.V., A Textbook on Chemical Engineering Thermodynamics, Prentice Hall of India Ltd., 2013
3. Fried J.R., Polymer Science and Technology, Prentice-Hall of India, New Delhi, 2005

Supplementary Reading:

1. Rao Y.V.C., An Introduction to Thermodynamics, University Press (India) Pvt. Ltd., 2004

Web Resources:

Weblinks:

1. mit.espe.edu.ec/courses
2. www.ipieca.org/Resources
3. ocw.mit.edu
4. www.cambridge.org › Home › Academic › Engineering › Chemical engineering

MOOCs:

1. https://www.class-central.com/search?q=chemical+engineering+thermodynamics
2. http://nptel.ac.in/courses/103101004/

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos
3. Problem based learning
4. Technical quizzes

Assessment Scheme:

Class Continuous Assessment (CCA) : 100 Marks

Tutorial Assignments	Test	MCQ	Attendance
50	30	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Tut	Assess
1	**First Law-** Scope of thermodynamics, fundamental and derived quantities, first law of thermodynamics: Formulation of 1st law of thermodynamics, state and path functions, thermodynamic systems, steady state flow system, phase rule, reversible process, heat capacity.	**6**	**2**	
2	**Volumetric Properties of Pure Fluids -** PVT behavior of pure substance, the virial equation, constant volume, constant pressure, adiabatic, polytrophic processes, real gas, applications of virial equation, critical properties, Van der Waal equation, Limitations of 1st Law, Statements of 2nd law, ideal and actual engine efficiencies, Concept of entropy and derivation from second law, mathematical statement of 2nd law, statement of 3rd law.	**6**	**2**	
3	**Thermodynamic Cycles -** Various thermodynamic cycles, power cycles with external combustion or heat pump cycles, power cycles with internal combustion, Refrigeration cycle (p-v, t-s, h-s, and h-x diagrams) for vapor compression and absorption refrigeration systems, Evaluation of COP, liquefaction.	**6**	**2**	
4	**Thermodynamic Properties of Fluids -** Fundamental property relations for closed systems, Maxwell relationships, residual properties by equations of state, 2-phase systems, Clausius-Clapeyron equation, thermodynamic diagrams, Concept of availability.	**6**	**2**	
5	**Solution Thermodynamics -** Fundamental Property Relation, Chemical potential and Phase equilibria, Partial molar properties, Ideal gas mixtures, Fugacity and coefficient: Pure species and Species in Solution, LCST & UCST- criteria of good solvent for polymer solutions.	**6**	**2**	

COURSE STRUCTURE

Course Code	**ES**			
Course Category	*Humanities and social sciences*			
Course Title	**Environmental Science**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	2	0	0	1 + 0 + 0 = 1

Pre-requisites:

Course Objectives:

1. To impart sense of community responsibility by becoming aware of scientific issues in the larger social context.
2. To develop an interdisciplinary approach to complex environmental problems using basic tools of the natural and social sciences including biology chemistry, political sciences and technology.
3. To inculcate ability to work effectively as a member of interdisciplinary team to solve environment related social issues.

Course Outcomes:

After completion of this course students will be able to;

1. Correlate core concepts and methods from ecological and physical sciences and their application in environmental problem solving. CL-II)
2. Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.(CL-V)
3. Apply systems, concepts and methodologies to analyze and understand interactions between social and environmental processes (CL-III)

Course Contents:

Multidisciplinary nature of environmental science - Definition, scope and importance. Need for public awareness.

Natural resources - Renewable and non-renewable resources : Natural resources and associated problems - Forest resources, Water resources, Mineral resources, Food resources, Energy resources, Land resources. Role of an individual in conservation of natural resources. Case Studies.

Ecosystem, biodiversity and its conservation - Concept, structure, functions and types of an ecosystem. Introduction - Definition of biodiversity, genetic, species and ecosystem diversity. Bio-geographical classification of India .Value of biodiversity. Biodiversity at global, national and local levels. India as a mega-diversity nation. Hot-sports of biodiversity. Threats to biodiversity. Conservation of biodiversity.

Environmental pollution - Definition, Causes, effects and control measures of Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards, Solid waste Management. Role of an individual in prevention of pollution. Disaster management : floods, earthquake, cyclone and landslides.

Social issues and the environment - From Unsustainable to Sustainable development. Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Resettlement and rehabilitation of people, its problems and concerns. Environmental ethics, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation. Consumerism and waste products. Environmental regulations. Issues involved in enforcement of environmental legislation. Public awareness.

Learning Resources:

Reference Books:

1. Bharucha E., The Biodiversity of India, 1st edition, Mapin Publishing Pvt. Ltd., Ahmedabad, India, 2000.
2. Miller T.G., Jr., Environmental Science, 2nd edition, Wadsworth Publication, 1989.

Supplementary Reading:

1. De A.K., Environmental Chemistry, 7th edition, Wiley Eastern Ltd., 2014.
2. Down to Earth- Magazine, Centre of Science and Environment, New Delhi, Editor – Sunita Narian

Web Resources:

Web-links

1. https://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf
2. http://www.nptel.ac.in/courses/120108005/
3. http://www.nptel.ac.in/courses/120108004/
4. http://www.nptel.ac.in/courses/120108002/

MOOCs (*On-line courses for self-learning)*

1. https://www.coursera.org/learn/global-warming
2. https://www.coursera.org/learn/global-environmental-management
3. https://www.edx.org/course/climate-change-science-ubcx-climate1x-3
4. https://www.edx.org/course/sustainable-tourism-society-environmental-aspects

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning.

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Presentations
30	20

Term End Examination : 50 Marks
Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Multidisciplinary nature of environmental science** - Definition, scope and importance. Need for public awareness.	**1**	**-**	
2	**Natural resources** - Renewable and non-renewable resources : Natural resources and associated problems - Forest resources, Water resources, Mineral resources, Food resources, Energy resources, Land resources. Role of an individual in conservation of natural resources. Case Studies.	**4**	**-**	
3	**Ecosystem, biodiversity and its conservation** - Concept, structure, functions and types of an ecosystem. Introduction - Definition of biodiversity, genetic, species and ecosystem diversity. Bio-geographical classification of India .Value of biodiversity. Biodiversity at global, national and local levels. India as a mega-diversity nation. Hot-sports of biodiversity. Threats to biodiversity. Conservation of biodiversity.	**5**	**-**	
4	**Environmental pollution** - Definition, Causes, effects and control measures of Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards, Solid waste Management. Role of an individual in prevention of pollution. Disaster management : floods, earthquake, cyclone and landslides.	**5**	**-**	
5	**Social issues and the environment** - From Unsustainable to Sustainable development. Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Resettlement and rehabilitation of people, its problems and concerns. Environmental ethics, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation. Consumerism and waste products. Environmental regulations. Issues involved in enforcement of environmental legislation. Public awareness.	**5**	**-**	

SYLLABUS

SYBTech (Polymer Engineering)

Trimester - V

COURSE STRUCTURE

Course Code	**ES224**			
Course Category	*Basic Sciences*			
Course Title	**Organic Chemistry**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites :
HSC Chemistry, FYBTech/Diploma Chemistry

Course Objectives:
1. To impart knowledge of fundamentals of organic chemistry.
2. To inculcate understanding of mechanism of organic reactions, structural effects and stereochemistry.

Course Outcomes:
After completion of this course the students will be able to:
1. Illustrate correlation between effect of structure of organic compound with its reactivity.(CL-I)
2. Explain step by step electronic changes involved in organic reactions. (CL-II)
3. Recall and visualize three dimensional structures of organic compounds. (CL-I)
4. Apply the concept of aromaticity and reactions shown by aromatic compounds.(CL-III)

Course Contents:

Sources of organic compounds: Sources of different types of organic compounds like hydrocarbons, carbohydrates, Nitrogen containing organic compounds etc.

Structural Effects and Reactivity - Hybridization of carbon- sp, sp^2, sp^3, Electronic theory of valency, electrovalency, covalency, coordinate valency and hydrogen bonding. Bond cleavage. Reagents, Reaction intermediates – Carbonium ion, carbanion, free radical and carbenes, structure, formation and stability. Basic structural electronic effects – Inductive, resonance, electromeric, hyperconjugation.

Isomerism - Types of isomerism- Structural and stereo isomerism with examples. Conformational isomerism of ethane, propane, butane, cyclohexane, monosubstituted cyclohexane. Optical isomerism - concept of elements of symmetry, optical isomerism with one and two chiral centers (AA and AB type), enantiomers, threo, erythro, meso, distereoisomers. Geometrical isomerism (cis, trans, R, S and E, Z). Examples showing variation in properties with different isomerism.

Reaction Mechanism - Nucleophilic aliphatic substitution by alkyl halides - SN1 and SN2 reactions, Factors affecting SN1 and SN2 reactions. SN2 verses SN1 reactions. Free radical substitution reactions - Halogenations of alkanes. Electrophilic additions - additions to C = C, Markovnicov's rule. Diel's Alder reaction, Nucleophilic additions - Mechanism and examples of Grignard reaction, Aldol condensation, free radical addition reactions, peroxide effect. Elimination - E1and E2 reactions,

Saytzeff and Hofmann elimination. Rearrangement - Beckman, Pinacol. Favorskii Rearrangement.

Aromatic Compounds - Structure of benzene and concept of aromaticity (Huckel's rule), benzenoid and non-benzenoid aromatic compounds. Nomenclature of substituted benzene compounds. Electrophilic substitution in benzene and monosubstituted benzene with orientation effect. Mechanism of Friedel–Craft alkylation and acylation reactions, nitration, halogenation, sulphonation of benzene, phenol and nitrobenzene.

Laboratory Work :

List of experiments (any 7 experiments)

1. Volumetric estimation of amide from the given solution of amide.
2. Volumetric estimation of acetone from the given solution of acetone.
3. Preparation of m-nitroaniline from m-dinitrobenzene.
4. Preparation of benzoic acid from benzamide.
5. Organic qualitative analysis.(sample – 1)
6. Organic qualitative analysis.(sample – 2)
7. Organic qualitative analysis.(sample – 3)
8. Organic qualitative analysis.(sample – 4)
9. Organic qualitative analysis.(sample – 5)
10. Organic qualitative analysis.(sample – 6)

Learning Resources:

Reference Books:

1. Morrison R.T. and Boyd R.N., Organic Chemistry, 6th edition, Prentice Hall of India Private Ltd., 2011.
2. Sykes P., A Guide Book to Mechanism in Organic Chemistry, 6th edition, Pearson, 2003.
.

Supplementary Reading:

1. Hoffman R.V., Organic Chemistry, 2nd edition, Wiley India Pvt. Ltd., 2004.
2. Clayden J., Greeves N. and Warren S., Organic Chemistry, 2nd edition, Oxford University Press, 2012.
3. Chang R., Chemistry, 9th edition, Tata McGraw-Hill, 2008.

Web Resources:

Weblinks

1. Benzene and its other Compounds : http://nptel.ac.in/courses/104103071/17
2. Nucleophilic Substitution Reactions : http://nptel.ac.in/courses/104101005/6
3. Grignard reactions : http://nptel.ac.in/courses/104101005/10
4. Elimination Reactions: http://nptel.ac.in/courses/104101005/7
5. Free radical Reactions : http://nptel.ac.in/courses/104101005/12
6. Molecular Rearrangement : http://nptel.ac.in/courses/104101005/11
7. Stereochemistry : http://nptel.ac.in/courses/104101005/4

MOOCs *(On-line courses for self-learning)*

1. https://www.coursebuffet.com/course/71/saylor/organic-chemistry-i
2. https://www.coursebuffet.com/course/276/coursera/introductory-organic-chemistry-part-2-univ- of-illinois-at-urbana-champaign

Pedagogy:

- Co-teaching
- Power point presentations
- Videos
- Demonstrations
- Systematic use of group work and project based learning

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignment	Test	Presentations	MCQ	Oral	Attendance and Initiative
10	10	10	10	Nil	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Regularity and Punctuality	Understanding the objective	Understanding of Procedure	Experiment skills	Ethics
10	10	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	*Lab*	*Assess*
1	**Sources of organic compounds:** Sources of different types of organic compounds like hydrocarbons, carbohydrates, Nitrogen containing organic compounds etc.	02	-	
2	**Structural Effects and Reactivity** - Hybridization of carbon- sp, sp^2, sp^3, Electronic theory of valency, electrovalency, covalency, coordinate valency and hydrogen bonding. Bond cleavage. Reagents, Reaction intermediates – Carbonium ion, carbanion, free radical, carbenes and their structure, formation and stability. Basic structural electronic effects – Inductive, resonance, electromeric, hyperconjugation.	06	-	

3	**Isomerism** - Types of isomerism- Structural and stereo isomerism with examples. Conformational isomerism of ethane, propane, butane, cyclohexane, monosubstituted cyclohexane. Optical isomerism - concept of elements of symmetry, optical isomerism with one and two chiral centers (AA and AB type), enantiomers, threo, erythro, meso, distereoisomers. Geometrical isomerism (cis, trans, R, S and E, Z). Examples showing variation in properties with different isomerism.	08	-	
4	**Reaction Mechanism** - Nucleophilic aliphatic substitution by alkyl halides - SN1 and SN2 reactions, Factors affecting SN1 and SN2 reactions. SN2 verses SN1 reactions. Free radical substitution reactions - Halogenations of alkanes. Electrophilic additions - additions to C = C, Markovnicov's rule. Diel's Alder reaction, Nucleophilic additions - Mechanism and examples of Grignard reaction, Aldol condensation, free radical addition reactions, peroxide effect. Elimination – E1and E2 reactions, Saytzeff and Hofmann elimination. Rearrangement - Beckman, Pinacol. Favorskii Rearrangement.	08	08	
5	**Aromatic Compounds** - Structure of benzene and concept of aromaticity (Huckel's rule), benzenoid and non-benzenoid aromatic compounds. Nomenclature of substituted benzene compounds. Electrophilic substitution in benzene and monosubstituted benzene with orientation effect. Mechanism of Friedel –Craft alkylation and acylation reactions, nitration, halogenation, sulphonation of benzene, phenol and nitrobenzene.	06	12	

COURSE STRUCTURE

Course Code	**PO221**			
Course Category	*Polymer Engineering*			
Course Title	**Heat Transfer**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites:
FYBTech/Diploma Mathematics, Engineering Material Science, Fluid Mechanics

Course Objectives:

1. To study various modes of heat transfer and the laws governing them.
2. To study basic principles of condensation and boiling and understand their applications.
3. To classify, select and understand the types of process design aspects for heat exchangers and evaporators
4. To identify real plant opportunities in energy saving and optimization.

Course Outcomes:

After completion of this course students will be able to;

1. Demonstrate the knowledge of basic physics and mathematics involved in three modes of heat transfer and their applications.
2. Identify, formulate and solve engineering problems related to heat transfer.
3. Identify and select appropriate heat exchange equipment for a given duty and design the same.

Course Contents:

Conduction : Heat transfer modes and Laws, Material properties of importance in heat transfer, Heat transfer in Cartesian, cylindrical and Spherical coordinate systems, Thermal Resistance, Insulation and critical radius, Unsteady state Heat conduction

Convection : Dimensionless groups in Heat Transfer, Heat transfer by Natural Convection from plate and cylinder. Heat transfer by Forced Convection in Laminar and turbulent flow applied to circular pipe, Momentum and Heat Transfer Analogies, Enhanced heat Transfer: Concepts of Fins.

Radiation : Basic Concepts and Laws of Radiation, Solid angle and Radiation Intensity, concepts of Radiation Shields, Introduction to different solar energy transmitting systems.

Heat Exchangers : Basic types of heat exchangers, Flow arrangements, Overall heat transfer coefficient and fouling factor calculations, Mean temperature difference, Effectiveness – NTU Method, Concept of Heat Exchange Networks.

Phase Change Heat Transfer : Types of condensation, Study of condensation on a vertical plate, vertical tube and horizontal tubes, Effect of superheated vapor and non-condensable gases, Types of boiling, boiling curves, The concept of heat pipe

Heat Transfer Equipment Design : Heat exchanger design considerations and standards, Types of evaporators, Design of single and multiple effect evaporators, Applications of Heat Transfer in Polymer Engineering systems as: Estimation of Viscosity and Specific Heats, Thermal Conductivity and Diffusivity, Design of Heating Chamber of Moulding Machine

Laboratory Work :

List of Experiments (any 7 experiments)

1. To determine thermal conductivity of a metal bar.
2. To determine efficiency of a Pin Fin.
3. To determine the emissivity of a test plate.
4. To determine heat transfer coefficient in forced convection.
5. To determine heat transfer coefficient in natural convection
6. Parallel flow / counter flow heat exchanger
7. Composite wall apparatus
8. Study of Multiple effect evaporators.
9. To Study shell and tube heat exchanger.
10. To study unsteady state heat transfer.

Learning Resources:

Reference books:

1. Sukhatme S.P., A Textbook on Heat Transfer, University Press (I) Pvt. Ltd., 4th edition, 2005.
2. Holman J.P., Heat Transfer, Tata McGraw-Hill, 9th edition, 2002.
3. Eduardo C., Heat Transfer in Process Engineering, McGraw-Hill, 2010.
4. Kern D.Q., Process Heat Transfer, McGraw Hill, 1997.

Supplementary Reading:

1. Cengel Y.A., Heat Transfer A Practical Approach, McGraw Hill, 2th edition, 2004.

Web Resources:

Weblinks

1. mit.espe.edu.ec/courses
2. www.ipieca.org/Resources
3. ocw.mit.edu
4. www.cambridge.org › Home › Academic › Engineering › Thermal-fluids engineering
5. https://www.hrs-heatexchangers.com/resource

MOOCs:

1. https://www.class-central.com/tag/heat%20transfer
2. https://onlinecourses.nptel.ac.in/noc18_ch08
3. https://www.edx.org/course/advanced-transport-phenomena-delftx-tp201x-0

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos
3. Problem based learning
4. Technical quizzes

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Performance	Oral	Problem based Learning	Attendance and Timely submission
20	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Conduction -** Modes and Laws, Material properties, Cylindrical and spherical coordinate systems, Thermal Resistance, Insulation and critical radius, Unsteady state heat conduction.	**6**	**4**	
2	**Convection -** Dimensionless groups, Natural convection through plate and cylinder, forced convection through laminar and turbulent flow, momentum and heat transfer analogies, Enhanced heat transfer.	**6**	**4**	
3	**Radiation -** Basic Concepts and Laws of Radiation, Solid angle and Radiation Intensity, concepts of Radiation Shields, Introduction to different solar energy transmitting systems.	**6**	**4**	
4	**Heat Exchangers -** Basic types of heat exchangers, Flow arrangements, Overall heat transfer coefficient and fouling factor calculations, Mean temperature difference, Effectiveness – NTU Method, Concept of Heat Exchange Networks.	**6**	**4**	
5	**Phase Change Heat Transfer and equipment design -** Study of condensation and boiling, effect of superheated vapours on non condensable gas, boiling curves, heat exchanger design and types of evaporators.	**6**	**4**	

COURSE STRUCTURE

Course Code	**PO222**			
Course Category	*Polymer Engineering*			
Course Title	**Polymer Chemistry**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites
HSC and FYBTech/Diploma Chemistry, Organic Chemistry

Course Objectives:
1. To provide the basic building blocks of polymer science by imparting fundamental knowledge.
2. To provide in-depth knowledge of various polymerization mechanisms including copolymerization, kinetics, molecular weight and polymer modifications.

Course Outcomes:
On completion of the course, the students will
1. be able to apply the knowledge of fundamentals of polymer science.
2. be able to understand the kinetics and relate the polymer synthesis mechanisms.
3. have knowledge of copolymerization and polymer modifications.

Course Contents:

Introduction to polymer science : basic concepts such as monomer, polymer, oligomer, initiator, functionality, molecular weight, polydispersity, viscosity, etc., classification of polymers, nomenclature of polymers, generalized mechanisms of step and chain polymerization, various average molecular weights (Mn, Mw, Mv and Mz) and molecular weight distribution (MWD), molecular weight determination techniques, polymerization techniques such as bulk, solution, suspension and emulsion.

Radical chain polymerization, effect of monomer substituents on polymerizability, types of initiators in radical chain polymerization, free radical polymerization mechanism, termination and transfer reactions, inhibition and retardation, ceiling temperature, kinetics of free radical chain polymerization.

Ionic chain polymerization, types of initiators in cationic and anionic chain polymerizations, anionic and cationic polymerization mechanism, termination and transfer reactions, comparison of radical cationic and anionic polymerizations.

Step polymerization, reactivity of functional groups, need for stoichiometric control, gelation, crosslinking, Carother's equation, ring-opening polymerization, generalized synthesis of polyesters, polyamides and polycarbonates, kinetics of step polymerization.

Copolymerization, chain copolymerization, introduction, types, copolymerization equation, monomer reactivity ratio, types of copolymerization behavior, step copolymerization, introduction, types, methods of synthesis, examples of commercial step and chain copolymers.

A short introduction to polymer reactions, polymer modification reactions, vulcanization, polymer degradation, factors or agents causing degradation, polymer recycling, incineration, pyrolysis.

Laboratory Work :

List of experiments (any 7 experiments)

1. Study of various laboratory practices like material handling, handling of laboratory equipments, basic laboratory techniques etc.
2. Monomer Purification
3. Bulk polymerization techniques.
4. Solution polymerization techniques.
5. Interfacial polymerization technique.
6. Preparation of glyptal resin.
7. Preparation of melamine formaldehyde resin
8. Determination of acid value of glyptal resin.
9. Determination of MW by viscometry.
10. Determination of gel point.

Learning Resources:

Reference Books:

1. Gowarikar V.R., Polymer Science, 2nd edition, New Age International Pvt. Ltd., 2015
2. Odian G., Principles of Polymerization, 4th edition, Wiley India Pvt. Ltd., 2004

Supplementary Reading:

1. Stevens M.P., Polymer Chemistry - An Introduction, 2nd edition, Oxford University Press, 1999
2. Fried J.R., Polymer Science and Technology, 2nd edition, PHI Publications Pvt. Ltd., 2004

Web Resources:

Weblinks:

1. http://www.open.edu/openlearn/science-maths-technology/science/chemistry/introduction-polymers/content-section-0?active-tab=content-tab
2. https://ocw.mit.edu/courses/materials-science-and-engineering/3-064-polymer-engineering-fall-2003/lecture-notes/
3. https://ocw.mit.edu/courses/chemical-engineering/10-569-synthesis-of-polymers-fall-2006/

MOOCs:

1. http://nptel.ac.in/courses/104105039/

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos, OHP.
3. Problem based learning
4. Technical quizzes

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Performance	Oral	Understanding	Attendance and Timely submission
15	10	15	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	***Lab***	***Assess***
1	**Introduction to polymer science :** basic concepts such as monomer, polymer, oligomer, initiator, functionality, molecular weight, polydispersity, viscosity, etc., classification of polymers, nomenclature of polymers, generalized mechanisms of step and chain polymerization, various average molecular weights (Mn, Mw, Mv and Mz) and molecular weight distribution (MWD), molecular weight determination techniques, polymerization techniques such as bulk, solution, suspension and emulsion.	**06**	**04**	
2	**Radical chain polymerization** : effect of monomer substituents on polymerizability, types of initiators in radical chain polymerization, free radical polymerization mechanism, termination and transfer reactions, inhibition and retardation, ceiling temperature, kinetics of free radical chain polymerization.	**06**	**04**	
3	**Ionic chain polymerization** : types of initiators in cationic and anionic chain polymerizations, anionic and cationic polymerization mechanism, termination and transfer reactions, comparison of radical cationic and anionic polymerizations.	**06**	**04**	

4	**Step polymerization** : reactivity of functional groups, need for stoichiometric control, gelation, crosslinking, Carother's equation, ring-opening polymerization, generalized synthesis of polyesters, polyamides and polycarbonates, kinetics of step polymerization.	**06**	**04**	
5	**Copolymerization** : chain copolymerization, introduction, types, copolymerization equation, monomer reactivity ratio, types of copolymerization behavior, step copolymerization, introduction, types, methods of synthesis, examples of commercial step and chain copolymers.	**06**	**04**	
6	**A short introduction to polymer reactions :** polymer modification reactions, vulcanization, polymer degradation, factors or agents causing degradation, polymer recycling, incineration, pyrolysis.	**02**	**02**	

COURSE STRUCTURE

Course Code	**PO223**			
Course Category	*Polymer Engineering*			
Course Title	**Polymer Materials – I**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites
FYBTech/Diploma Chemistry, Physics; SYBTech Chemistry, Engineering Materials Science

Course Objectives:
1. To impart the knowledge pertaining to structure and properties of polymers containing specific elements.
2. To impart the knowledge pertaining to processing and applications of polymers.
3. To impart the knowledge pertaining to industrial manufacturing of polymers.
4. To develop ability of selecting polymeric materials for required application.
5. To develop ability for chemical identification of polymeric materials.

Course Outcomes:
After completing the course the students will be able to demonstrate:
1. Understanding of various aspects related to industrial manufacturing of polymeric materials.
2. Understanding of basic polymer properties, processing and their applications.
3. Ability to select appropriate materials for required applications.

Course Contents:

Industrial manufacturing processes, properties, additives, compounding, processing and applications of –

Polymers containing Carbon and Hydrogen – Polyethylenes and copolymers, Polypropylene and copolymers, Styrenics (GPPS, HIPS, EPS).

Polymers containing Carbon, Hydrogen and Oxygen - Acrylics, Polyacetals, Polyvinyl alcohol, Polyvinyl acetate, Polycarbonate, Saturated polyesters and copolyesters), Cellulosics.

Polymers containing Carbon and/or Hydrogen, Halogens, Sulphur – Chlorinated polymers, Fluorinated polymers, Polyphenylenesulphide, Polysulphones.

Polymers containing Carbon, Hydrogen and/or Nitrogen, Oxygen – Polyamides, Polyimides, Polyacrylonitrile, Styrenics (ABS, SAN)

Laboratory Work :

List of Experiments (any 7 experiments)

1. Identification of Polymers containing C and H
2. Identification of Polymers containing C, H and O
3. Identification of Polymers containing C,H,N,O and halogens
4. Identification of Elastomer
5. Determination of curing time of resins
6. Determination of filler content
7. Determination of density & melting point
8. Determination of K-value of PVC
9. Determination of percentage purity of plasticizer
10. Determination of vinyl acetate content in EVA

Learning Resources:

Reference books:

1. Brydson J., Plastics Materials, 7th edition, Elsevier, 2005
2. Mayo S.W., Manufacture of Plastics, Reinhold Publishing Corporation, Chapman & Hall Ltd., London, 1964

Supplementary Reading:

1. Mark H.F., Bikales N.M., Overberger C.G. and Menges G., Encyclopedia of Polymer Science and Engineering, John Wiley and Sons, Chichester, 1985

Web Resources:

Weblinks

1. https://ocw.mit.edu/courses/materials-science-and-engineering/3-064-polymer-engineering-fall-2003/
2. https://online-distance.ncsu.edu/program/master-of-materials-science-and-engineering/#tabsPnl1-tab-1
3. http://www.mse.umd.edu/whatismse/polymers

MOOCs

1. http://nptel.ac.in/courses/113105028/
2. https://onlinecourses.nptel.ac.in/noc18_mm08

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos
3. Problem based learning
4. Technical quizzes

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Practical performance	Understanding	Oral	Problem based Learning	Attendance and timely submission
10	10	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Polymers containing Carbon and Hydrogen** - Polyethylenes and copolymers, Polypropylene and copolymers, Styrenics (GPPS, HIPS, EPS).	**6**	**4**	
2	**Polymers containing Carbon, Hydrogen and Oxygen** - Acrylics, Polyacetals, Polyvinyl alcohol, Polyvinyl acetate, Polycarbonate, Saturated polyesters and copolyesters), Cellulosics.	**6**	**4**	
4	**Polymers containingCarbon and/or Hydrogen, Halogens, Sulphur** - Chlorinated polymers, Fluorinated polymers, Polyphenylenesulphide, Polysulphones.	**6**	**4**	
5	**Polymers containing Carbon, Hydrogen and/or Nitrogen, Oxygen** - Polyamides, Polyimides, Polyacrylonitrile, Styrenics (ABS, SAN)	**6**	**4**	

SYLLABUS

SYBTech (Polymer Engineering)

Trimester - VI

COURSE STRUCTURE

Course Code	**ES231**			
Course Category	*Basic Sciences*			
Course Title	**Mathematics – III**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	0	1	3 + 0 + 0 = 3

Pre-requisites :
FYBTech/Diploma Mathematics

Course Objectives :

1. To learn linear differential equations and its applications in chemical/polymer engineering.
2. To understand integral transform techniques and their applications.
3. To learn vectors calculus for applications in engineering field.
4. To learn partial differential equation and their applications.

Course Outcomes :
After completion of this course students will be able to

1. solve linear differential equations using various methods. (CL III)
2. apply Laplace transform and Fourier transform techniques to solve differential equations involved in heat transfer and chemical/polymer engineering problems. (CL III)
3. perform vector differentiation and integration, analyze the vector fields and apply to fluid flow equations.(CL IV)
4. solve partial differential equations used in boundary value problems (CL III)

Course Contents :

Linear Differential Equation - Linear Differential Equation of n^{th} order with constant coefficients, Method of variation of parameters, Cauchy's and Legendre's Differential Equations, Applications to chemical/polymer engineering problem involving batch reactions.

Transform Techniques - Fourier transform : Fourier Integral theorem, Fourier Sine and Cosine transforms, Inverse Fourier Transform. Laplace transform : Definition, Properties, Laplace transform of standard functions, Inverse Laplace transform, Applications of Laplace transform for solving ordinary differential equations.

Vector Calculus - Vector Differential : Physical interpretation of vector differentiation, Vector differential operator, Gradient, Divergence and Curl, Directional derivative, Vector identities. Vector Integration : Line, Surface and Volume Integration, Work done, Green's Lemma, Stoke's and Divergence Theorem.

Partial Differential Equations - Basic concepts, Solution of partial differential equations, method of separation of variables Solution of one and two dimensional Heat flow equations, Wave equation, Solution of boundary value problems using Fourier Transform.

Tutorial Exercises:

1. Linear Differential Equations by Shortcut ,General, Variation of Parameter methods
2. Applications of Linear Differential Equations.
3. Fourier Sine and Cosine Transforms.
4. Laplace Transform and Inverse Laplace Transform
5. Vector differentiation, gradient, divergence and curl.
6. Vector integration, Work done, Green's Lemma, Stoke's and Divergence Theorem
7. Wave equation, one dimensional Heat flow equations.
8. Two dimensional Heat flow equations using Fourier transform.

Two tutorials will be conducted using Mathematical Software. Tutorial shall be engaged in four batches (batch size of about 15 students).

Learning Resources :

Reference Books -

1. Kreyszig E., Advanced Engineering Mathematics, 10th edition, Wiley Eastern Limited 2015.
2. Greenberg M.D., Advanced Engineering Mathematics, 2nd edition, Pearson, 2009.
3. Grewal B.S., Higher Engineering Mathematics, 43rd edition, Khanna Publishers, 2014

Supplementary Reading -

1. O' Neil P., Advanced Engineering Mathematics, 8th edition, Cengage Learning, 2015.
2. Weber H.J. and Arfken G.B., Mathematical Methods For Physicists, 6th edition, Academic Press 2011.

Web Resources -

Web links -

1. Introduction to second order LDE - https://www.youtube.com/watch?v=tGtCajxHoDw
2. Fourier Transform, Fourier Series, and frequency spectrum https://www.youtube.com/watch?v=r18Gi8lSkfM

MOOCs -

NPTEL, MIT OPEN COURSEWARE

1. https://ocw.mit.edu/courses/mathematics/18-02sc-multivariable-calculus-fall-2010/
2. https://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/video-lectures/lecture-9-solving-second-order-linear-odes-with-constant-coefficients/
3. http://nptel.ac.in/courses/111103021/18

Pedagogy:

- Team Teaching
- Tutorials and class tests
- Audio- Video technique

Assessment Scheme:

Class Continuous Assessment (CCA): 100 marks

Assignment/ short term Question-Answers tests	Tutorial	Mid-term Test	Attendance
20	50	20	10

Term End Examination : 50 marks

Syllabus :

Module No.	Contents	Workload in Hrs.		
		Th	Tut	Assess
1	**Linear Differential Equation** - Linear differential equation of n^{th} order with constant coefficients, Method of variation of parameters, Cauchy's and Legendre's differential equations, Applications to chemical/polymer engineering problem involving batch reactions.	08	02	-
2	**Transform Techniques** - Fourier transform : Fourier integral theorem, Fourier Sine and Cosine transforms, Inverse Fourier transform. Laplace transform : Definition, Properties, Laplace Transform of standard functions, Inverse Laplace transform, Applications of Laplace transform for solving ordinary differential equations.	08	02	-
3	**Vector Calculus** - Vector Differential : Physical interpretation of Vector differentiation, Vector differential operator, Gradient, Divergence and Curl, Directional derivative, Vector identities. Vector Integration : Line, Surface and Volume integration, Work done, Green's Lemma, Stoke's and Divergence Theorem	08	02	-
4	**Partial Differential Equations** - Basic concepts, Solution of partial differential equations, method of separation of variables solution of one and two dimensional Heat flow equations, Wave equation, Solution of boundary value problems using Fourier transform.	08	02	-

COURSE STRUCTURE

Course Code	**PO231**			
Course Category	*Polymer Engineering*			
Course Title	**Polymer Materials – II**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites:
FYBTech/Diploma Chemistry, SYBTech Chemistry

Course Objectives:

1. To impart knowledge pertaining to fundamentals of thermosets and rubbers
2. To impart knowledge about properties, processing and applications of thermosets and rubbers.
3. To impart the knowledge pertaining to manufacturing of thermosets and rubbers.
4. To develop ability of selecting polymeric materials for required application.

Course Outcomes:

After completing the course the students will be able to demonstrate:

1. Understanding of various aspects related to manufacturing of thermosets and rubbers.
2. Understanding of basic polymer properties, processing and their applications.
3. Ability to select appropriate materials for required applications.

Course Contents :

Thermosets : Synthesis and cross-linking reactions, properties, formulations, compounding, processing and applications of –

Phenolic resins, Urea and Melamine formaldehyde resins**,** Unsaturated polyester resins, Epoxy and polyurethanes

Introduction to raw materials used, characteristic properties and applications of alkyd and vinyl ester resins.

Rubbers :

Fundamentals – Molecular requirements for a material to function as elastomers, Mastication, Vulcanization, stress-strain relationships for vulcanized and unvulcanized rubber

Additives in rubber formulation – Antioxidants, Antiozonants, Fillers, Plasticizers, softeners and extenders, vulcanizing system, peptizers, tackifiers, blowing agent.

Review of properties, processing and applications of rubbers - Natural rubber, Styrene-butadiene rubber, butyl rubber, thermoplastic elastomers, polychloroprene rubber, nitrile rubber, etc.

Laboratory Work :

List of Experiments (any 7 experiments)

1. Synthesis of Novolak and Resol phenolic resins
2. Synthesis of Urea and Melamine formaldehyde resins
3. Effect of temperature, accelerator and catalyst on curing of unsaturated polyester resin
4. To find out epoxy value, epoxy equivalent of given resin and
5. Study on curing of epoxy resin
6. Determination of molecular weight by end group analysis
7. Study on effect of vulcanization on swelling of rubbers

Learning Resources :

Reference Books -

1. Goodman S.H., Handbook of Thermoset Plastics, 2nd edition, Noyes Publisher, 1986.
2. Brydson J., Plastics Materials, 7th edition, Elsevier, 2005
3. Blow C.M., Rubber Technology and Manufacture, Butterworth-Heinmann, 2nd edition, 1982
4. Hoffmann W., Rubber Technology Handbook, Hanser Publishers, 1989
5. Barlow F.W., Rubber Compounding, Mercel Dekker Inc., 1993

Supplementary Reading -

1. Saunders K.J., Organic Polymer Chemistry, Chapman & Hall, 1988
2. Morton M., Rubber Technology, Kluwer, Academic Publishers, 2010.
3. Bhowmick A.K. and Stephens H.L., Handbook of Elastomers, 2nd edition, Mercel Dekker, 2000
4. Rodgers B., Rubber Compounding Chemistry and Application, CRC Press, 1st edition, 2004

Web Resources -

Web-links –

1. http://nptel.ac.in/courses/103107082/34
2. http://nptel.ac.in/courses/113105028/20

MOOCs

1. https://www.rubber.org/online-educational-classes
2. https://www.tut.fi/ms/muo/vert/Summaries.pdf

Pedagogy :

- Co-teaching
- Power point presentations
- Videos
- Assignemnts and Quizzes/MCQs

Assessment Scheme :

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
20	15	5	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Practical performance	Understanding	Oral	Problem based Learning	Attendance and timely submission
10	10	10	10	10

Term End Examination : 50 Marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Thermosets** - Synthesis and cross-linking reactions, properties, formulations, compounding, processing and applications of – Phenolic resins, Urea and Melamine formaldehyde resins	**5**		
2	**Thermosets** - Synthesis and cross-linking reactions, properties, formulations, compounding, processing and applications of – Unsaturated polyester resins.	**3**		
3	**Thermosets** - Introduction to raw materials used, characteristic properties and applications of alkyd and vinyl ester resins.	**2**		
4	**Thermosets** - Synthesis and cross-linking reactions, properties, formulations, compounding, processing and applications of – Epoxy and polyurethane			
5	**Rubber Fundamentals** – Molecular requirements for a material to function as elastomers, Mastication, Vulcanization, stress-strain relationships for vulcanized and unvulcanized rubber	**3**		
6	**Additives in rubber formulation –** Antioxidants, Antiozonants, Fillers, Plasticizers, softeners and extenders, vulcanizing system, peptizers, tackifiers, blowing agent.	**4**		
7	**Review of properties, processing and applications of rubbers -** Natural rubber, Styrene-butadiene rubber, butyl rubber, thermoplastic elastomers, polychloroprene rubber, nitrile rubber, etc.	**8**		

COURSE STRUCTURE

Course Code	**PO232**			
Course Category	*Polymer Engineering*			
Course Title	**Polymer Structure Property Relations**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites

FYBTech/Diploma Physics and Chemistry, SYBTech Chemistry, Polymer Chemistry, Polymer Materials, Engineering Material Science

Course Objectives :

1. To understand the effect of chemical structure (types of elements and bonds present in polymer chain) on polymer properties
2. To understand the effect of molecular level chemical (intermolecular bonds) and physical structure (size, shape, chain flexibility, morphology) on polymer properties.
3. To understand correlation between structure and properties, thereby, requirements for processing techniques as well as applications

Course Outcomes :

On completion of the course, the students will

1. Predict properties based on structure, thereby, selection of appropriate polymeric material for particular application.
2. apply effect of various morphological parameters like crystallization, orientation, spherulitic growth on structure and thus polymer properties.
3. tailor-make a polymer material as per the desired end properties of product.

Course Contents :

Effect of various Elements and types of Bonds on polymer properties - Various Elements and Types of Bonds present in the polymer molecule, and their effect on properties such as Mechanical, Chemical, Thermal, Electrical, Optical, etc. Effect of intermolecular forces on the structure and properties like solubility, melting, cohesive energy density, permeability, mechanical, chemical, thermal, electrical, optical, etc. Effect of various monomeric ingredients (including additives) present in polymer composition on the properties and applications.

Effect of Molecular size and shape on polymer properties - Concept of Molecular size and shape (Molecular weight and its distribution), and Methods for converting low to high molecular weight during various processing techniques. Effect on various properties such as processability, mechanical, chemical, thermal, electrical, optical, etc.

Molecular flexibility and its effect on polymer properties - Molecular Flexibility and Freedom of Rotation of Bonds. Its effect on properties like Tg, Tm, crystallinity, etc. Effect of structural restriction on rotation, thereby, on properties such as mechanical, electrical, optical, etc. Effect of copolymer and blends on polymer properties. Concept of First and second order transitions, super cooled state.

Effect of Morphology on polymer properties - Intermolecular order – amorphous, crystalline and orientation states. Relation between Tm and Tg, and their significance. Study of crystallization and factors leading to crystallinity. Its effect on various properties like processing, mechanical, thermal, etc. Fringed micelle theory, Spherulitic growth and its effect on various properties. Thermodynamic and kinetic factors affecting rate of crystallization, orientation, and relation between crystallization and orientation. Effect of orientation on various properties like mechanical, chemical, thermal, electrical, optical adhesion, etc.

Laboratory Work :

List of Experiments (any 7 experiments)

1. To study Differential Scanning Calorimetry (DSC) –fundamentals, working principle, instrumentation, and applications alongwith interpretation of scans for various polymer systems.
2. To study Thermogravimetric Analysis (TGA) and Differential Thermogravimetry (DTG) – fundamentals, working principle, instrumentation and applications alongwith interpretation of thermograms with case studies.
3. To study Fourier Transform Infra-red Spectroscopy (FTIR) –fundamentals, working principle, calibration and application; identifying polymer from the spectra using identification chart.
4. To study working of Gel Permeation Chromatography (GPC) –working principle, instrumentation, universal calibration curve alongwith finding out molecular weight, molecular weight distribution using GPC data for few polymers
5. To study X-ray diffraction (XRD) – fundamentals, working principle and application alongwith interpretation of the d-spacing as well as understanding morphology of polymer system from diffraction pattern
6. To study the importance of barrier properties and factors affecting them. To find out permeability of polymer film towards various solvents.
7. To study microscopic techniques used for characterization of polymers.
8. To develop and study the growth of spherulites.
9. To study effect of orientation on mechanical properties.

Learning Resources :

Reference Books :

1. Deanin R.D., Polymer Structure, Properties and Applications, Plastics World and Cahners Publication, 1972
2. Sharples A., Introduction to Polymer Crystallization, St. Martin's Press, N.Y., 1966.
3. Tobolsky A.V., Properties and Structure of Polymers, John Wiley and Sons**,** N. Y., 1960.

4. Sperling L.H., Introduction to Physical Polymer Science, 3rd edition, Wiley Interscience, 2001

Supplementary Reading :

1. Billmeyer Jr. and Fred W., Textbook of Polymer Science, 3rd edition, John Wiley and Sons, 1984.

Web Resources:

MOOCs

1. http://nptel.ac.in/courses/113105028/11

Pedagogy:

1. Co-teaching
2. Digital media viz. power point presentations, videos, OHP.
3. Assignments
4. Technical quizzes / MCQs

Assessment Scheme:

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Attendance	Understanding / Performance	Timely correction and submission	Oral based on experiment	Problem based Learning
10	25	5	10	-

Term End Examination : 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Effect of various Elements and types of Bonds on polymer properties** - Various Elements and Types of Bonds present in the polymer molecule, and their effect on properties such as Mechanical, Chemical, Thermal, Electrical, Optical, etc. Effect of intermolecular forces on the structure and properties like solubility, melting, cohesive energy density, permeability, mechanical, chemical, thermal, electrical, optical, etc. Effect of various monomeric ingredients (including additives) present in	**8**		

	polymer composition on the properties and applications.			
2	**Effect of Molecular size and shape on polymer properties -** Concept of Molecular size and shape (Molecular weight and its distribution), and Methods for converting low to high molecular weight during various processing techniques. Effect on various properties such as processability, mechanical, chemical, thermal, electrical, optical, etc.	**7**		
3	**Molecular flexibility and its effect on polymer properties** - Molecular Flexibility and Freedom of Rotation of Bonds. Its effect on properties like Tg, Tm, crystallinity, etc. Effect of structural restriction on rotation, thereby, on properties such as mechanical, electrical, optical, etc. Effect of copolymer and blends on polymer properties. Concept of First and second order transitions, super cooled state.	**7**		
4	**Effect of Morphology on polymer properties -** Intermolecular order – amorphous, crystalline and orientation states. Relation between Tm and Tg, and their significance. Study of crystallization and factors leading to crystallinity. Its effect on various properties like processing, mechanical, thermal, etc. Fringed micelle theory, Spherulitic growth and its effect on various properties. Thermodynamic and kinetic factors affecting rate of crystallization, orientation, and relation between crystallization and orientation. Effect of orientation on various properties like mechanical, chemical, thermal, electrical, optical adhesion, etc.	**8**		

COURSE STRUCTURE

Course Code	**PO233**			
Course Category	*Polymer Engineering*			
Course Title	**Polymer Rheology**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	3	2	0	2 + 1 + 0 = 3

Pre-requisites
Courses in Engineering Mathematics, Fluid Mechanics, Polymer Materials

Course Objectives:
1. To learn flow behavior of fluids and polymers
2. To understand effect of flow during various processing techniques.
3. To learn the effect of temperature, pressure, flow profiles on polymer viscosity

Course Outcomes :
On completion of the course, the students will
1. understand polymer melt flow behavior and to bring out co-relation between polymer rheology and polymer processing
2. apply the concept of effect of various flow profiles on viscosity and thus study the effect on polymer properties.
3. choose the right processing conditions for various processing techniques.
4. carry out rheological testing and correlate them to set the processing parameters and also choose the right polymeric grade during processing.
5. interpret the practical data and analyze it using certain mathematical models.

Course Contents :

Introduction to Polymer Rheology - Introduction to Rheological Principles, Definition and importance of Rheology, types of fluids, Non-Newtonian fluids, time-dependent fluids, time independent fluids, viscous elastic fluids, Pseudoplastic fluids, Dilatant fluids, Bingham plastic fluids, Normal stress difference and Weissenberg's effect. Introduction to tensors.

Viscoelastic Behavior - Stress relaxation, relaxation modulus, creep compliance dynamic modulus, dynamic compliance, dynamic viscosity. Mechanical models – Maxwell model, Voigt – Kelvin model, Zener model, Boltzmann Principle of Superposition.WLF equation. Glass-transition and theories of glass transition - free volume theory. Molecular theories – Rouse theory, Doi – Edward theory.

Parameters Influencing Polymer Rheology - Effect of pressure on viscosity, Effect of temperature, activation energy, effect of molecular weight and molecular weight distribution on viscosity,

molecular at dependence of zero shear viscosity, effect of crosslinking, crystallinity branching, copolymerization, effect of fillers, fiber filled polymer melts, effect of plasticizers, shear rate dependence of viscosity.

Melt Flow Analysis - Laminar flow through circular cross section, annulus, slit, parallel plates, irregular profiles. Flow analysis using power law. Flow in coni-cylindrical dies – pressure drop due to shear, pressure drop due to extensional flow and pressure drop at die entry, flow in wedge shaped die. Swelling due to shear stresses and swelling due to tensile stresses.

Rheometry - Basic concept of constant stress and constant strain, Different types of Rheometers - Cone and plate, Concentric cylinder, Parallel disk, Concentric rotating disk, Controlled stress rotational, Extruder type Torque, Extensional.

Laboratory Work :

List of Experiments (any 7 experiments)

1. To study different types of fluids with examples.
2. To find M.F.I. of different polymers using melt flow indexer.
3. To study the variation in viscosity with respect to temperature using capillary rheometer.
4. Fitting of rheological models using capillary rheometer (power low model, Ellis model, etc.)
5. Estimation of Bagley's correction factor using capillary rheometer.
6. Study of cone and plate viscometer.
7. Study of Torque Rheometer.
8. Study of Brook field's viscometer.
9. Study of oscillating disc viscometers for rheological characterization of elastomers.
10. To study small amplitude oscillatory shear properties using parallel plate geometry.

Learning Resources :

Reference Books :

1. Gupta B.R., Applied Rheology in Polymer Processing, 1st edition, Asian Book Pvt. Ltd, 2005.
2. Cogswell F.N., Polymer Melt Rheology, 1st edition, John Wiley and Sons, 1981,
3. Crawford R.J., Plastics Engineering, 3rdedition, Butterworth–Heinemann, 2006

Supplementary Reading :

1. Wissburn K.F., Nostrand R. Van and Dealy J.M., Melt Rheology and its Role in Plastic Processing Theory and Applications, Chapman & Hall, 1995.
2. Ghosh P., Polymer Science & Technology, 2ndedition, Tata McGraw Hill Publication, 1990.

Web Resources :

MOOCs

1. https://onlinecourses.nptel.ac.in/noc18_ch07

Pedagogy :

1. Co-teaching
2. Digital media viz. power point presentations, videos, OHP.
3. Problem based learning
4. Technical quizzes / MCQs

Assessment Scheme :

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Test	MCQ	Attendance
15	15	10	10

Laboratory Continuous Assessment (LCA) : 50 Marks

Performance	Understanding	Attendance and Timely submission	Oral	Problem based Learning
10	15	10	10	5

Term End Examination : 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	**Introduction to Polymer Rheology -** Introduction to Rheological Principles, Definition and importance of Rheology, types of fluids, Non-Newtonian fluids, time-dependent fluids, time independent fluids, viscous elastic fluids, Pseudoplastic fluids, Dilatant fluids, Bingham plastic fluids, Normal stress difference and Weissenberg's effect. Introduction to tensors.	**8**		
2	**Viscoelastic Behavior -** Stress relaxation, relaxation modulus, creep compliance dynamic modulus, dynamic compliance, dynamic viscosity. Mechanical models – Maxwell model, Voigt – Kelvin model, Zener model, Boltzmann Principle of Superposition.WLF equation. Glass-transition and theories of glass transition - free volume theory. Molecular theories – Rouse theory, Doi – Edward theory.	**7**		
3	**Melt Flow Analysis -** Laminar flow through circular cross section, annulus, slit, parallel plates, irregular profiles. Flow analysis using power law. Flow in coni-cylindrical dies – pressure drop due to shear, pressure drop due to	**7**		

	extensional flow and pressure drop at die entry, flow in wedge shaped die. Swelling due to shear stresses and swelling due to tensile stresses.			
4	**Rheometry** - Basic concept of constant stress and constant strain, Different types of Rheometers - Cone and plate, Concentric cylinder, Parallel disk, Concentric rotating disk, Controlled stress rotational, Extruder type Torque, Extensional.	**8**		

COURSE STRUCTURE

Course Code	IC			
Course Category	*Humanities and Social Science*			
Course Title	**Indian Constitution**			
Teaching Scheme and Credits	**Th**	**Lab**	**Tut**	**Total Credits**
Weekly load hrs	2	0	0	1 + 0 + 0 = 1

Pre-requisites

Course Objectives:

1. To provide basic information about Indian constitution.
2. To identify individual role and ethical responsibility towards society.

Course Outcomes :

On completion of the course, the students will

1. Have general knowledge and legal literacy and thereby to take up competitive examinations
2. Understand state and central policies, fundamental duties
3. Understand Electoral Process, special provisions
4. Understand powers and functions of Municipalities, Panchayats and Co-operative Societies
5. Understand Engineering ethics and responsibilities of Engineers.
6. Have an awareness about basic human rights in India

Course Contents :

Introduction to the Constitution of India, The Making of the Constitution and Salient features of the Constitution.
Preamble to the Indian Constitution Fundamental Rights and its limitations.
Directive Principles of State Policy and Relevance of Directive Principles, State Policy, Fundamental Duties.
Union Executives – President, Prime Minister Parliament Supreme Court of India.
State Executives – Governor Chief Minister, State Legislature High Court of State.
Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th and 91st Amendments.
Special Provision for SC and ST, Special Provision for Women, Children & Backward Classes Emergency Provisions.
Human Rights - Meaning and Definitions, Legislation Specific Themes in Human Rights, Working of National Human Rights Commission in India
Powers and functions of Municipalities, Panchyats and Co-operative Societies.

Learning Resources :

Reference Books :

1. Basu D.D., "Introduction to the Constitution on India", Students edition, Prentice Hall EEE, 19th / 20th editions, 2012.
2. Haries C.E., Pritchard M.S. and Robins M.J., "Engineering Ethics", Thompson Asia, 2003.

Supplementary Reading :

Web Resources :

Web-links -

MOOCs

Pedagogy :

- Power Point Presentation
- Quizzes
- Interactive Discussions

Assessment Scheme :

Class Continuous Assessment (CCA) : 50 Marks

Assignments	Presentations
30	20

Term End Examination : 50 marks

Syllabus:

Module No.	Contents	Workload in Hrs		
		Th	Lab	Assess
1	Introduction to the Constitution of India, The Making of the Constitution and Salient features of the Constitution. Preamble to the Indian Constitution Fundamental Rights and its limitations.	**5**		
2	Directive Principles of State Policy and Relevance of Directive Principles, State Policy, Fundamental Duties. Union Executives – President, Prime Minister Parliament Supreme Court of India.	**5**		
3	State Executives – Governor Chief Minister, State Legislature High Court of State. Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th and 91st	**5**		

	Amendments.			
4	Special Provision for SC and ST, Special Provision for Women, Children & Backward Classes Emergency Provisions. Human Rights - Meaning and Definitions, Legislation Specific Themes in Human Rights, Working of National Human Rights Commission in India. Powers and functions of Municipalities, Panchyats and Co-operative Societies.	**5**		