File Ref.No.Ac.A3/Faculty of Technology/2023

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Faculty of Technology - Programmes offered at the Department of Polymer science and Rubber Technology - Resolution of the Academic Council - Communicated - Orders issued.

ACADEMIC A SECTION

No.CUSAT/AC(A).A3/4085/2024 Dated,KOCHI-22,26.09.2024

Read:-Item No. I (f) (3) of the minutes of the meeting of the Academic Council held on 30.04.2024

ORDER

The Academic Council considered along with the recommendations of it's standing committee, the Minutes of the Faculty of Technology held on 08.04.2024 and resolved to approve the following :

i. The Regulations, Curriculum and Syllabus of the Executive M.Tech in Polymer Technology (3 year programme) with effect from 2024 admission onwards (Appendix I).
ii. The revised Curriculum framework and Syllabus for the existing B.Tech (Polymer Science and Engineering) with effect from 2024 admission onwards (Appendix II).
iii. The revised syllabus for the existing M.Tech (Polymer Technology) with effect from 2024 admission onwards (Appendix III).

Orders are, therefore, issued accordingly.

Dr. Arun A U *
Registrar

To:

1. The Dean, Faculty of Technology
2. Chairperson, BoS under Faculty of Technology
3. The Head, Deparftment of Polymer Science and RubberTechnology
4. All AR/DR Examination wing - with a request to forward to concerned sections
5. The Director, IQAC/ DoA
6. CIRM/Conference Sections
7. PS To VC/PVC;PA To Registrar/CE.

* This is a computer generated document. Hence no signature is required.

CURRICULUM FRAMEWORK AND SYLLABUS
(OUTCOME BASED EDUCATION)

M. TECH. POLYMER TECHNOLOGY (EXECUTIVE)

(with effect from the academic year 2024–25)

COCHIN UNIVERSITY OF SCIENCE & TECHNOLOGY

Kalamassery, Cochin - 682022 Kerala, India Phone: 0484 – 2575723

April 2024

Vision

The Department strives to develop a Centre of Excellence in Polymer Technology in the country by strengthening in-house infrastructure and taking up collaborative Research and Development in frontier areas.

Mission

As a Department we are committed to:

- Acquire state-of-the-art infrastructure and take up inter-disciplinary research in frontier areas.
- Achieve academic excellence in the field of Polymer Science and Rubber Technology through innovative teaching - learning processes.
- Prepare well-trained human resource in Polymer Science and Rubber Technology who can contribute positively to the developmental efforts of the Nation.
- Promote good academia - industry interaction.

Programme outcome

PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, techniques, skills, and modern tools of polymer Science and engineering to the solution of polymer engineering problems.

PO2.Problem Analysis: Identify, formulate, research literature, and analyze engineering problems related to Polymer Science and Engineering to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the needs of public health and safety, and the cultural, societal, and environmental considerations in the field of Polymer Science and Rubber Technology.

PO4. Conduct investigations of complex Problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the **information to provide valid conclusions for broadly defined polymer science and engineering problems.**

PO5. Modern Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to Polymer Science and Engineering activities with an understanding of the limitations.

PO6. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice related to Polymer Science and Engineering.

.

POST GRADUATE PROGRAMME IN TECHNOLOGY:

M. TECH. IN POLYMER TECHNOLOGY (EXECUTIVE)

FOR WORKING ROFESSIONALS

REGULATIONS

1. SCOPE

1.1 These Regulations shall apply to the Executive M. Tech. programme (Web-enabled) run in by the Departments /Schools of the Cochin University of Science and Technology.

1.2 The provisions herein supersede all other Regulations with respect to such programmes unless otherwise provided.

2. DEFINITIONS

- Department/School means Departments/Schools instituted in the University as per Statutes and Act.
- Core course means a course that the student admitted to a particular programme must successfully complete in order to receive the Degree and which cannot be substituted by any other course. Core course is offered by the Department where the student takes admission.
- Elective course means a course, which can be substituted by equivalent courses from the same or other Departments/Schools.
- Audited course means a course which can be opted by a student but which will not accrue any credit.

3. ADMISSIONS

3.1 Eligibility

This programme is open to working professionals sponsored by an industry.

a) B.Tech or equivalent degree / AMIE in Polymer Science and Rubber Technology/ Chemical Engineering /Technology or B. Tech in Mechanical Engineering/ Civil Engineering/ Electrical Engineering or M.Sc. Polymer Chemistry/ Chemistry/Applied Chemistry/Physics/Mathematics/Statistics with at least 60% marks in the qualifying examination from any recognized University or Institution.

b) Professional experience of at least two years in the relevant field

3.2 Selection

The candidates who meet the above eligibility critieria will be identified and sponsored by the industry. University will prepare rank list based on the percentage of marks in the qualifying degree plus extra one mark for every additional full year of experience beyond

the minimum requirements. The maximum in this category will be limited to five.

4. PROGRAMME STRUCTURE

4.1 The programme will be of six semester duration.

4.2 The theory classes will be conducted in online mode. The practicals and end- semester examination will be conducted in physical mode. Other activities can be in hybrid mode.

4.3 The minimum credits to be acquired for awarding the degree will be 94.

4.4 The minimum number of candidates for running this programme will be ten and the maximum will be twenty.

4.5 The Department Council (DC) shall make recommend the core and elective courses including the detailed syllabus which are to be approved by the concerned Board of Studies, Faculty and Academic Council

4.6 There shall be two kinds of courses: Core and Elective. Elective courses, if any offered through Massive Open On line Course (MOOC) can have three credits. Practical course / seminar will have one or two credits.

4.7 In the case of online courses attended by the student, a certificate of satisfactory completion and marks/ grade if any issued by the authority who conducted the course must be submitted to the Head of the Department. The Department can conduct a viva on the subject of the online course if necessary. On the completion of this, the Department council can award the respective weightage/grade to the student.

4.8 The number of credits for the project work in fourth, fifth and sixth semesters shall be in the range of 10 – 12 each.

5 COURSE REGISTRATION

5.1 Every Department/School shall have Faculty Members as Student Advisors. Each student will be assigned to an Advisor/Mentor, by the Department council within one week from the commencement of the classes, who will counsel the student on the choice of elective courses depending on the student's academic background and objective. The student will then register for the courses he plans to take for the semester within the time prescribed by the University. The student should have completed the prescribed prerequisites if any for a course before registration.

5.2 The Department offering a course shall prescribe the maximum number of students that can be admitted taking into consideration the facilities available.

5.3 The student can drop any elective/audit course(s) within 15 working days after the commencement of the classes.

5.4 University shall publish a Bulletin listing all the courses offered in every semester specifying the credits, prerequisites, list of topics the course intends to cover, the instructor who is giving the courses, the time and place of the classes for the courses. Each course shall have a code consisting of first two digits indicating the year of revision of syllabus/curriculum, following three digits denoting the program code, the next two digits indicating the semester and last two digits denote the serial number of the course.

6 EVALUATION

6.1 A student would be considered to have progressed satisfactorily at the end of a semester if he/she has a minimum of 75 % attendance. The evaluation is completely internal.

6.2 The entire system of evaluation is internal. The evaluation scheme for each semester contains two parts, a continuous assessment and a semester end examination. The student shall be evaluated continuously throughout the semester and marks shall be awarded on the basis of tests / assignments as detailed below :

6.3 There shall be two class tests, assignment and an end semester examination. The first class test carries 20 marks and will be based on the portions of the syllabi covered till then. The second class test also carries 20 marks and will be based on the portions covered till then after the first class test. A maximum of 10 marks will be awarded for the assignments

6.4 The end semester examination will be for 50 marks and shall contain questions from the entire syllabus of the course. The duration of the end semester examination shall be three hours.

6.5 All practical examinations will also be internally evaluated as per the procedures laid down by the Department Councils concerned.

6.6 Marks obtained in the continuous assessment shall be displayed on the notice board and grievances if any may be addressed to the teacher concerned/Head of the Department with supporting documents. The teacher and the HOD will examine the case and decide on his/her grievance. If the student is not convinced with the decision, he/she can approach the appellate authority, which is the Department council, in writing and the Council shall examine the same and take a final decision which has to be intimated to the student in writing. The decision of the appellate authority shall be final.

6.7 There shall be only a single evaluation for the semester end examination. Immediately after the end semester examination is over, the Head of the Department shall make arrangements to complete the evaluation and finalize the

results within 10 working days.

6.8 The pass minimum in a subject is 50 %, with a separate minimum of 45% for end semester examination

6.9 The final marks and grade in all the courses obtained by the students in that se- mester will be displayed in the notice board. Those who could not obtain 50% marks (Grade D) in total for a course will be declared as failed in that course. Those who fail in any course shall approach the teacher concerned if necessary, for a re- examination of the semester end examination. Within ten days of the dis- play of the results in the notice board, the department shall conduct an additional semester end examination for these candidates. They will be awarded 75% of the marks scored in the re-examination.

6.10 If the candidate fails again in the re-examination, he/she may appear for the supplementary examination along with the junior batches which will be governed by the rules of the University regarding supplementary examinations.

7 PROJECT WORK

7.1 The major project work will be done in the parent company with one supervisor from the Department and one from the parent company. For combined supervision the Department Council shall verify the academic/ research credentials of the Supervisor from the Industry.

7.2 The research problem will be decided in mutual agreement of the supervisors from the Company and the Department.

7.3 The evaluation at the end of IV, V Semesters shall be conducted by an examination committee consisting of the Head of the Department and both the supervisors.

7.4 At the end of Semester VI, the students will have to submit a dissertation on his / her project work to the Head of the Department/School within the last date prescribed for the purpose.

7.5 The dissertation will be evaluated by an examination committee consisting of the Head of the Department and another faculty member and the project supervisors. The candidate shall make an open presentation of his/her dissertation which will be followed by a viva-voce examination.

For the purpose of assessment, the performance of a student in the project dissertation may be divided into the following sub components:

At the end of IV & V semesters Assessment by the project guide (based on periodic assessment of the work of the candidate) -	50%
Assessment by the examination committee	- 50%

At the end of VI semester Assessment by the project guide (based on periodic assessment of the work of the candidate) - 50%

Assessment by the examination committee - 50%

8 DECLARATION OF RESULTS

The result of the examinations will be finalised and published by the Department Council, which will act as the passing board and the minutes shall be sent to the Controller of Examinations for issue of Grade card. The University shall issue mark lists/Grade card at the end of each semester.

9 GRADE CARD

9.1 The University under its seal shall issue a Grade Card to the students on completion of each semester. The Grade card shall contain the following:

a. Title of the course taken as core and elective.

b. The grades awarded for each course along with the course credit.

c. The number of credits (core and elective separately) earned by the student and the Grade Point Average.

d. The total credits (core and elective) earned till that semester.

9.2 The following grades will be awarded based on the overall performance in each subject.

Range of marks	Grades	Weightage
90 and above	S-Outstanding	10
80 to <90	A-Excellent	9
70 to <80	B-Very good	8
60 to >70	C-Good	7
50 to <60	D-Satisfactory	6
Below 50%	F-Failed	0

Overall performance at the end of the semester will be indicated by Grade Point Aver- age (GPA) calculated as follows.

$$GPA = \frac{(G1C1+G2C2+G3C3+ \ +GnCn)}{(C1+C2+C3+ +Cn)}$$

Where 'G' refers to the grade weightage and 'C' refers to the credit value of corresponding course

undergone by the student. At the end of the final semester Cumulative Grade Point Average (CGPA) will be calculated based on the above formula, considering the Credits and Grades earned during the entire programme of study.
Classification for the Degree/Diploma will be given as follows based on the CGPA :

First Class with distinction:	8 and above
First Class	6.5 and above
Second Class	6 and above

9.3 The Grade Card issued at the end of the final semester shall contain the details of all the courses taken which shall include the titles of the courses, the credits associated with each course, the CGPA and the class.

9.4 A student shall complete the M.Tech. programme in 6 (six) consecutive semesters by acquiring the minimum total credit requirement of 94.

10. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Vice-Chancellor shall, for a period of one year from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

PROGRAMME STRUCTURE

	Credits						
Semester	I	II	III	IV	V	VI	**Total**
Core 1	3	3	3	3			**12**
Core 2	3	3	0	0			**6**
Core 3	3	0	0	0			**3**
Elective1		3	3	3	3	3	**15**
Elective2			3	3			**6**
Total (theory)	**9**	**9**	**9**	**9**	**3**	**3**	**42**
Lab	1	1	1	1			**4**
Seminar	1	1	1	1	1	1	**6**
Mini Project	2	2					**4**
LS & PP			4				**4**
Major project				10	12	12	**34**
Sem total (theory plus others)	**13**	**13**	**15**	**21**	**16**	**16**	**94**

LS & PP Literature survey and project proposal

Sl No.	Courses	Core/ Elective
1	A**dvanced Polymer Science**	**Core**
2	A**dvanced Rubber Processing**	**Core**
3	**Advanced Tyre Compounding and Manufacture**	**Core**
4	**Advanced Polymer Rheology**	**Core**
5	**Testing and Characterisation**	**Core**
6	**Research Methodology and IPR**	**Core**
7	**Rubber Products Manufacture**	**Core**
1	Latex Technology1	Elective
2	Simulation and Modelling	Elective
3	CAD/ CAM	Elective
4	Statistical Analysis	Elective
5	Advanced Polymer Nanocomposites	Elective
6	Mould and Die Design	Elective
7	Tyre reinforcement materials	Elective
8	Latex Technology2	Elective
9	Tyre Engineering	Elective
10	Tyre testing	Elective
11	Speciality polymers and composites	Elective
12	Polymer recycling	Elective
13	Biopolymers	Elective
14	Adhesives	Elective
15	Surface coatings	Elective
16	MOOC course	Elective
17	MOOC course	Elective

Curriculum for first semester

Course code	Subject	C/E	Hrs per week			Credit	Marks		
			L	T	P		CE	EE	Total
24-511-0101	Advanced Polymer Science and Technology	C	3	0	0	3	50	50	100
24-511-0102	Advanced Rubber Processing	C	3	0	0	3	50	50	100
24-511-0103	Advanced Tyre Compounding and Manufacture	C	3	0	0	3	50	50	100
20-511-0111	Lab 1 (Advanced Polymer Science)	C	0	0	4	1	100	–	100
24-511-0151	Seminar	C	0	0	1	1	50		50
24-511-0152	Mini project	C	0	0	2	2	100		100
	Total						400	150	550

SYLLABUS

SEMESTER I

24-511-0101 Advanced Polymer Science and Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Explain the mechanism and kinetics of addition and condensation polymerization. (Understand)

CO 2: Explain basics of copolymerization and coordination polymerisation reactions and describe the synthesis of polymers according to the need of polymer industry. (Analyse)

CO 3: Understand the special synthesis routes for polymerisation. (Understand)

CO 4: Analyze polymer structure and properties based on molecular weight determination, spectroscopic, thermal and microscopic techniques. (Analyze)

CO 5: Get an insight in to the degradation of commercial polymers and the management of polymer wastes. (Analyse)

Mapping of course outcomes with program outcomes:

Level - Low (1), medium (2) and high (3)

Unit 1. Mechanistic aspects of polymerization– Chain reaction (Addition) polymerization – Basics. Free radical Polymerization: monomers, generation of initiators, mechanism of free radical polymerization, chain transfer reactions, inhibition and retardation, kinetics of free radical polymerization. Ionic Polymerization: cationic and anionic, selection of monomers, chain transfer reactions, kinetics. Step reaction (condensation) polymerization–Basics. Mechanism of condensation polymerisation, poly condensation reaction, network condensation reaction. Kinetics of step reaction polymerization: catalyzed and non catalyzed, Carothers equation, prediction of gel point.

Unit 2. Copolymerisation: general characteristics, mechanisms, free radical, ionic, condensation, kinetics of copolymerization, composition of copolymers, block and graft copolymers. Coordination polymerization: basics, stereo regular polymers, tacticity in polymers. Mechanism of coordination polymerization: coordination catalysts, monometallic, bimetallic . Polymerization techniques: homogeneous polymerization techniques-bulk, solution, heterogeneous polymerization techniques- emulsion, suspension.

Unit 3. Special synthesis routes– Cyclopolymerisation: general features, mechanism. Ring-opening polymerization, Metathesis polymerisation, ring -opening metathesis polymerisation (ROMP). Living polymerization: atom -transfer-radical-polymerization (ATRP), reversible addition fragmentation chain transfer (RAFT).

Unit 4. Characterization techniques – Molecular characterization of polymers– average molecular weight, molecular weight distribution, determination of molecular weight – end group analysis, colligative property measurement –Osmometry; light scattering, solution viscosity and gel permeation chromatography. Spectroscopy techniques: Infra red, NMR and UV-visible. Thermal properties: differential scanning calorimetry, differential thermal analysis, thermogravimetry, dynamic mechanical analyzer. Microscopic techniques: optical and electron microscopy. Crystallinity studies: density measurements, XRD.

Unit 5. Polymer Degradation and Stabilization–Principles of thermal, photo, oxidative and biodegradation in polymers. Methods/equipments used for monitoring the degradation in polymers. Mechanism of degradation of some commercial polymers. Biodegradation of polymers. Waste Management.

References

1 F.W. Billmeyer, A Text Book of Polymer Science, 3rd Edn., Wiley & Sons (2009).

2 Herman F. Mark (Ed.),Encyclopedia of Polymer Science and Engg., Vol 15, 4th Edn., Wiley & Sons (2014).

3 P.J.Flory, Principle of Polymer Chemistry, Cornell University Press (1986).

4 V. R. Gowariker, N. V. Viswanathan and J. Sreedhar,Polymer science, John Wiley & Sons (2010).

5 J.F.Rabek, Experimental methods in polymer chemistry, Wiley & Sons, Imprint:Academic Press (2012).

6 Hans-George-Elias, Macromolecules Vol.1, Plenum press, Springer (1986).

7 George Odion, Principles of Polymerization, 4th Edn., Wiley & Sons (2007).

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	3	3	2	2
CO 2	3	2	3	3	2	2
CO 3	2	2	2	2	2	2
CO 4	2	3	3	3	2	2
CO 5	3	3	3	2	2	2

24-511-0102 Advanced Rubber Processing

Course Outcome
On successful completion of the course, the students will be able to:

CO 1: Explain the basics of NR latex preservation, processing and dry rubber production.

CO 2: Understand the types and role of compounding ingredients, their mechanism of action.

CO 3: Understand the role of fillers and reinforcement, design rubber compounds.

CO 4: Explain various rubber processing techniques used to manufacture rubber products.

CO 5: Identify different unit operations for rubber product manufacturing.

Unit 1. Natural rubber – Preserved field latex, latex concentrates - centrifuging and creaming, ribbed smoked sheets, crepe rubber, technically specified solid block forms (crumb rubber), superior processing rubbers and other modified forms of natural rubber.

Unit 2. Rubber Compounding: Vulcanization: sulphur and non-sulphur systems, assessment of state of cure, mechanism of vulcanization. Additives used in rubber compounding: accelerators, activators, antidegradants, plasticisers, special purpose additives. Quality tests for additives.

Unit 3. Reinforcement: principle of reinforcement, filler properties-particle size, surface area and filler structure, carbon black-types, structure, properties and manufacture. General compound design.
Unit 4. Rubber Processing – Machinery used for mixing: two roll mill, internal mixers and continuous mixers, extrusion technology, calendering, fabric coating and spreading process.

Unit 5. Moulding techniques – Compression, transfer and injection moulding. Vulcanisation methods: rotocure, autoclave open steam, hot air, fluidised bed, LCM, molten salt bath and high energy radiation curing.

References

1 C. M. Blow, C. Hepburn, Rubber Technology and Manufacture, 2nd Edn., Butterworth Scientific (1982).
2 Werner Hofmann, Rubber Technology Handbook, Hanser Gardner Publications (1990).
3 P. K. Freakly, Rubber Processing and Production Organisation, Springer Science & Business Media (2012).
4 Anil K. Bhowmick, Howard L. Stephens, Handbook of Elastomers, 2nd Edn., CRC Press (2000).
5 Anil K Bhowmick, Malcolm M.Hall Henry A.Benarey (Eds.), Rubber Products Manufacturing Technology, Marcel Dekker Inc. (1994).
6 Robert F. Ohm (Ed.), The Vanderbilt Rubber Handbook, 13th Edn., R. T. Vanderbilt Company, Inc. (1990).

Mapping of course outcomes with program outcomes:
Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	1	2
CO 2	3	2	2	2	3	2
CO 3	3	2	3	2	3	2
CO 4	2	2	2	2	3	2
CO 5	3	3	3	2	3	2

24-511-0103 Advanced Tyre Compounding and Manufacture

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Learn the history of the development of tyre technology (Understand)

CO 2: Gain familiarity with the design of various types of tyres and their functions. (Understand)

CO 3: Get an insight into the materials used for the manufacture of tyres and tubes. (Understand)

CO 4: Comprehend and envisage the processes involved in the design and production of the components of various types of tyres and tubes.(Apply)

CO 5: Learn the non-destructive and destructive tests done on tyres and tubes. (Understand)

Unit 1. Introduction to the history and development of tyres. Indian and global status of tyre industry. Performance of various types of tyres: bias, bias belted and radial. Components of a tyre : geometry and basic functions. Functions of pneumatic tyres: load carrying capacity, vibration and noise reduction, tyre function as a spring, contribution to driving control and road holding. Basic functions of pneumatic tyres.

Unit 2. Radial tyres, advantages of radial tyres. Tubed and tubeless tyres. Components of radial tyres. Construction of bicycle tyres, Aircraft tyres. Benefits of filling nitrogen in tyres. Role of Indian Tyre Technical Advisory Committee. Tyre size designation. Winter tyres.

Unit 3. Introduction to the materials used in tyre manufacture–Ingredients of rubber compounds for tyres, tubes and tyre curing bladders. Typical formulations for tyre components. Compounding for radial tyres. Textiles used in tyre manufacture. Treatment of textiles - RFL dipping. Cord-rubber composites and their properties– Failure mechanism of cord reinforced rubber. Mechanics of tyre pavement interaction. Tyre forces on dry and wet road surfaces. Tractive forces on dry surface, wet surface, snow and irregular pavements. Braking and traction of tyres.

Unit 4: Manufacture of tyres: two wheelers, cars, trucks, OTR, farm and aircrafts. Calendering process. Bias cutting. Extrusion of tread, side wall and other components. Dual extrusion of cap and base. Bead construction. Tyre building: machines for bias and radial tyres, components of tyre building machines. Inputs for tyre building : inner liner, plies, bead assemblies, tread, breakers, belts and side walls. Sequence of building. Green tyre preparation. Awling, shaping and curing in Bag-O-matic press. Typical cure cycle. Post cure inflation. Determination of optimum cure time by thermocouple studies. Cured tyre inspection. Tyre finishing. Design and manufacture of bicycle and automobile tubes.

Unit 5. Measurement of tyre properties – Static & loaded dimension and size.Tyre construction analysis, endurance test, wheel and plunger tests, traction and noise measurements. Force and moment characteristics, cornering coefficient, aligning torque coefficient, load sensitivity and load transfer sensitivity. Rolling resistance, non-uniformity, dimensional variations, force variations, radial force variation, lateral force variation, conicity and ply steer. Tyre balancing. Mileage evaluations. Tyre flaws and separations (X- ray, holography, etc.). Tyre maintenance and service practices. Standards (BIS) for tyres, tubes and flaps. Role of Indian Tyre Technical Advisory Committee.

References

1 John F. Purdy, Mathematics Underlying the Design of Pneumatic Tires, University of Michigan (1963 – Digitized on 25 Jul 2011).
2 ITTAC Standards Manual, Indian Tyre Technical Advisory Committee, New Delhi (2018).
3 L. J. K. Setright, AutomobileTyres, Chapman and Hall (1972).
4 Tom French, Tyre Technology, Taylor & Francis (1989).
5 Dr. S.N. Chakravarthy, Introduction to Tyretechnology, Polym Consultants- New Delhi (2012).
6 Samuel Kelly Clark, Mechanics of Pneumatic Tires, U.S. Departmentof Transportation, National Highway Traffic Safety Administration (1981 - Digitized on 17 Dec 2007).

7 F.J. Kovac, Tyre Technology, Goodyear Tyre& Rubber Company (1973).
8 Tyre Condition Guides, Indian Tyre Technical Advisory Committee, New Delhi (2018).

Mapping of course outcomes with program outcomes:
Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	2
CO 2	2	2	2	2	2	2
CO 3	2	3	2	2	3	2
CO 4	2	2	2	1	2	2
CO 5	1	1	2	1	2	2

24-511-0111 Advanced Polymer Science

Course Outcome

On successful completion of the course, the students will be able to:

CO1 : Identify the plastics and rubbers used in various unknown polymeric products.

CO2 : Estimate molecular weight of polymers by different techniques.

CO3 : Understand the various synthesis methods for the preparation of polymers

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

1. Identification of rubbers, plastics and thermoplastic elastomers -NR, SBR, PB, IR, IIR, EPDM, Hypalon, Thiokol, Silicone, CR, NBR, PE, PP, PS, PVC, PVA, PF, UF, MF
Polyester, SIS, SBS, SEBS

2. Estimation of polymer molecular weights

) Viscometry

) End group analysis

3. Determination of effect of free radical initiators on molecular weight

4. Preparation of Polymers

a) Preparation of polystyrene/PMMA through various synthesis techniques such as bulk, solution, suspension and emulsion polymerisation techniques

) Grafting of NR

References

1 Rabek, Experimental methods in Polymer Chemistry, John Wilely & sons (1998)

2 D. Braun, H. Cherdron, H. Ritter, Polymer Synthesis: Theory and Practice, Springer Science and Business Media (2001)

3 Stanley R. Sandler, Wolf Karo, Joanne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization: A Laboratory Manual, Elsevier (1998)

4 K.J. Saunders , Identification of Plastics and Rubber, Chapman and Hall

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	1	2
CO2	2	1	1	2	1	2
CO3	2	2	1	1	1	2

CURRICULUM FRAMEWORK AND SYLLABUS
(OUTCOME BASED EDUCATION)

B. TECH. (POLYMER SCIENCE AND ENGINEERING)

(with effect from the academic year 2024–25)

COCHIN UNIVERSITY OF SCIENCE & TECHNOLOGY

Kalamassery, Cochin - 682022 Kerala, India Phone: 0484 – 2575723

April 2024

Vision

The Department strives to develop a Centre of Excellence in Polymer Technology in the country by strengthening in-house infrastructure and taking up collaborative Research and Development in frontier areas.

Mission

As a Department we are committed to:

- Acquire state-of-the-art infrastructure and take up inter-disciplinary research in frontier areas.
- Achieve academic excellence in the field of Polymer Science and Rubber Technology through innovative teaching - learning processes.
- Prepare well-trained human resource in Polymer Science and Rubber Technology who can contribute positively to the developmental efforts of the Nation.
- Promote good academia - industry interaction.

OUTCOME BASED EDUCATION

Programme Educational Objectives (PEO)

PEO1: To mould well-trained human resources in the field Polymer Science and Rubber Technology to support the Nation in its endeavor to be self - reliant and self- sufficient.

PEO2: To instill in students a quest for exploring new knowledge areas, improving academic credentials and acquiring new leadership and entrepreneurial skills

PEO3: To prepare graduates who are morally upright and sensitive to the environmental issues and needs of the society.

Graduate Attributes for Polymer Science and Engineering (GA)

1. Problem Analysis: Identify, formulate, research literature, and solve complex Polymer Science and Engineering problems reaching substantiated conclusions using fundamental principles of Basic Science, Engineering science, and relevant domain disciplines.
2. Design /Development of Solutions: Evaluate Polymer Science and Engineering problems and design products and processes that meet specific needs of the industry with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
3. Conduct Investigations of Polymer Science and Engineering Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

4. Professional Ethics: Understand and commit to professional ethics and cyber regulations, responsibilities, and norms of a professional in Polymer Science and Engineering.
5. Life-long Learning: Recognize the need and have the ability, to engage in independent learning for continuous development as a Polymer Engineer.
6. Project Management And Finance: Demonstrate knowledge and understanding of the Polymer Science and Engineering principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
7. Communication Efficacy: Communicate effectively with the Polymer Science and Engineering community, and with society at large, through academic/ technical reports, proper documentation and effective presentations.
8. Societal and Environmental Concern: Understand and assess societal, environmental, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional Polymer Science and Engineering practice.
9. Individual and Team Work: Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary environments.
10. Innovation and Entrepreneurship: Identify a timely opportunity and pursue it to create value and wealth for the betterment of the individual and society at large.

Program Outcomes (POs)

A graduate of this major should be able to:

PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, techniques, skills, and modern tools of polymer Science and engineering to the solution of polymer engineering problems.

PO2.Problem Analysis: Identify, formulate, research literature, and analyze engineering problems related to Polymer Science and Engineering to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the needs of public health and safety, and the cultural, societal, and environmental considerations in the field of Polymer Science and Rubber Technology.

PO4. Conduct investigations of complex Problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the **information to provide valid conclusions for broadly defined polymer science and engineering problems.**

PO5. Modern Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to Polymer Science and Engineering activities with an understanding of the limitations.

PO6.The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, *safety, legal*, and cultural issues and the consequent responsibilities relevant to Polymer Science and Engineering.

PO7. Environment and Sustainability: Understand the impact of polymer science and engineering solutions in a societal and global context.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice related to Polymer Science and Engineering.

PO9. Individual and team work: Function effectively as a member or leader on a technical team and in multidisciplinary settings.

PO10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions regarding broadly defined polymer science and engineering activities.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to polymer engineering related work.

PO12. Life-long learning: Exhibit a commitment to quality and timeliness, and develop the ability to engage in life-long learning for continuous improvement.

Anderson's Revised Bloom's Taxonomy of Cognitive Levels

Level	Description	Sample Objectives
Remember	Recognizes students' ability to remember and recall certain facts.	The students will *recall* the four major food groups without error. The students will *list* at least three characteristics peculiar to the Cubist movement.
Understand	Involves students' ability to read course content, understand and interpret important information and put other's ideas into their own words.	The students will *summarize* the main events of a story in grammatically correct English. The students will *describe* in prose what is shown in graph form.
Apply	Students take new concepts and apply them to another situation.	The students will *apply* previously learned information about socialism to reach an answer. The students will *demonstrate* the principle of

		reinforcement to classroom interactions.
Analyze	Students have the ability to take new information and break it down into parts to differentiate between them	The students will read a presidential debate and *point out* the passages that attack a political opponent personally rather than the opponent's political programs. Students will *discriminate* among a list of possible steps to determine which one(s) would lead to increased reliability for a test.
Evaluate	Involves students' ability to look at someone else's ideas or principles and see the worth of the work and the *value* of the conclusions	Given any research study, *evaluate* the appropriateness of the conclusions reached based on the data presented. The students will *compare* two pieces of sculpture, giving reasons for their positive evaluation of one over the other
Create	Students are able to take various pieces of information and form a whole *creating* a pattern where one did not previously exist	After studying the current economic policies of the United States, student groups will *design* their own goals for fiscal and monetary policies. The students will write a different but plausible ending to a short story.

B.TECH DEGREE COURSES IN POLYMER SCIENCE AND ENGINEERING UNDER FACULTY OF TECHNOLOGY

REGULATIONS -WITH EFFECT FROM 2024-25

1. **Effective from:** This regulation of the B. Tech. programme in Polymer Science and Engineering offered by the Department of Polymer Science and Rubber Technology is with effect from 2024-25 admission. The B. Tech. (Polymer Science and Engineering) course will follow the **OBE system**.
2. **Total Credit**: The curriculum of the B. Tech. programme shall have a minimum total of **162 credits.**
   a) This consists of core subjects, professional electives, open electives and industrial electives.
   b) The professional electives may be taken from the Department or from other Departments in the campus. In cases where the elective is from other Departments, the evaluation will be done by them.
   c) The **open elective** is to be taken from the courses offered **by NPTEL/ SWAYAM.** The electives from these lists will be by the identified and approved Department.
   d) The credit obtained from these courses will be transferred to the University
   e) The maximum number of open courses will be 20% of the total electives.
   f) **The industrial elective** will be offered jointly with an industry. The evaluation will be done jointly with the industry in a method mutually agreed upon.
3. **Mode of Evaluation**: The performance of the students in theory and practical courses will be evaluated based on continuous assessment and end- semester examination. For theory courses and practical courses, continuous assessment and end semester examination will carry 50 % weightage each. The level of difficulty of the questions will be: of 30 % easy, 40 % medium difficulty and 30 % tough.
4. **Assessment**: In each theory courses, the assessment pattern will be as follows:

   a) Continuous Assessment:

Sl. No.	Break up	Maximum marks
1	1st Periodical Test	15
2	2nd Periodical Test	15
3	Assignments	15
4	Attendance	5

b) The marks awarded for attendance will be as follows:

Percentage Attendance	Marks
95-100	5
90 to less than 95	4
85 to less than 90	3
80 to less than 85	2
75 to less than 80	1

c) End Semester Examination:

The examination will be of 3 hours duration for which maximum marks will be 50.

d) Practical Courses

In each practical course, assessment pattern will be as follows:

Continuous assessment: 50 marks. For continuous assessment, marks may be awarded on the basis of regularity and performance of the student in the laboratory sessions.

e) Normally both question paper setting and valuation of answer papers for all the periodical tests shall be carried out by the teacher who has handled the course. The question paper for the end semester examination for theory papers will be set by an external examiner. The Controller of Examinations will make necessary arrangements for settling the question papers and valuation of answer books for the end semester examination.

f) The laboratory practicals will be assessed by continuous evaluation based on the performance in regular practical sessions, attendance, practical records and viva voce examination.

g) In the case of project work, a committee consisting of the Project Co-coordinator (appointed by the Head of the Department), project guide and at least one senior faculty member will carry out the assessment based on at least two interim reviews and a final review just before the submission of the project report.

h) The Viva voce examination at the end of VIII Semester will be conducted by a panel of examiners consisting of the Head of the Department and one senior faculty of the Department and one external expert.

i) A candidate shall allowed to improve the continuous assessment marks in theory / laboratory courses subject to the following conditions :

1. He / she shall not combine the course work with his / her regular course work.
2. He / she shall repeat the theory/ practical course in a particular course only once and satisfy the minimum attendance requirement of 75 percent in that particular course.
3. He / shall not be allowed to repeat the course work of any semester if he / she has already passed the semester examination in full.

5. Pass requirements.

A candidate has to obtain a minimum of 50 percent marks for continuous assessment and end semester examination put together with a minimum of 45* percent marks in the end semester examination for a pass in theory courses. That is, he / she has to score a minimum of 23* marks out of 50 for the external examination of theory papers and 50 percent for continuous evaluation of practicals.

** Changed to 40% (20 marks out of 50) in the academic council. ** will be studied by a committee.*

6. Promotion to Higher Semesters

A candidate shall be eligible for promotion from one semester to the next semester only if the following conditions are satisfied:

a) He/ she has secured a minimum of 75% attendance.
b) Promotion from one semester to the next semester shall be subject to the condition that the candidate to be promoted to the n^{th} semester should have earned a minimum of (n-2)*10 credits**. This norm is applicable only from 5^{th} semester onwards.
c) His / her progress and conduct have been satisfactory.

7. Attendance

a) The percentage of attendance of a candidate for a semester shall be indicated by a letter code as given below

Percentage Attendance	Letter Code
90 and aboveAbove	H
75 to less than 90	N
Less than 75	L

b) A student whose attendance is less than 75% for a semester is not eligible to appear for the end semester examination.
c) The Vice Chancellor shall have the power to condone shortage of attendance up to 10 percent on medical grounds on the recommendations of the Head of Division / Department. However such condonation for shortage of attendance shall be given only twice during the entire course.

8. Grading

a) Grades shall be awarded to the students in each course based on the total marks obtained in continuous assessment and the end semester examination. The grading pattern shall be as follows:

Marks obtained (Percentage)	**Grade**	**Grade Points**
90-100	S	10
80 to less than 90	A	9
70 to less than 80	B	8
60 to less than 70	C	7
50 to less than 60	D	6
Less than 50	F	0

b) A student is considered to have credited a course or earned credits in respect of a course if he / she secures a grade other than F for that course.

c) Grade Point Average.

The academic performance of a student in a semester is indicated by the Semester Grade Point Average (SGPA)

$$SGPA = \frac{G1C1+O2C2+O3C3+GnCn}{C1+C2+C3+Cn}$$

Where G refers to the grade point and C refers to the credit value of corresponding course undergone by the student.

d) The cumulative grade point average (CGPA) will be

calculated as $$CGPA = \frac{S1T1+S2T2+S3T3+SnTn}{T1 + T2 + T3 +Tn}$$

Where 'S' refers to the grade point average, 'T' refers to the total credits in that semester.

e) Grade Card

The Grade Card issued at the end of the semester to each student by the Controller of Examinations will contain the following:

1. The code, title, number of credits of each course registered in the semester, marks (internal, external , total, month & year of pass the subject)

2. The letter grade obtained (grade number)
3. The attendance code
4. The total number of credits earned by the student up to the end that semester and
5. SGPA & CGPA (CGPA for final semester only)

A CGPA of 8.0 and above will be classified as **FIRST CLASS WITH DISTINCTION** and a **CGPA above** will be classified as **FIRST CLASS.** The percentage conversion formula is Percentage of marks = (CGPA or SGPA – 0.5) * 10

CURRICULUM									
SEMESTER I									
Sl.	**Course Code**	**Subject**	**L**	**T**	**P**	**Credits**	**Marks**		
No.							Internal	External	Total
1	24-214-0101	Engineering Mathematics I	2	1	0	3	50	50	100
2	24-214-0102	Engineering Physics	2	1	0	3	50	50	100
3	24-214-0103	Engineering Chemistry	2	1	0	3	50	50	100
4	24-214-0104	Engineering Graphics	1	2	0	3	50	50	100
5	24-214-0105	Basic Electrical Engineering	2	1	0	3	50	50	100
		and Electronics							
6	24-214-0106	Soft Skill Development	2	0	0	2	50	50	100
7	24-214-0111	Introduction to Industrial	0	0	2	1	50	-	50
		Chemical Analysis (Lab)							
8	24-214-0112	Basic Electrical Engineering and Electro	0	0	2	1	50	-	50
9	24-214-0113	Language Lab	0	0	2	1	50	-	50
10	24-214-0131	Seminar (Non – Credit)	0	0	3	–			
11	24-214-0135	Library (Non – Credit)	0	0	4	–			
		Total	**11**	**6**	**13**	**20**	**450**	**300**	**750**
SEMESTER II									
1	24-214-0201	Engineering Mathematics II	2	1	0	3	50	50	100
2	24-214-0202	Engineering Mechanics	2	1	0	3	50	50	100
3	24-214-0203	Environmental Studies	3	0	0	3	50	50	100
4	24-214-0204	Mechanical Engineering	2	1	0	3	50	50	100
5	24-214-0205	Introduction to	3	0	0	3	50	50	100
		Macromolecular Science and Engineering							
6	24-214-0206	Fluid Mechanics	2	1	0	3	50	50	100
7	24-214-0211	Mechanical Engineering Workshop	0	0	3	1	50	-	50
8	24-214-0212	Polymer Synthesis (Lab)	0	0	2	1	50	-	50
9	24-214-0231	Seminar (Non – Credit)	0	0	3	–			
10	24-214-0235	Library (Non – Credit)	0	0	4	–			
		Total	**14**	**4**	**12**	**20**	**400**	**300**	**700**
SEMESTER III									
1	24-214-0301	Engineering Mathematics III	2	1	0	3	50	50	100
2	24-214-0302	Natural Rubber Production and Techno	3	0	0	3	50	50	100
3	24-214-0303	Strength of Materials	2	1	0	3	50	50	100
4	24-214-0304	Heat and Mass Transfer	2	1	0	3	50	50	100
5	24-214-0305	Organic Chemistry	3	0	0	3	50	50	100
6	24-214-0306	Computer Programming	2	0	3	3	100	-	100
7	24-214-0311	Identification of Polymers	0	0	2	1	50	-	50
		(Lab)							
8	24-214-0312	Chemical Engineering (Lab)	0	0	2	1	50	-	50
9	24-214-0331	Seminar (Non – Credit)	0	0	3	–			
10	24-214-0335	Library (Non – Credit)	0	0	3	–			
		Total	**14**	**3**	**13**	**20**	**450**	**250**	**700**

SEMESTER IV									
1	24-214-0401	Applied Statistics	2	1	0	3	50	50	100
2	24-214-0402	Quality Management Systems and Safe	3	0	0	3	50	50	100
3	24-214-0403	Polymer Synthesis	3	0	0	3	50	50	100
4	24-214-0404	Science and Engineering of Rubbers	3	0	0	3	50	50	100
5	24-214-0405	Plastic Materials	3	0	0	3	50	50	100
6	24-214-0406	Universal Human Values	3	0	0	3	50	50	100
7	24-214-0411	Polymer Synthesis, Modification and c	0	0	2	1	50	-	50
8	24-214-0431	Seminar	0	0	2	1	50	-	50
9	24-214-0435	Library (Non – Credit)	0	0	4	–			
		Total	**17**	**1**	**8**	**20**	**400**	**300**	**700**
SEMESTER V									
1	24-214-0501	Plastic Processing	3	0	0	3	50	50	100
2	24-214-0502	Polymer Physics	3	0	0	3	50	50	100
3	24-214-0503	Rubber Processing and Products Manu	3	0	0	3	50	50	100
4	24-214-0504	Fiber Science and Technology	3	0	0	3	50	50	100
5	24-214-0521-23	Elective I	3	0	0	3	50	50	100
6	24-214-0524-26	Elective II	3	0	0	3	50	50	100
7	24-214-0511	Polymer Characterization and properti	0	0	2	1	50	-	50
8	24-214-0512	Analysis of Rubber Compounds	0	0	2	1	50	-	50
		and Ingredients (Lab)							
9	24-214-0531	Review Seminar	0	0	2	1	50	-	50
10	24-214-0535	Library (Non – Credit)	0	0	4	–			
		Total	**18**	**0**	**10**	**21**	**450**	**300**	**750**
SEMESTER VI									
1	24-214-0601	Latex Technology	3	0	0	3	50	50	100
2	24-214-0602	Characterization and Testing Methods	3	0	0	3	50	50	100
3	24-214-0603	Polymer Products Design	3	0	0	3	50	50	100
4	24-214-0604	Polymer Rheology	3	0	0	3	50	50	100
5	24-214-0621-23	Elective III	3	0	0	3	50	50	100
6	24-214-0624-26	Elective IV	3	0	0	3	50	50	100
7	24-214-0651	Minor Project	0	0	4	2	100	-	100
8	24-214-0611	Latex and Dry rubber Technology (Lab	0	0	2	1	50	-	50
9	24-214-0631	Seminar	0	0	2	1	50		50
10	24-214-0635	Library (Non – Credit)	0	0	4	–			
		Total	**18**	**0**	**12**	**22**	**500**	**300**	**800**

SEMESTER VII									
1	24-214-0701	Polymer Composites and Blends	3	0	0	3	50	50	100
2	24-214-0702	Introduction to MouId and Die Design	3	0	0	3	50	50	100
3	24-214-0703	Failure Analysis of Polymers	3	0	0	3	50	50	100
4	24-214-0704	Industrial Management	3	0	0	3	50	50	100
5	24-214-0721-23	Elective V	3	0	0	3	50	50	100
6	24-214-0724-27	Elective VI	3	0	0	3	50	50	100
7	24-214-0711	Polymer Products Testing (Lab)	0	0	2	1	50	-	50
8	24-214-0731	Review paper based on Elective	0	0	2	1	50		50
9	24-214-0732	Soft skill/ start up workshop (Non – Cr	0	0	3	–			
10	24-214-0735	Library (Non – Credit)	0	0	3	–			
		Total	**18**	**0**	**10**	**20**	**400**	**300**	**700**
SEMESTER VIII									
1	24-214-0841	Project Work Report and Viva Voce	0	0	22	12	200	200	400
2	24-214-0842	Industrial Training	0	0	4	3	50	50	100
3	24-214-0861	Open Elective I	2	0	0	2	–	100	100
4	24-214-0862	Open Elective II	2	0	0	2	–	100	100
		Total	**4**	**0**	**26**	**19**	**250**	**450**	**700**
		Overall Total	**114**	**14**	**104**	**162**	**3300**	**2500**	**5800**

Electives

Elective I	24-214-0521	Paints and Surface Coatings
	24-214-0522	Adhesives Technology
	24-214-0523	Disaster Management
Elective II	24-214-0524	Biodegradable Polymers
	24-214-0525	Polymers and Environment
	24-214-0526	Polymers for packaging
Elective III	24-214-0621	Polymers for Electrical & Electronics Applications
	24-214-0622	Footwear Technology
	24-214-0623	Polymer Recycling
Elective IV	24-214-0624	Specialty Polymers
	24-214-0625	Materials Science
	24-214-0626	Introduction to Biomaterials and Medical Devices
Elective V	24-214-0721	Tyre Technology
	24-214-0722	Polymer process modelling and simulation
	24-214-0723	Smart and intelligent polymers
Elective VI	24-214-0724	Polymers for Space applications
	24-214-0725	Polymer nanocomposites
	24-214-0726	Professional Ethics in Engineering
	24-214-0727	Advanced Energy Harvesting and Storage Technology

LIST OF APPROVED OPEN ELECTIVES

Tentative list of online courses approved by DC. Further courses may be selected by students which need to be approved by the Department.

COURSE ID	COURSE NAME	WEBSITE URL
24-214-0861	Material and Energy Balances	https://onlinecourses.nptel.ac.in/noc24_bt27/preview
24-214-0862	I Think Biology	https://onlinecourses.nptel.ac.in/noc24_bt36/preview
24-214-0863	Environmental Quality Monitoring & Analysis	https://onlinecourses.nptel.ac.in/noc24_ch15/preview
24-214-0864	Characterization of Polymers, Elastomers and Composites	https://onlinecourses.nptel.ac.in/noc24_ch35/preview
24-214-0865	Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts	https://onlinecourses.nptel.ac.in/noc24_ge19/preview
24-214-0866	Evaluation of Textiles Materials	https://onlinecourses.nptel.ac.in/noc24_te02/preview
24-214-0867	Textile Production Design and Development	https://onlinecourses.nptel.ac.in/noc24_te04/preview
24-214-0868	Textured Yarn Technology	https://onlinecourses.nptel.ac.in/noc24_te05/preview
24-214-0869	Membrane Technology	https://nptel.ac.in/courses/103103163
24-214-0870	Polymer Reaction Engineering	https://nptel.ac.in/courses/103107206
24-214-0871	Product Design and Manufacturing	https://nptel.ac.in/courses/112104230
24-214-0872	Material Characterization	https://nptel.ac.in/courses/113106034

SUMMARY

Category	**Credits**		
	Theory	Lab	Total
Basic Sciences	21	1	22
Eng. Sciences	15	3	18
Humanities/management/computer/UHV	17	1	18
Core	54	7	61
Prog. Elective	18	0	18
Open Elective	4	0	4
Project & Industrial training	15	0	15
Seminar & minor project	6	0	6
Total Credits			**162**

SYLLABUS

SEMESTER I

24-214-0101 Engineering Mathematics I

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Explain the concept of partial derivative (understand)
CO2: Estimate Maxima and minima of multi variable functions (analyse)
CO3 : Evaluate area, arc length volumes & surface area if solids of revolution
CO4: Evaluation of multiple integrals, apply it in plane area, surface area & volumes of solids (apply)
CO 5: Solve ordinary differential equations & linear differential equations with constant coefficients
CO 6: Apply linear differential equations in engineering problems
CO 7: Compute different operations related to matrix & finding rank
CO 8: Solve system of algebraic equations using matrix

Mapping of course outcomes with program outcomes:
Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1	1	1									1
CO 2	1	1	1	1								1
CO 3	1	1	1	1								1
CO 4	1	1	1	1								1
CO 5	1	2	1	1								1
CO 6	1	1	1	1								1
CO 7	1	1	1	1								1
CO 8	1	1	1	1								1

Unit 1. Partial differentiation – Concept of partial derivative, chain rule, total derivative. Euler's theorem for homogeneous functions. Differentials and their applications in errors and approximations. Jacobians: maxima and minima of functions of two variables (proof of the result not required), simple applications. Co-ordinate systems : rectangular co-ordinates, polar coordinates – in plane and in space, cylindrical polar co-ordinates, spherical polar co-ordinates.

Unit2. Integral calculus – Application of definite integrals : area, volume, arc length, surface area. Multiple integral : evaluation of double integrals, change of order of integration, evaluation of triple integrals, change of variables in integrals. Applications of multiple integrals : plane area, surface area & volumes of solids.

Unit 3. Ordinary differential equations – First order differential equations – exact differential equations. Bernoulli's equations – methods of solution and simple applications. Linear differential equations of higher orders with constant coefficient – methods of solution of these equations. Cauchy's linear differential equations. Simultaneous linear differential equations: simple applications of linear differential equations in engineering problems – electrical circuits, mechanical systems.

Unit 4. Rank of a Matrix,Normal and Echelon forms ,Eigen values and Eigen vectors, Solutions of

linear system of equations Cayley Hamilton theorem(proof is not required) & its applications

References

1. S.S. Sastry, Engineering mathematics, Vol.1., 4th Edn., PHI Learning (2009).
2. Erwin Kreyzig, Advanced Engineering Mathematics, 10th Edn., John Wiley& Sons (2010).
3. T. Veerarajan, Engineering Mathematics, 3rd Edn., Tata McGraw Hill Publishers (2012).
4. B.S.Grewal, Higher Engineering Mathematics, 43rd Edn., Khanna Publishers (2015).

Revised – Unit 4 (25 %)

24-214-0102 Engineering Physics

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Describe the concepts of interference and diffraction of light. (Understand)
CO 2: Explain the polarization of light. (Understand)
CO 3: Interpret modern devices and technologies based on lasers. (Apply)
CO 4: Demonstrate the technologies based on optical fibres. (Apply)
CO 5: Explain the basic principles of crystal physics. (Understand)
CO 6: Describe the types and properties of metallic glasses. (Understand)
CO 7: Discuss the basic concepts of quantum mechanics. (Understand)
CO 8: Explain the Schrodinger equation. (Understand)

Mapping of course outcomes with program outcomes:
Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1	1	1						1			1
CO 2	1	1	1									1
CO 3	1	1	1	1		1			1	1		1
CO 4	1	1	1									1
CO 5	1	1	1	1								1
CO 6	1	1	1									1
CO 7	1	1	1	1					1			1
CO 8	1	1	1	1								1

Unit 1. Interference of light – Michelson interferometer, applications: interference in thin films, antireflection coatings, interference filters. Fringes produced by air wedge, Diffraction of light, zone plate: plane diffraction grating, reflection and transmission gratings. Determination of wavelength of light, dispersive and resolving powers. Polarization of light: double refraction, Nicol's prism, quarter and half wave plates, elliptically and circularly polarized light, optical activity, specific rotation, half-shade polarimeter, applications of polarized light.

Unit 2. Laser – Introduction, properties, interaction of radiation with matter, absorption, spontaneous and stimulated emission, principle of laser, Einstein coefficients – conditions for getting laser, population inversion, metastable state. Basic components of a laser, different types of lasers. Construction, working and applications of Ruby laser, Neodymium YAG laser, He-Ne laser. Applications of laser in medicine, industry, science and communication. Holography – basic principle, comparison with ordinary photography. Recording and reconstruction of holograms, applications. Fibre optics – basic structure of an optical fibre, propagation of light in an optical fibre. Classifications: step-index fibre and graded index fibre, single mode and multimode. applications.

Unit 3. Crystallography – Basis, space lattice, unit cell, unit cell parameters, crystal systems, Bravais lattices. Three cubic lattices: SC, BCC, and FCC. Number of atoms per unit cell, coordination number, atomic radius, packing factor. Relation between density and crystal lattice constants. Lattice planes and Miller indices. Separation between lattice planes in SC – Bragg's law. Bragg's x-ray spectrometer. Liquid crystals: display systems – merits and demerits. Metallic glasses: types of metallic glasses (metal-metalloid glasses, metal-metal glasses) – properties of metallic glasses (structural, electrical, magnetic and chemical properties)

Unit 4. Quantum mechanics – Dual nature of matter & radiation, Matter waves, de Broglie wavelength, wave packet, uncertainty principle, wave function, physical interpretation. Time dependent Schrodinger equation for a free particle, time independent Schrodinger equation. Applications of Schrodinger wave equation for a free particle, Particle in a box (one dimensional and three-dimensional cases), Simple harmonic oscillator (one dimensional case).

References

1. S. Mani Naidu, A Text book of Engineering Physics, Pearson (2010).
2. A.S. Vasudeva, Modern Engineering Physics, 6th Edn., S. Chand & Co. (2013).
3. S.O. Pillai and Sivakami, Applied Physics, 2nd Edn., New Age International (P) Ltd. (2008).
4. G.S. Raghuvanshi, Engineering Physics, 3rd Edn., Prentice Hall of India (2016).
5. 5 Prabir K. Vasu and Hrishikesh Dhasmana, Engineering Physics, Ane books Pvt. Ltd. (2010).
6 M.R. Sreenivasan, Physics for Engineers, 2nd Ed., Anshan (2011).
7 J. Jacob Philip, A Textbook of Engineering Physics, 2nd Edn., Educational Distributors and Publishers (2012).

Revised – 20 %

24-214-0103 Engineering Chemistry

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Interpret the basic principles and concepts of quantum chemistry. (Understand)
CO2:Explain energy level diagrams of diatomic molecules, quantum confinement, electronic and geometric changes during bulk to nano transition. (Understand)
CO3: Describe bonding in solids and theories in solid state chemistry, fundamentals of X-ray diffraction. (Understand)
CO4: Describe solid surface characterization techniques. (Understand)
CO5: Explain fundamentals of electrochemistry. (Understand)
CO6: Describe principles of electrochemical devices. (Apply)
CO7: Explain the chemistry of a few important engineering materials. (Understand)
CO8: Discuss the properties and applications of engineering materials. (Understand)

Mapping of course outcomes with program outcomes:
Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1	1	1						1			1
CO 2	1	1	1									1
CO 3	1	1	1							1		1
CO 4	1	1	1									1
CO 5	1	1	1									1
CO 6	1	1	1	2	1	1	1	1	1	1		1
CO 7	1	1	1	1		1	1	1	1	1	1	1
CO 8	1	1	1	1		1	1	1	1	1	1	1

Unit 1. Quantum Chemistry – Schrodinger equation: Derivation from classical wave equation, operator form of the equation. Application of Schrodinger equation to 1-D box solutions. Significance of wave functions, probability, and energy. Application of 1-D box solutions to conjugated molecules. Forms of hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Energy level diagrams of diatomic molecules, Pi-molecular orbitals of butadiene, and benzene and aromaticity.

Unit 2. Solid state chemistry – Fundamentals, bonding in solids. Born-Haber cycle. Point defects. Methods to improve reactivity of solids. Free electron theory, band theory, Fermi level in semiconductors,. Conventional and organic superconductors, high temperature superconductors, Liquid crystals, Liquid crystalline mesophases, defect in liquid crystals, . X-ray diffraction-Fundamentals of X-ray scattering, Bragg's law. Solid surface characterization: electron spectroscopy for chemical analysis, , . BET isotherm – thermodynamics of adsorption, Langmuir theory of adsorption, the BET Model, BDDT classification on type of isotherms.

Unit 3. Electrochemistry – Fundamentals: electrode potentials, types of electrodes, salt bridge, emf measurement, concentration cells, acids and bases, buffer solutions, pH measurements, polarization, overvoltage. Power generation: secondary cells, fuel cells, photovoltaic effect, solar cells. Corrosion: different forms of corrosion, prevention of corrosion. Phase Rule : terms involved and examples, application of phase rule to one component water system, two-component systems (simple eutectic systems).

Unit 4. Engineering materials – Significance of polymer materials, Industrial polymers : Thermoplastics, thermosets, elastomers, fibers, adhesives. Nanomaterials : definition, classification and applications. , Nanometals and nanoceramics – examples and properties. . Lubricants : classification, functions and properties. Mechanism of lubrication. Refractories : classification and properties. Manufacture, setting and hardening of portland cement, lime and plaster of paris. Lubricants : introduction. Mechanism of lubrication, solid and liquid lubricants. Properties of lubricants : viscosity index, flash and fire point, cloud and pour point, aniline value. Refractories : classification and properties.

References

1. Bruce. M. Mahan, R. J. Meyers, University Chemistry, 4th Edn., Pearson publishers (2009).
2. Pradeep T. "Nano: The Essentials" McGraw Hill Education India (2007)
3. Peter W. Atkins, Julio de Paula, James Keele, Atkin's Physical Chemistry, 11th Edn., Oxford publishers (2018).
4. M. J. Sienko, R. A. Plane, Chemistry: Principles and Applications, 3rd Edn., Mc Graw- Hill publishers (1980).
5. B.L. Tembe, M.S. Krishnan, Kamaluddin, Engineering Chemistry (NPTEL Web Course).
6. Shashi Chawla, A Text book of Engineering Chemistry, Dhanpat Rai & Co. (2017).
7. C.N.R. Rao, A. Muller, A.K. Cheetham, "The Chemistry of Nanomaterials", Wiley-VCH, 2003

Revised – 25 %

24-214-0104 Engineering Graphics

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Prepare drawings as per Indian standards. (Apply)
CO 2: Understand the construction of conic sections. (Understand)
CO 3: Produce orthographic projection of straight lines and planes. (Understand)
CO 4: Draw orthographic projection of solids. (Analyse)
CO 5: Draw the projection of polyhedra and solids of revolution. (Apply)
CO 6: Understand development of surface of different geometric shapes. (Apply)
CO 7: Construct isometric scale, isometric projections and views. (Analyse)
CO 8: Draw different views of simple machine elements. (Apply)

Mapping of course outcomes with program outcomes: Level – Low (1), Medium (2) and High(3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1	1	1		1				1	1		1
CO 2	1	1	1									1
CO 3	1	1	1							1		1
CO 4	1	1	1									1
CO 5	1	1	1									1
CO 6	1	1	1	1	1	1			1	1		1
CO 7	1	1	1	1	1	1			1	1		1
CO	1	1	1	1		1						1

8												

Unit 1. Introduction to engineering graphics – Drawing instruments and their use. Familiarisation with current Indian standard code of practice for general engineering drawing. Scales : plain, Vernier, diagonal. Conic sections : construction of ellipse, parabola, hyperbola. Construction of cycloid, involute,– drawing tangents and normal to these curves.

Unit 2. Introduction to orthographic projections – Plane of projection, principles of first angle and third angle projections, projection of points in different quadrants. Orthographic projection of straight lines parallel to one plane and inclined to the other plane, straight lines inclined to both the planes, true length and inclination of lines with reference planes, traces of lines. Projection of plane laminae of geometrical shapes in oblique positions.

Unit 3. Projection of characterisation and solids of revolution – Frustum, projection of solids with axis parallel to one plane and parallel or perpendicular to other plane, projection of solidswith axis inclined to both the planes, projection of solids on auxiliary planes. Section of solids by planes inclined to horizontal or vertical planes – true shape of sections. Introduction to isometric projection, isometric scales. Isometric projections : prisms, pyramids, cylinders, cones and spheres.

Unit 4. Development of surface – Cubes, prisms, cylinders, pyramids and cones. Introduction to perspective projections : visual ray method and vanishing point method. Perspective view of circles, prisms and pyramids. Introduction to machine drawing (basic concepts) : different views of hexagonal nut and bolt, square bolt. Conversion from isometric view to orthographic views of simple machine elements.

References

1. K.C. John, Engineering graphics, PHI Learning (2013).
2. N.D. Bhat, Elementary engineering drawing, 53rd Edn., Charotar Publishing House(2014).
3. Gill P.S. Engineering drawing (Geometric drawing), B.D Kataria&Sons (2013).
4. K.C. John, P.I. Varghese, Machine Drawing, V.I.P. publishers (2007).
5. N.D. Bhatt, V. M. Panchal, Machine Drawing, 47th Edn.,Charotar Publishing (2012).
6. P.I. Varghese, Engineering Graphics, Tata McGraw Hill Education (2013).

Revised – 5 %

24-214-0105 Basic Electrical Engineering and Electronics

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Analyse and solve electric circuits. (Analyse)
CO 2: Understand the principles of electromagnetic induction. (Understand)
CO 3: Identify meters for measuring electrical quantities. (Remember)
CO 4: Recognize the basic elements and phases in AC circuits. (Understand)
CO 5: Understand the behaviour of semiconductor junctions and diodes. (Understand)
CO 6: Choose diodes in rectification and regulation. (Apply)
CO 7: Explain special semiconductor devices. (Understand)
CO 8: Describe fundamentals of instrumentation and communication. (Understand)

Mapping of course outcomes with program outcomes:
Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1	1	1		1				1	1		1
CO 2	1	1	1									1
CO 3	1	1	1									1
CO 4	1	1	1									1
CO 5	1	1	1									1
CO 6	1	1	1	1	1				1	1		1
CO 7	1	1	1	1	1	1			1	1		1
CO 8	1	1	1	1		1			1	1		1

Unit 1. Elementary Concepts of DC electric circuits – Definition of voltage,current, resistance, power;Resistances in Series and parallel ;Current and Voltage Division Rules;. Voltage and Current sources;Capacitors and inductors,V-I relations and energy stored .Capacitors in series and parallel;Ohm's Law ,Kirchhoff's laws, Network analysis by mesh current method,, Superposition theorem, Thevenin's theorem, Norton's theorem, simple illustrative problems on network theorems. Review of Electrostatics : Coulomb's Law, electric field strength and electric flux density.

Unit 2. Review of electromagnetic induction – Magnetic circuits, magnetic field of a coil, magnetic flux, flux density, field strength , Ampere turns calculation –Faraday's Law, Lenz's Law. Mutually induced emf.. Measuring instruments : Working principle of Galvanometer, Ammeter, Voltmeter, Watt meter & Energy meter (elementary concepts). AC Fundamentals : Generation of alternating emf ,, sinusoidal AC voltage characteristics and definitions, general representation of voltage or current, phase relations, average value, effective (root mean square) value. Basic elements and phasors: Response of basic R, L and C elements to a sinusoidal voltage or current, phasor diagrams, frequency response of the basic elements, Complex representation of vectors (rectangular & polar forms), Series RLC circuit, Impedance triangle, Power triangle, Average power and power factor.

Unit 3. Basic electronics – Passive components : resistor, capacitor, inductor, color coding. Transformer – different types, construction. Semiconductors : Energy band diagram, intrinsic & extrinsic semi conductors, doping, PN junction. Special Diodes – Zener diodes, characteristics, application, LED,LCD,Solar Cell, Photodiode. Rectifiers : Half wave, full wave and bridge rectifiers, ripple factor and regulation. Transistors : PNP and NPN transistors, theory of operation, Configurations characteristics, comparison. Special semiconductor devices FET, SCR, , V-I characteristics, applications.

Unit 4. Fundamentals of instrumentation – Transducers : definition, classification – active & passive. Transducer for position, pressure, velocity, vibration and temperature measurements. CRO : Principle of operation, block diagram, CRT, Application-Measurement of amplitude, frequency and phase. Fundamentals of communication : Block diagram of general communication system, concept of modulation, demodulation. Types – AM, FM, PM.. Basic concepts of digital communication, block diagram.

References

1. B. L. Theraja, Basic Electronics – Solid State, S. Chand & Co. (2016).
2. Leonard S. Bobrow, Fundamentals of Electrical Engineering, 2nd Edn., Oxford University Press (2003).
3. Edward Hughes, Ian McKenzie Smith, Hughes Electrical Technology, Addison Wesley Publication (1995).
4. G.K. Mithal, Ravi Mittal, Electronic Devices & Circuits: Applied Electronics Vol. 1, Khanna Publishers (1997).
5. Robert L. Boylestad, Introductory Circuit Analysis, 13th Edn., Pearson Education (2015).
6. Rajendra Prasad, Fundamentals of Electrical Engineering, 2nd Edn., PHI Learning (2009).

Revised – 40 %

24-214-0106 Soft Skill Development

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the role and importance of verbal communication. (Understand)

CO 2: Read, comprehend and answer questions based on literary, scientific and technological texts. (Apply)

CO 3: Understand the fundamental grammar. (Understand)

CO 4: Practice words and styles used for formal and informal communication. (Apply)

CO 5: Develop presentation skills through oral, poster and power point. (Apply)

CO 6: Improve communication skills through group discussions and debates. (Apply)

CO 7: Develop self-motivation, raised aspiration, belief in one's own abilities and commitment to achieving one's goal. (Apply)

CO 8: Demonstrate emotional maturity and emotional health. (Apply)

Mapping of course outcomes with program outcomes:
Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1								1	1		
CO 2	1								1	1		1
CO 3	1								1	1		
CO 4	1								1	2		1
CO 5	1								2	2		1
CO 6	1								1	1		1
CO 7	1								1	1		1
CO 8	1								1	1		1

Unit 1. Role and importance of verbal communication – Everyday active vocabulary, common words used in transitions, enhancing vocabulary, affixes and changes in pronunciation and grammatical functions, words often confused in pronunciation and usage. Passage comprehension: skimming, scanning techniques, note making, note taking and summarizing. Deciphering meaning from contexts. Types of meaning: literal and contextual. Constructive criticism of speeches and

explanations.

Unit 2. Fundamental grammar – Simple structures, passivizing the active sentences, reported speech, the judicious use of tenses and moods of verbs, forming questions and conversion from questions to statements and vice versa, forming open-ended and close- ended questions. Words and style used for formal and informal communication. Practice converting informal language to formal, the diction and the style of writing. Dealing with the nuances of ambiguous constructions in language. Learning authoritative writing skills, polite writing and good netiquette. Writing for internships and scholarships. Types of Resume writing ,Types of report writing .

Unit 3. Communication – Kinesics, proxemics, haptics, and other areas of non-verbal communication, fighting communication barriers, positive grooming and activities on the same. Different types of interviews and presentation : oral, poster, ppt. Organizing ideas for group discussions, the difference between GD and debates. Effective listening and seeking to understand others' perspectives. Non-violent negotiation and persuasion, communicating across age groups, cultures or identity groups. Higher order thinking and evaluation, information seeking, research, and independent learning, synthesis, creativity, problem analysis and problem solving. Decision making, self- reflection and learning from experience.

Unit 4. Developing positive self – Understanding oneself, realistic awareness of oneself and one's abilities, strengths and potential, self-esteem, self-efficacy, steps for improvement. Intra-personal skills : self- control, emotional regulation and self-discipline, conscientiousness, dutifulness, reliability, truthfulness, honesty and trustworthiness. Goal orientation and initiative. Time management – benefits of time management ,Eisen Hover, Time management matrix characterisation work. Interpersonal skills : cross cultural competence and valuing diversity of perspectives, respecting and expressing concern for others. Empathy and ability to notice the effect of one's actions on others, tolerance for disagreement, conflict management and resolution. Global and local awareness

References

1. Steve Duck, David T. McMahan, Communication in Everyday Life, 3rd Edn., Sage (2017).
2. Gamble Teri Kwal, W.Gamble Michael, The Public Speaking Playbook, 2nd Edn., Sage (2017).
3. Meenakshi Raman, Sangeeta Sharma, Technical Communication: Principles and Practice, 3rd Edn., Oxford University Press (2015).
4. Daniel Goleman, Emotional intelligence: Why it can matter more than IQ, Random House (2012). 5 Devadas Menon, Stop sleepwalking through life!, Yogi Impressions Books Pvt. Ltd. (2013).
5. Barun K. Mitra, Personality Development and Softskills, Oxford University Press (2012).

Revised – 5 %

24-214-0111 Introduction to Industrial Chemical Analysis (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1:	Analyze the purity of monomers supplied by industries.
CO 2:	Analyze the characteristic properties of natural rubber.

Mapping of course outcomes with program outcomes: Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	1	1			1	1	1				1
CO 2	2	1	1			1	1	1	1	1	1	1

Experiments

1. Acidimetry and Alkalimetry: Estimation of Hydrochloric acid, Sodium hydroxide, Hardness of water
2. Estimation of percentage purity of monomers – glycerol, formaldehyde, methylmethacrylate, urea, phenol
3. Iodimetry and Iodometry: Estimation of Iodine
4. Determination of iodine value of NR.
5. Determination of saponification value of oil.

References

1 A.O. Thomas, B.Sc. Practical Chemistry

24-214-0112 Basic Electrical Engineering and Electronics (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Apply basic electrical engineering knowledge for house wiring practice.

Mapping of course outcomes with program outcomes: Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1		1	1	1	1	1	1		1

Experiments

1. One lamp controlled by one switch
2. Series and parallel connections of lamps.
3. Stair case wiring.
4. Hospital Wiring.
5. Godown wiring.
6. Fluroscent lamp.
7. Connection of plug socket.
8. Different kinds of joints.
9. Winding of transformers.
10. Soldering practice.
11. Familiarisation of CRO.

24-214-0113 Language Lab

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Test pronunciation skills through stress on word accent, intonation, and rhythm.
CO 2: Use the English language effectively for writing business letters, resumes, minutes of meetings and reports.
CO 3: Use the English language effectively to face interviews, group discussions, and public speaking.

Mapping of course outcomes with program outcomes: Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1								1	1	1	1
CO2	2								1	1	1	1
CO3	1								1	1	1	1

Following course content is prescribed for the Language Laboratory sessions:

1. Introduction to the Sounds of English- Vowels, Diphthongs & Consonants.
2. Introduction to Stress and Intonation.
3. Preparing business letters
4. Preparing a resume
5. Conducting a meeting and writing the minutes
6. Writing a report
7. Situational Dialogues / Role Play.
8. Oral Presentations- Prepared and Extempore.
9. 'Just A Minute' Sessions (JAM).
10. Describing Objects / Situations / People.
11. Debate
12. Group discussion

SEMESTER II

24-214-0201 Engineering Mathematics II

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Illustrate the application and physical meaning of gradient, divergence and curl(Apply)
CO 2: Evaluate line, surface and volume integrals(Evaluate)
CO 3: Solve Fourier series. (Apply)
CO 4: Apply Fourier integrals. (Apply)
CO 5: Solve Laplace equations. (Apply)
CO 6: Use Laplace transforms in solving initial value problems, unit step functions, impulse functions & periodic functions. (Apply)
CO 7: Working of Difference operators and their inter relations(Understand)
CO 8: Do Interpolation with equal intervals and unequal intervals

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	1	1	1	1							1
CO 2	1	1	1	1	1							1
CO 3	1	1	1	1								1
CO 4	1	1	1	1								1
CO 5	1	1	1	1								1
CO 6	1	1	1	1								1
CO 7	1	1	1									1
CO 8	1	1	1									1

Unit 1. Vector Calculus- Scalar and Vector point functions, gradient and directional derivative of a scalar point function, divergence and curl of a vector point function, their physical meaning. Evaluation of line integrals, surface integrals and volume integrals. Gauss's divergence theorem, Stoke's theorem (no proofs).Conservative force fields, scalar potential

Unit 2. Fourier series and Fourier integrals – Fourier series of periodic functions, Euler formulae for Fourier coefficients, functions having period 2p, arbitrary period, even and odd functions, half range expansions, Fourier integral, Fourier cosine and sine transformations, linearity property, transform of derivatives, convolution theorem (no proof).

Unit 3. Laplace transforms – Linearity property, transforms of elementary functions, Laplace transforms of derivatives and integrals, differentiation and integration of transforms, convolution theorem (no proof), use of Laplace transforms in the solution of initial value problems, unit step function, impulse function, transform of step functions, transforms of periodic functionsUnit 4. Difference operators and their inter relations. Newton's forward and backward interpolation formulae. Lagrange interpolation

References

1. R.K. Jain, S.R.K. Iyengar, Advanced Engineering Mathematics, 4th Edn., Narosa Publishers (2014).

2. C. Ray Wylie, Louis Barrett , Advanced Engineering Mathematics, 6th Edn., McGraw-Hill Education (1995).
3. N.P. Bali, Manish Goyal, A Textbook of Engineering Mathematics, 9th Edn., Laxmi Publications
4. (2016)
5. B.S.Grewal,Higher Engineering Mathematics,Khanna publications New Delhi,2011

Revised syllabus – 50 %

24-214-0202 Engineering Mechanics

Course Outcome
On completion of the course, the students will be able to:

CO 1: Understand the principles of statics, the concept of free body diagrams and resolution of forces. (Understand)
CO 2: Apply the principles of mechanics, concept of free body diagrams and resolution of forces. (Apply)
CO 3: Explain the parallel forces in a plane. (Understand)
CO 4: Ascertain the physical and mathematical meaning of moment of inertia. (Apply)
CO 5: Explain the concept of rectilinear motion. (Analyse)
CO 6: Apply D'Alembert's principle in rectilinear motion. (Apply)
CO 7: Explain the concept of curvilinear translation. (Analyse)
CO 8: Apply D'Alembert's principle in curvilinear translation. (Apply)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	1	1		1				1			1
CO 2	1	1	1		1				1			1
CO 3	1	1	1						1			1
CO 4	1	1	1	1					1			1
CO 5	1	1	1	1								1
CO 6	1	1	1						1			1
CO 7	1	1	1									1
CO 8	1	1	1						1			1

Unit 1. Introduction to Mechanics: Definition and classification of mechanics – rigid body (statics and dynamics) and deformable body mechanics. Forces and Force systems: Force and its characteristics, Principles of statics – concept of resultant and equilibrant, Composition and resolution of forces, force systems. Coplanar Concurrent force system: Equilibrium of two, three and more than three forces, Moment of a force, Varignon's theorem of moments, Equations of equilibrium, Friction and its effects on bodies. Coplanar Parallel force System: Two parallel forces, General case of parallel forces in a plane, Centre of parallel forces, Centre of gravity, Centre of mass, Centroids of curves, areas and volumes – regular and composite, Pappus's theorems, Equilibrium of distributed forces in a plane, Applications of the concept of centroid in engineering practice.

Unit 2. Moment of Inertia: Concept of moment of inertia and second moment of area, Moment of inertia of regular and composite solids, Second moment of area of regular and irregular surfaces, Polar moment of inertia / second moment of area, Product of inertia, Principal moments of inertia and principal axes, Applications of the concepts in engineering practice. Coplanar non-

concurrent force system: Resultant of a general case of force system in a plane, Equilibrium equations, Applications in engineering practice. Analysis of Plane trusses and frames: Concept of load carrying mechanism in trusses and frames – internal (axial) forces, two force and multi force members, Analysis of plane trusses by Method of joints and Method of sections, Analysis of Plane frames by Method of members, Applications of trusses and frames in structures.

Unit 3. Introduction to Dynamics: Definitions, Units, Divisions – Kinematics, Kinetics. Rectilinear translation: Kinematics of rectilinear motion – displacement, velocity, acceleration, Kinetics – Differential equations of motion, D'Alembert's principle in rectilinear translation and its applications, Motion of a particle due to a constant force, Motion of a particle due to a force proportional to displacement – Simple harmonic motion, Momentum and impulse, Work and energy, Conservation of energy, Collision of two bodies – direct central impact.

Unit 4. Curvilinear translation: Kinematics of curvilinear translation – components of displacement, velocity and acceleration, normal and tangential acceleration, Kinetics – Differential equations of motion, Motion of a projectile – projection on horizontal and inclined surfaces, D'Alembert's principle in curvilinear motion and its applications, Moment of momentum, Work and energy in curvilinear motion. Rotation of a rigid body: Kinematics of rotation – angular displacement, velocity and acceleration, RPM, Relations of kinematic parameters of linear and angular motions, Kinetics – Equation of motion of a rigid body rotating about a fixed axis, Rotation under the action of a constant moment, Rotation proportional to angular displacement.

References

1 S. Timoshenko, D. H. Young, Sukumar Pati, J. V. Rao, Engineering Mechanics, 5th Edn., McGraw Hill Education (2013).

2 Ferdinand P. Beer, E. Russell Johnston, David Mazurek, Phillip J. Cornwell, Brian Self, Sanjeev Sanghi,
Vector Mechanics For Engineers Statics And Dynamics, 12th Edn., Tata McGraw Hill (2019).

3 H. L. Merram, L. G. Kraige, Engineering Mechanics, Vol. 1: Statics (SI version), 7th Edn., John Wiley and Sons (2013).

4 E. M. S. Nair, N. Biju, A Textbook of Engineering Mechanics, Vol. 1: Statics, Educational Publishers & Distributors (2012).

5 J. Benjamin, A textbook of Engineering Mechanics, 4th Edn., Pentex Book Publishers & Distributors
(2015).

6 N. Biju, Theory and Problems in Engineering Mechanics (Dynamics), Educational Publishers
& Distributors (2002).

7 R. S. Khurmi, N. Khurmi, Principles of Engineering Mechanics, S. Chand Publishing (2019).

Revised – 40 %

24-214-0203 Environmental Studies

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the importance of environmental studies. (Understand)

CO 2: Identify the natural resources and suitable methods for conservation and sustainable development. (Understand)

CO 3: Realize the importance of ecosystem for maintaining ecological balance. (Analyse)
CO 4: Explain the importance of biodiversity and its conservation. (Understand)
CO 5: Identify environmental pollutants and abatement mechanisms. (Understand)
CO 6: Comprehend the concept of Disaster management and Environmental protection Act. (Remember)
CO 7: Understand environmental problems arising due to developmental activities and population growth. (Understand)
CO 8: Explain simple ecosystems. (Apply)

Mapping of course outcomes with program outcomes:
Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	1				1	1	1	1			1
CO 2	1	1				1	1		1			1
CO 3	1	1				1	1		1			1
CO 4	1	1				1	1		1			1
CO 5	1	1				1	1	1	1			1
CO 6	1	1	1			1	2	2	1			1
CO 7	1	1	1			1	2	1	1			1
CO 8	1	1										1

Unit 1. Multidisciplinary nature of environmental studies – Definition, scope and importance, need for public awareness. Natural Resources: renewable and non-renewable resources, natural resources and associated problems. Forest resources: use and over-exploitation, deforestation, case studies, timber extraction, mining, dams and their effects on forest and tribal people, Different types of forest found in India. Water resources: use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources, case studies. Food resources: world food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. Energy resources: growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies. Land resources: land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

Unit 2. Ecosystems – Concept of an ecosystem: structure and function of an ecosystem, producers, consumers and decomposers, energy flow in the ecosystem, ecological succession, Examples of succession with different stages, food chains, food webs and ecological pyramids. Structure and functions of the ecosystems: forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries). Biodiversity and its conservation: introduction, definition of genetic, species and ecosystem diversity. Biogeographical classification of India. Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values. Biodiversity at global, national and local levels. India as a mega-diversity nation. Hot-spots of biodiversity, biodiversity hot spots in India. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.

Unit 3. Environmental Pollution – Definition. Cause, effects and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards. Solid waste management: causes, effects and control measures of urban and industrial

wastes. Role of an individual in prevention of pollution. Pollution case studies. Disaster management: floods, earthquake, cyclone and landslides. Environmental legislation: Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Issues involved in enforcement of environmental legislation.

Unit 4. Environmental ethics – Issues and possible solutions. Climate change: global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies: waste land reclamation, consumerism, waste products. 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. Human population and the environment: population growth, variation among nations, population explosion – family welfare programme, environment and human health, human rights, value education, Diseases emerged/associated with climate change/environmental pollution, women and child welfare, role of Information technology in environment and human health, case studies. Field work: visit to a local area to document environmental assets river, forest, grassland, hill, mountains, visit to a local polluted site- urban, rural, industrial, agricultural, study of common plants, insects, birds. Study of simple ecosystems: pond, river, hill slopes, etc

References

1. R. Rajagopalan, Environmental studies: From Crisis to Cure. Oxford University Press (2005).
2. ErachBharucha, Textbook of Environmental studies and ethics, Universities Press (2005).
3. Jayashree, V. M. Parikh. Balsaraf, P.B. Dwivedi, Environmental Studies, Ane Books Pvt. Ltd (2010)
4. AninditaBasak, Environmental Studies, Pearson (2009).
5. S.P.Misra, Essential Environmental Studies, 3rd Edn., Ane Books Pvt. Ltd. (2011).
6. Benny Joseph, Environmental Science & Engineering, Tata McGraw Hill Education Pvt. Ltd., (2010)

Revised – 5 %

24-214-0204 Mechanical Engineering

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Understand the properties of engineering materials. (Understand)
CO 2: Identify various moulding tools and equipment used for material processing. (Remember)
CO 3: Describe different types of boilers. (Understand)
CO 4: Understand various engines. (Understand)
CO 5: Comprehend the machine elements and mechanical power transmission. (Understand)
CO 6: Describe belt and gear drives. (Understand)
CO 7: Gain knowledge on various welding techniques. (Apply)
CO 8: Understand soldering and brazing. (Remember)

Mapping of course outcomes with program outcomes:

Level – Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	1				1			1			1
CO 2	1	1				1			1			1
CO 3	1	1				1	1		1			1
CO 4	1	1				1	1		1			1
CO 5	1	1				1	1		1			1
CO 6	1	1				1	1					1
CO 7	1	1				1	1		1			1
CO 8	1	1										

Unit 1. Material Science – Classification of engineering materials: mechanical, thermal and chemical properties of materials. Fuels: classification, solid, liquid, gaseous and nuclear, calorific values (HCV & LCV), determination of calorific values. Pattern making: types, materials, allowances. Moulding tools and equipment: sand, preparation of sand, desirable properties, additives, cope, drag, cover, core prints, gating, reserving. Refrigeration and air conditioning: Introduction, simple vapour compression system, comfort air conditioning, winter air conditioning and summer air conditioning.

Unit 2. Boilers and Engines – Classification of boilers: sample vertical, Cochran, locomotive, Babcox, wilcox and La-mant boilers, boiler mountings and accessories, electric furnaces. Internal Combustion engines: classification, 2 stroke, petrol and diesel fuel system, simple carburetor, diesel fuel pump, injector petrol fuel pump. Ignition system: battery coil, magnets codling system, lubrication system. Equilibrium of forces in a plane. Plane trusses – Method of joints. Method of sections. Plane frames: Method of members. Principle of virtual work: Equilibrium of ideal systems, stable and unstable equilibrium. Equilibrium of forces in a plane. Plane trusses – Method of joints. Method of sections. Plane frames: Method of members. Principle of virtual work: Equilibrium of ideal systems, stable and unstable equilibrium.

Unit 3. Introduction to machine elements – shafts, fly wheels, bearings, clutches, cone clutches, single plate clutch, shaft couplings. Mechanical Power Transmission: belt, rope, chain, gear drives. Belt drive: open, closed, velocity rates, slip, length of belt power transmitter, stopped pulling. Gear drive: types of gears, types of gear drives, spur gear nomenclatures, velocity ratio.Unit 4. Welding – Classification, oxy-acetylene welding, gear welding equipment, arc welding equipment, arc welding, resistance welding, thermal welding, TIG, safety devices. Introduction to soldering and brazing. Metalworking-hot and cold working, rolling -extrusion-drawing forging- bending-shearing – punching metal cutting -cutting tools- classification, materials, Cutting fluids-Purpose-desirable qualities, Machine Tools: Lathes- Types of Lathes, Engine Lathe-parts- operations, Milling machine- Planning machine- Drilling machine- Shaping machine-Guiding machine-Main parts.

References

1. P. K. Nag, Engineering Thermodynamics, 5th Edn., McGraw Hill Education Pvt. Ltd (2013).

2. V. Raghavan, Materials Science and Engineering: A First Course, 6th Edn.,Prentice Hall India Learning Pvt. Ltd. (2015).
3. Rajendar Singh, Introduction to Basic Manufacturing Processes and Workshop Technology, New Age International (2006).
4. S. K. Hajra Choudhury, Nirjhar Roy, Elements of Workshop Technology, 13th Edn., Media Promotors & Publishers Pvt. Ltd. (2010).

Revised – 10 %

24-214-0205 Introduction to Macromolecular Science and Engineering

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the basics of polymer science . (Remember)
CO 2: Identify polymers based on its structure and properties. (Understand)
CO 3: Explain the mechanism of addition polymerization. (Understand)
CO 4: Comprehend the kinetics of free radical and ionic polymerization. (Analyse)
CO 5: Explain the mechanism of condensation polymerization . (Understand)
CO 6: Describe the kinetics of step reaction polymerization and copolymerization.(Analyse)
CO 7: Explain the synthesis of important polymers . (Understand)
CO 8: Describe the polymerisation techniques according to the need of polymer industry (Analyse)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	1			1	1	1			1		1
CO 2	1	1	1	1		1			1			1
CO 3	1	1	3	2		1	1					2
CO 4	1	1	1	1		1			1			1
CO 5	1	1	3	2		1	1					2
CO 6	1	1	1	1		1	1					1
CO 7	1	1	3	2		1	1					2
CO 8	1	1	2	2					1			2

Unit 1. Introduction to Polymer Science: Concept of macromolecules, Historic developments in polymeric materials, Basics of polymer science: monomers, functionality, degree of polymerisation, kinetic chain length, oligomers, molecular forces, molecular weight of polymers, average molecular weight, molecular weight distribution, Classification of polymers: Natural and synthetic polymers, Chemical & Physical structure and properties of polymers: Rubbers, plastics and fibers; thermoplastics and thermosets. Status of polymer industries: global scenario of polymer industry, polymer industries in India.

Unit 2. Mechanism of polymerization: Classification of polymerization mechanism, Chain reaction polymerization and step reaction polymerization. Chain reaction (Addition) polymerization – Basics, classification based on the type of initiators. Free radical Polymerization: mechanism of free radical polymerization, generation of free radicals, initiation, propagation, termination, chain transfer reactions, inhibition and retardation, kinetics of free radical polymerization. Ionic Polymerization: classification, cationic and anionic polymerisation, selection of monomers, chain transfer reactions, kinetics of ionic polymerisation.

Unit 3. Step reaction (condensation) polymerization–Basics. Mechanism of condensation polymerization: general characteristics, addition- elimination reactions, ring versus chain formation, interfacial condensation, interchange reactions, poly condensation reaction, three dimensional network condensation reaction. Kinetics of step reaction polymerization: catalyzed and non catalyzed, Carothers equation, molecular-weight control, prediction of gel point.

Unit 4. Polymerization techniques: homogeneous polymerization techniques-bulk, solution, Heterogeneous polymerization techniques- emulsion, suspension,. Polymer synthesis – Synthesis and properties of polyethers, polyacetals, polylactams, polyesters, polycarbonates, polyamides. Type of reactors: batch reactors, tubular flow reactors, stirred tank reactors.

References

1 F.W. Billmeyer, A Text Book of Polymer Science, 3rd Edn., Wiley & Sons (2009).

2 Herman F. Mark (Ed.),Encyclopedia of Polymer Science and Engg., Vol 15, 4th Edn., Wiley & Sons (2014).

3 P.J.Flory, Principle of Polymer Chemistry, Cornell University Press (1986).

4 V. R. Gowariker, N. V. Viswanathan and J. Sreedhar,Polymer science, John Wiley & Sons (2010).

Revised – 70 %

24-214-0206 Fluid Mechanics

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Summarize various properties of fluids and pressure measurements. (Understand)

CO 2: Distinguish different types of flow systems. (Understand)

CO 3: Explain the concepts of flow in boundary layers and basic equations of fluid flow. (Apply)

CO 4: Describe various discharge measuring devices. (Analyze)

CO 5: Identify the pumps used for fluid flow. (Apply)

CO 6: Derive the equation for pressure drop in packed bed. (Apply)

CO 7: Examine the fluidization behaviour. (Apply)

CO 8: Outline the fluid flow around immersed solids and identify the method for separating the solids from the fluid. (Apply)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	1	1		1		1					1
CO 2	1	1	1						1			1
CO 3	1	1	1				1		1			1
CO 4	2	1	1	1					1			1
CO 5	1	1	1						1			1
CO 6	1	1	1									1
CO 7	2	1	1			1	1		1			1
CO 8	1	1	1									1

Unit 1. Fluid Mechanics –Basics. Properties of fluids: density, compressibility and bulk modulus of elasticity, surface tension and capillarity, pressure, viscosity-Newton's law of viscosity, dynamic and kinematic viscosity, variation of viscosity with temperature, , Newtonian and non-Newtonian fluids. Pascal's law, variation of pressure with elevation. Pressure measurement: mercury barometer, piezometer tube, U- tube manometer, inclined tube manometer, pressure gauge.

Unit 2. Fluids in motion – Velocity field, velocity gradient, Reynolds experiment, Reynolds number, laminar flow, turbulent flow, transition region. Boundary-layers: flow in boundary-layers, boundary- layer formation in thin plate and straight tube, transition length, boundary-layer separation and wake formation. Basic equations of fluid flow: stream lines and stream tubes, equation of continuity, Bernoulli equation, Hagen-Poiseulle equation. Fluid friction in pipes: friction loss from sudden expansion and contraction of cross section, effect of fittings and valves.

Unit 3. Transportation and metering of fluids – Pipe and tubing, joints and fittings. Valves: gate valve and globe valve. Discharge measurement: venturi meter, orifice meter, rotameter, pitot tube, weirs. Pumps: reciprocating positive displacement pumps-working principle, rotary positive displacement pumps-working principle of gear and vane pumps, centrifugal pumps-working principle, characteristic curves, NPSH, cavitation, priming.

Unit 4. Flow past immersed bodies – Flow through packed beds: Ergun equation. Drag, drag coefficients, form drag and stream lining, stagnation point, settling under gravity, terminal velocity, hindered settling, Stoke's law range, Newton's law range and intermediate law range. Fluidization: characteristics of fluidization, minimum fluidization velocity, aggregative and particulate fluidization, applications, continuous fluidization: slurry and pneumatic transport. Sedimentation: flocculation, batch sedimentation, equipment for sedimentation Cyclone separators, hydroclones.

References

1 P.E. Irving Granet, Fluid Mechanics for Engineering Technology, 3rd Edn., Prentice Hall

(1989).
2 W.L.Badger, J.T.Banchero, Introduction to Chemical Engineering, Mc Graw Hill Inc.(1955).
3 Warren L. Mc Cabe, Julian C. Smith, Peter Harriott, Unit operations of Chemical Engineering,
7th Edn., Mc Graw Hill Higher education (2005).
4 J. R. Backhurst, J H Harker, J.M.Coulson , J.F.Richardson, R.P. Chhabra, Chemical Engineering
Volume 1: Fluid Flow, Heat Transfer and Mass Transfer, 6th Edn., Butterworth Heinemann (1999).
5 Victor L.Streeter, E. Benjamin Wylie, K.W. Bedford, Fluid Mechanics, 9th Edn., Tata McGraw Hill (2010).

Revised – 25 %

24-214-0212 Polymer Synthesis (Lab)

Course Outcome
On successful completion of the course, the students will be able to:

CO 1: Synthesize various polymers through addition and condensation haracterizati techniques

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			1	1	1	1	1			1

1. Polymer Synthesis

a) Washing of monomers using separating funnel
b) Preparation of polymethylmethacrylate through bulk technique
c) Preparation of polystyrene through bulk technique
d) Preparation of polystyrene haracth Solution technique
e) Preparation of polystyrene through suspension technique
f) Preparation of polystyrene through emulsion technique
g) Preparation of nylon 66 through interfacial condensation technique
h) Regeneration of cellulose
i) Preparation of UF, PF – Novolacs, Resols

References

1. Rabek, Experimental methods in polymer chemistry, John Wilely& sons (1998).

2. D. Braun, H. Cherdron, H. Ritter, Polymer Synthesis: Theory and Practice, Springer Science and Business Media (2001)
3. Stanley R. Sandler, Wolf Karo, Joanne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization: A Laboratory Manual, Elsevier (1998)

20-214-0211 Mechanical Engineering Workshop

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Identify and use tools,and make different types of joints used in carpentry, fitting and sheet metal shop

CO 2: Compare basic fabrication techniques of different types of welding

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1	1			1			1
CO2	1				1	1			1			1

Preliminary exercises for beginners in all the following shops. Specific models may be designed by the teachers

1) Fitting shop
2) Sheet metal shop
3) Foundry shop
4) Welding shop
5) Carpentry shop

SEMESTER III

24-214-0301 Engineering Mathematics III

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Compute different types of complex function. (Apply)
CO 2: Apply conformal mapping to elementary functions. (Apply)
CO 3: Understand different methods of numerical solution
CO 4 : Apply it to solve initial value problems
CO 5: Identify & formulate partial differential equations. (Understand)
CO 6: Solve different types of partial differential equations. (Apply)
CO 7: Understand the one dimensional wave and heat equations. (Understand)
CO 8: Solve one dimensional wave & heat equations and Laplace equations using method of separation of variables. (Apply)

Mapping of course outcomes with program outcomes:
Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1								
CO2	1	1										1
CO3	1	1		1								1
CO4	1	1		1								1
CO5	1	1	1	1								1
CO6	1	1	1	1								1
CO7	1	1	1	1								1
CO8	1	1	1	1								1

Unit 1. Complex, analytic functions and conformal mapping – curves and regions in the complex plane, complex functions, limit, derivative, analytic function, Cauchy – Riemann equations. Elementary complex functions: powers, exponential function, logarithmic, trigonometric and hyperbolic functions. Conformal mapping: Linear fractional transformations, mapping by elementary function like Z^2, e^z, sin z, cos z, sin hz, and Cos hz, Z + 1/Z

Unit 2. Numerical methods for ordinary differential equations. Taylor Series Method, Picard's Method, Runge-Kutta method of the fourth order and Milne's Predictor Corrector Method.

Unit 3. Partial differential equations – Formulation of partial differential equations. Solutions of equations of the form F (p,q) = 0, F(x,p,q) = 0, F(y,p,q) = 0, F(z,p,q) = 0, F1(x,p) = F2 (y,q), Lagrange's form Pp+Qq = R, Linear homogeneous partial differential equations with constant coefficient.

Unit 4. Vibrating string – one dimensional wave equation, D'Alembert's solution, solution by the method of separation of variables. One dimensional heat equation: solution of the equation by the method of separation of variables, solutions of Laplace's equation over a rectangular region and a circular region by the method of separation of variables.

References

1. R.K.Jain, S.R.K.Iyengar, Advanced engineering mathematics, 5th Edn., Narosa Publishers

(2016).
2. Erwin Kreyszig, Advanced Engineering Mathematic, 10th Edn.,John Wiley & Sons, Inc. (2011).
3. James Ward Brown, Ruel V. Churchill, Complex Variables &Applications , 9th Edn., Mc- Graw Hill Education (2014).
4. Merle C. Potter, Jack Goldberg,Edward F. Aboufadel, Advanced Engineering Mathematics, 3 rdEdn., Oxford University Press (2005).
5. B.S.Grewal,Higher engineering mathematics, 44 th Edn., Khanna Publishers (1965).

Revised- 25 %

24-214-0302 Natural Rubber Production and Technology

Course Outcome
On successful completion of the course, the students will be able to:

CO 1: Explain the history, present and future of natural rubber. (Remember)
CO 2: Understand the various tapping methods (Understand)
CO 3: Distinguish various concentration process. (Understand)
CO 4: Understand the formation of latex by biosynthesis in rubber tree (Understand)
CO 5: Get an insight on the preservation of NR latex. (Understand)
CO 6: Describe the process involved in the production of various forms of dry rubber. (Understand)
CO 7: Explain various modified forms of natural rubber. (Understand)
CO 8: Understand the production process and applications of skim rubber (understand)

Mapping of course outcomes with program outcomes:
Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										1
CO2	1	1										1
CO3	1	1	1									1
CO4	1		1	2	1							1
CO5	1	1	1		1						1	1
CO6	1	1	1	1	1							1
CO7	1	1	1	1	1							1
CO8		1	1	1	1						1	1

UNIT-1 HISTORY, SOURCES AND ITS IMPORTANCE: History & development of natural rubber as an important industrial raw material. Major sources – propagation of Hevea brasiliensis, different clones. Extraction of Latex – methods of extraction of latex–tapping, standard of tappability for

seedling and budded trees. Tapping knives, tapping task, tapping rest. Different systems and their intensity, intensive tapping, ladder tapping, slaughter & puncture tapping. Factors affecting tapping efficiency. Rain guarding; yield stimulation- statistics of NR, future prospects of NR, replacement possibilities of NR, uniqueness of NR, cost evaluation of NR for the last decades. Applications of NR by-products from NR plantation industry.

UNIT-2 PRESERVATION AND CONCENTRATION OF LATEX: - Definition of Latex – composition and function of non-rubber constituents, colloidal nature of latex, micro – organisms in latex and their role in destabilization, need for preservation of latex, short and long-term preservation – NH3 as ideal preservative, secondary preservatives – LATZ type. Propagulation and use of anticoagulants – examples. Coagulation and methods of coagulation of Latex. Preserved latex concentrate – need for concentration of Latex. Latex concentration methods – creaming, centrifuging, evaporation and electro-decantation. Creaming – principle, creaming agents and soaps used, process. Centrifuging – principle, machinery, centrifuging process, efficiency of centrifuging, factors affecting efficiency of centrifuging; quality enhancement methods of centrifuged latex, double centrifuging, importance of centrifuged latex as an industrial raw material and its present trends. Skim latex and skim rubber recovery of skim rubber, its applications-other latex concentration processes.

UNIT-3 PROCESSING OF NR LATEX INTO DRY MARKETABLE FORMS: Marketable forms of dry rubber – R.S.S., crepe block rubber. Processing of field latex into R.S.S., ADS, different grades,. Crepe rubbers – different grades and their processing, application of each grade, Technically Specified Rubber (TSR) – different grades, manufacturing details, quality enhancement, Baling and dispatch. Current status and future prospects.

UNIT-4 SPECIALITY NATURAL RUBBERS & RECLAIM RUBBER: Importance of specialty natural rubbers in rubber industry-- features, production methods, chemical aspects, applications and current status of the following specialty Natural rubbers – SP rubber, CV & LV rubber, OENR, tyre rubber, graft natural rubber, powdered natural rubber, DPNR, Latex black master batch, epoxidised NR, chlorinated NR,. Definition, objectives of reclaiming, reclaiming agents.

Reference

1. P.J. George, Kuruvilla Jacob (Eds.), Natural Rubber Agromanagement and Crop processing, Rubber Research Institute of India, Rubber Board (2000).
2. D. C. Blackley, Polymer Latices, Vol.1, 2nd Edn., Chapman &Hall (1997).
3. M.M.Patel, S.B. Rath, R.M. Sambandam, D.Joseph Francis (Eds.), Rubber Engineering by Indian Rubber Institute, Tata McGraw-Hill (2000).
4. 4.BIS & ASTM specifications.
5. Steven Blow, Handbook of Rubber Technology, Galgotia Publications (2004).
6. Rani Joseph, Practical Guide to Latex Technology, Smithers Rapra, (2013).

Revised: 50%

24-214-0303 Strength of Materials

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Assimilate the fundamentals of stress and strain and their relationships. (Understand)

CO2: Explain the loads at the ends and in between ends of uniform section.(Apply)

CO3: Explain the relation between elastic constants.(Apply)

CO4: Understand the compound stress and importance of principal stress.(Understand)

CO5: Explain the shear force and bending moment.(Understand)

CO6: Explain the relation between shear force and bending moment.(Analyse)

CO7: Describe the stresses and strains in thin cylinders and deflection of beams.(Evaluate)

CO8: Describe the stress in cantilever in different point load conditions.(Evaluate)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO 9	PO1 0	PO1 1	PO1 2
CO1	1		1									1
CO2	1	1	1									1
CO3	1	1	1									1
CO4	1		1	1					1			1
CO5	1	1	1	1								1
CO6	1	1	1	1								1
CO7	2	1	1	1					1			1
CO8	2	1	1	1	2	1			1			1

Unit 1. The concept of Stress and Strain : Definition of stress and strain at a point , normal stress and shear stress, Complementary shear stress, shear strain, Hooke's law and Poisson' s ratio, Constitutive equations, Elastic moduli, Relationship between elastic moduli of an elastic and isotropic material, Factor of safety, Allowable stress. Stress and Strain – Axially loaded members and loads at the ends and in between ends of uniform section, stepped bars, Composite bars. stress–strain diagram, linear strain, lateral strain, Poisson's ratio, Elastic constants: relation between 3 elastic constants, thermal strain energy, simple problems.

Unit 2. Principal stresses and strains - Stresses on inclined planes for axial and biaxial stress fields, principal stresses, Mohr's circle of stress, principal strains, strain rosette. Graphical – Compound stresses, , design of riveted joints , checking for shearing of plane, shearing of rivet, crushing of rivet.

Unit3. Shear force and bending moment: SF & BM diagram. Types of beams (determinate and indeterminate) - Cantilever Beam :simply supported beams, over hanging beam., loads and reactions in determinate beams, Loads: transverse and inclined loads, point loads, uniformly distributed loads, triangular loads, relationships between intensity of loading, Relation between SF & BM, Simple problems.

Unit 4. Thin cylinders under internal pressure: stresses, changes in dimensions and volume, simple problems. Deflection of beams: Differential equation for deflection, derivation, assumptions,-simply supported beams. Point load: Uniformly distributed load, cantilever point load at the end, not at the end, uniformly distributed load throughout the span and part of the span, Simple problems.

References

1. S. Ramamrutham, Strength of Materials, 5th Edn., Dhanpat Rai Publising Co. Ltd. Pvt. (2017).
2. R.S.Khurmi,N.Khurmi,ATextbookofStrengthofMaterials(Mechanicsofsolids), 26thEdn., S. Chand Publishing (2019).
3. R.K.Banzal,ATextBookofStrengthofMaterials,6thEdn.,LaxmiPublications(2017).
4. S.P.Timoshenko,D.H.Young,ElementsofStrengthofMaterials,5thEdn.,East-West Press (2003).

Revised: 40 %

24-214-0304 Heat and Mass Transfer

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Explain different modes of heat transfer. (Understand)
CO 2: Calculate rate of heat conduction through flat plate, cylindrical wall and hollow sphere. (Analyze)
CO 3: Describe typical heat exchange equipments. (Understand)
CO 4: Explain the concept of overall heat transfer coefficient. (Apply)
CO 5: Outline the concepts of evaporation and various types of evaporators. (Evaluate)
CO 6: Assess number of theoretical stages required in distillation column by Mc-Cabe Thiele method. (Evaluate)
CO 7: Impart fundamental concepts of mass transfer operations like diffusion, distillation, absorption, drying, filtration. (Understand)
CO 8: Understand the equipment needed for various mass transfer operations. (Understand)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	2	1									2	
CO3	1											
CO4	1	1	1									
CO5	1	1				1					1	
CO6	2	2	1	2								
CO7	1	1	1								1	
CO8	2	1	1	1		1					1	

Unit 1.Introduction to heat transfer –nModes of heat transfer : conduction, convection, radiation. Concept of heat conduction: Fourier' s law, one dimensional steady-state heat conduction equation for flat plate, hollow cylinder and hollow sphere, heat conduction through a series of resistances, numerical problems. Principles of heat flow in liquids:Typical heat exchange equipments-single pass tubular condenser, and double pipe heat exchanger-counter current and cocurrent flows, energy balance in exchangers and condensers. Concept of logarithmic mean temperature difference, derivation of expression for LMTD.Unit 2.Concept of overall heat transfer coefficient –nIndividual and over all heat transfer coefficients, derivation of expression for overall heat transfer coefficient, fouling factors, determination of overall heat transfer coefficient with and without fouling. Evaporators: Principle, types, material and energy balance, performance, capacity and economy. Factors affecting the performance of evaporators. Multiple effect evaporators: different feeding arrangements.

Unit 3.Distillation– Vapour-liquid equilibria : boiling point diagram, distribution diagram, constant- temperature vapour-liquid equilibrium, Raoults and Henrys laws , simple distillation, flash distillation, steam distillation. Relative volatility. Continuous binary rectification: number of ideal plates by Mcabe Thiele method, total and minimum reflux, plate efficiency, rectification columns-constructional details.

Unit 4.Mass transfer operations – Mass transfer operations law, steady state molecular diffusion in gases and liquids,. Gas absorption: absorption towers. Drying: classification of dryers, equilibrium moisture and free moisture, critical moisture content, drying equipment. Filtration: filtration equipment- plate and frame presses, rotary drum filter.

References

1 BinayK.Dutta, Heat Transfer Principles and Applications, PHI Learning Pvt Ltd. (2018).
2 W.L.Badger, J.T.Banchero, Introduction to Chemical Engineering, Mc Graw Hill Inc.(1955).
3 Warren L. Mc Cabe , Julian C. Smith, Peter Harriott,Unit operations of Chemical Engineering,7th Edn., Mc Graw Hill Higher education (2005).
4 J. R. Backhurst, J H Harker, J.M.Coulson , J.F.Richardson, R.P. Chhabra, Chemical Engineering Volume 1: Fluid Flow, Heat Transfer and Mass Transfer,6th Edn., Butterworth Heinemann (1999).
5 K.V. Narayanan, B. Lakshmikutty, Mass Transfer Theory and Applications, CBS Publishers & Distributors Pvt Ltd (2014).

Revised: 10 %

24-214-0305 Organic Chemistry

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Explain the phenomenon of hybridization and orbital overlap to form molecules. (Understand)
CO2: Identify stereoisomerism in various compounds. (Analyse)
CO3: Explain the mechanism of synthesis of special reagents and its applications. (Understand)
CO4: To understand the chemistry of heterocyclic compounds (Understand)
CO5: Understand the classification of various organic reactions. (Understand)
CO6: Analyse the structure and properties of carbohydrates and lipids. (Analyse)
CO7: Analyse the structure and properties of proteins, peptides and nucleic acids. (Analyse)

CO8: Explain various chromatographic techniques and its applications. (Understand)

Mapping of course outcomes with program outcomes:
Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										1
CO2	2	1										1
CO3	2	1	1									1
CO4	1	1										
CO5	2	1	1									1
CO6	1	1	1			1			1			
CO7	2	2	1			1			1			1
CO8	1		1			1			1		1	

Unit 1. Covalent bond – Hybridization and orbital overlap in molecules like ethane, ethylene, acetylene, benzene and cyclohexane, their geometry. Stereo isomerism: optical isomerism in lactic and tartaric acids, explanation, elements of symmetry and chirality, D & L configuration, Fischer and Newman projection formula, racemisation, racemic mixture, methods of resolution.

Unit 2. Grignard reagent and related compounds: Introduction, grignard reagent, alkyl lithium, synthetic applications. Ethers: reactions of epoxides, Claisen rearrangement mechanism, Zeisel's method of estimation of alkoxy groups. Heterocyclic compounds: structure, preparation and properties of furan, pyrrole, pyridine.. Reaction mechanism: polarity of bonds, inductive mesomeric and electromeric effects, resonance, hyper conjugation, steric effects.

Unit 3. Carbohydrates, proteins, and lipids – Carbohydrates: reaction and structure elucidation of glucose and fructose, structure of sucrose and maltose, elementary study of starch and cellulose, industrial uses of cellulose. Amino acids, proteins, and nucleic acids: L-amino acids as building block of proteins, zwitter ion property,. Nucleic acids: structure of DNA and RNA, Genetic code, protein synthesis. Lipids: biological functions and types of lipids, oils and fats, occurrence in foods, composition, industrial oils of vegetable origin, common fatty acids present in fats and oils, extraction, refining and hydrogenation of fats and oils, identification of fats and oils, physical and chemical properties, saponification value, acid value and iodine number,

Unit 4. Chromatography – Classification, principle of differential migration, adsorption phenomena, Rf value. Chromatographic techniques: parturition chromatography -theory and applications, thin layer, paper and ion exchange chromatography, liquid chromatography-HPLC, applications, gas chromatography-theory and application.

References

1. Arun Bahl, B.S. Bahl, Advanced Organic Chemistry, 2nd Edn., S. Chand Publishing (2012).
2. K.S.Tewari, N.K.Vishnoi, A Textbook of Organic Chemistry, 4th Edn.., Vikas Publishing (2017).
3. Robert Thornton Morrison, Robert Neilson Boyd, SaibalKanti Bhattacharjee, Organic Chemistry, 7th Edn., Pearson (2011).
4. Michael Smith, Jerry March, Advanced Organic Chemistry, 6th Edn., John Wiley & Sons, 6.

Inc. (2007).

Revised: 10 %

24-214-0306 Computer Programming

Course Outcome
On successful completion of the course, the students will be able to:

CO1: Understand the basics of computer programming python.(Understand)
CO 2: Explain the commands and its applications in computer programming python. (Analyse)
CO 3: Understand the programming using various control structures and data structures in python. (Understand)
CO 4: Implement object-oriented concepts in python. (Remember)
CO 5: Identify the use of NumPy for data analysis. (Understand)
CO 6: Write python programs using basic commands . (Understand)
CO 7: Apply the function command and exception handling in practical programs using python. (Apply)
CO 8: Write a python program involving the functions, constructors and python libraries. (Apply)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	1	1			1					1		
CO 2	2	1	1	1	1							
CO 3	1	1	1	1	1					1		
CO 4	1		1	1	1					1	1	
CO 5	1	1	1		1							
CO 6	2	2	1	1	1					1	1	
CO 7	2	1		1	1							
CO 8	2	1		1	1					1	1	

Unit 1. Introduction to computer programming: Python as a programming language. Python Data Types, Variables, operators, Assignments, Comments, Expressions, Control Structures, Looping and Branching.

Unit 2. List: Basic List Operations, List Iteration and Comprehensions, Indexing, Slicing, Two Dimensional Lists, Iterating through Two Dimensional Lists. Dictionaries: Basic Dictionary Operations, Changing Dictionaries in Place, Methods, Tuples and Sets (Properties, Operators, and Methods).

Unit 3.User-Defined Functions, Lambda Function, Zip Function, Parameter Passing (thrusting mutable and immutable parameters). Recursion, Memory Management During Recursive Function Calls. Global versus Local Namespaces. Objects and Classes, Defining a Class in Python, Constructors. Classes as Namespaces, Inheritance: Multiple and Multilevel Inheritance, Modifying Built in Classes Using Inheritance, Operator Overloading (Integer Class Operators only) Using Inheritance, Exception handling.

Unit 4. The NumPy Library, Ndarray, Basic Operations- Creating Arrays-array(), arrange(), reshape(),sum(), min() and max() methods, Item wise arithmetic operations, Indexing, Slicing and Iterating, Conditions and Boolean Arrays, Shape Manipulation, Array Manipulation, Structured Arrays, Reading and Writing Array Data on Files.

References

1. Mark Lutz, 'Learning Python', 5th Edition, O'Reilly Media, Inc. 2013
2. LjubomirPerkovic, "Introduction to Computing Using Python: An Application Development Focus", Wiley, 2012.
3. Charles Dierbach, "Introduction to Computer Science Using Python: A Computational Problem- Solving Focus", Wiley, 2013.
4. Kenneth A Lambert., Fundamentals of Python : First Programs, 2/e, Cengage publishing,2016

Revised: 100 %

24-214-0311 Identification of Polymers (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Identify the plastics and rubbers used in various unknown polymeric products.

Mapping of course outcomes with program outcomes:Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1							1			2

1. Identification of rubbers -NR, SBR, PB, IR, IIR, EPDM, Hypalon,Thiokol, Silicone, CR, NBR.
2. dentification of plastics-PE, PP, PS, PVC, PVA, PF, UF, MF, Polyester
3. Identification of thermoplastic elastomers -SIS, SBS, SEBS, Hytrel

References

1. J.Saunders , Identification of Plastics and Rubber, Chapman and Hall

24-214-0312 Chemical Engineering (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Measure the flow rate & viscosity of fluid, friction developed within the tube and plot the characteristic curves of centrifugal pump.

CO 2: Conduct experiments to find characteristics of some heat and mass transfer operations.

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO
CO1	1	1				1			1			
CO2	1	1				1			1			

1. Fluid flow measurement using orifice meter and venturimeter.
2. Weirs and notches.
3. Friction in straight pipes, bends and fittings.
4. Viscosity measurements by terminal setting velocity.
5. Characteristic curves of a centrifugal pump.
6. Calculation of heat transfer and mass transfer coefficients.
7. Simple distillation and steam distillation.

SEMESTER IV

24-214-0401 Applied Statistics

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Get a brief idea about collection, classification & properties of large data sets. (Understand)
CO 2: Fit a curve to the given data using regression lines & least square method. (Apply)
CO 3: Understand addition and multiplication theorems. (Understand)
CO 4: Identify & solve problems dealing with probability using Binomial, Poisson and Normal distributions. (Apply)
CO 5: Test hypothesis related to mean, standard deviation, variance, correlation coefficient and fitting using different statistical testing procedures. (Apply)
CO 6: Infer whether a process or product is under statistical control or not using control charts and Acceptance sampling procedures respectively. (Evaluate)
CO 7: Analysis variance using one way and two way data classifications. (Analyze)
CO 8: Get an idea about concepts of quality assurance like total quality control, company wide quality control & quality control circles. (Understand)

	Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) and High (3)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1				1	1		1
CO2	1											
CO3	1											
CO4	1											
CO5	2	1	1	1					1			1
CO6	2	1	1	1					1			1
CO7	2	1										1
CO8	2	1	1	1					1			1

Unit 1. Introduction to Statistics – Collection and classification, measures of central tendency, dispersion, skewness and kurtosis. Correlation & Regression: curve fitting by method of least squares, correlation coefficient and regression lines. Analysing quality of data, Descriptive analysis, interpreting correlations.

Unit 2.Probability – Introduction, addition and multiplication theorems, Baye's theorem, pectation, probability density functions and distribution functions, moment generating functions, binomial, Poisson and normal distribution (Theorems without proof). Fitting curves and realizing fitted parameter values, probability plots.

Unit 3. Sampling – Sampling distribution, standard error. Testing of hypothesis: large sample and small sample tests, test for correlation coefficient, test for goodness of fit. Statistical

quality control: control chart for variables and attributes, acceptance sampling, single sampling, double sampling, multiple sampling, sequential sampling plans, curves. Results of testing parameter values.

Unit 4.Design of experiments – Introduction, randomization, replication and local control, analysis of variance-one way and two way classification, CRD, RBD, LSD. Quality control: concepts of quality assurance, total quality control, company wide quality control, quality control circles, and simple statistical tool for quality circles. Interpreting ANOVA results with data, necessity of post-hoc test.

References

1. S.P.Gupta, Statistical Methods, 43rd Edn., Sultan Chand (2014).
2. E.L.Grant, Fundamentals of Statistical Quality Control, 7th Edn., McGraw Hill Education 3. (2000).
4. S.C.Gupta, V.K.Kapoor, Fundamentals of Applied Statistics, Sultan Chand & Sons-Tb (2014).
5. S.C.Gupta, V.K.Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons-Tb 6. (2018).

Revised -10 %

24-214-0402 Quality Management Systems and Safety

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the basics of organisational management. (Understand)
CO 2: Describes the concepts of Quality and Quality management. (Understand)
CO 3: Describes the basics of various ISO certification and Quality practices in the industry level. (Understand)
CO 4: Understand the concept and practice of six sigma (Understand)
CO 5: Describes the various customer related concepts. (Understand)
CO 6: Discuss performance appraisal and CPI. (Understand)
CO 7: Describes the safety concepts and techniques used in the industry. (Understand)
CO 8: Explain the principles and methods of hazard identification and risk assessment. (Understand)

	Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) and High (3)											
	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1					1			1	1	1	
CO2	1					1			1	1	1	1
CO3	1					1			1	1	1	1
CO4	1											1
CO5	1					1			1	1	1	
CO6	1					1			1	1	1	
CO7	1					1			1	1	1	1
CO8	1					1			1	1	1	1

Unit 1. Quality management –Quality concepts, terminology, quality Policy, quality management principles, quality system, quality assurance, quality control, quality characteristics, total quality management, quality cost, role of senior management, continual improvement.

Unit 2. Quality systems – ISO 9000: 2000 systems, ISO 14000, 17025 and 18000, quality auditing, , concept and practice of six sigma, interaction between quality management system and other management systems in an organization. Good laboratory practices, OECD principles of GLP.

Unit 3.Corrective and preventive actions – Customer satisfaction, customer perception of quality, customer complaints, quality of service, customer retention, performance appraisal, benefits, continuous process improvement.

Unit 4. Introduction to Safety – Laboratory safety, concepts of occupational health hazard and risks, causes of accidents, accident analysis and control, techniques used in safety analysis, safety management and organization, principles and methods of hazard identification and risk assessment, risk management, training, human behavioral approach in safety.

References

1. Dale H. Besterfiled, et al., Total Quality Management, 4th Edn., Pearson Education Ltd. (2015).
2. James R. Evans, William M.Lindsay, The Management and Control of Quality, 8th Edn., South- Western; International ed. (2010).
3. John S. Oakland. Total Quality Management – text with cases, 4th Edn.,New York Routledge (2013).
4. N S Sreenivasan, V Narayana. Managing Quality – Concepts and Tasks, New Age International(P) Ltd. (2005).
5. M. Zairi. Total Quality Management for Engineers, Wood Head Publishing (1991).
6. David Hoyle. ISO 9000 Quality Systems Handbook, 4th Edn., Butterworth-Heinemann (2001).

7. D.H. Stamatis, Six Sigma Fundamentals: A Complete Guide to the System, Methods and Tools, Productivity Press (2004).
8. VlastaMolak, Fundamentals of Risk Analysis and Risk Management, Lewis Publishers (1997)
9. Roger L. Brauer, Safety and Health for Engineers,3rd Edn., Wiley-Blackwell (2016)

Revised -10 %

24-214-0403 Polymer Synthesis

Course Outcome
On completion of the course, the students will be able to:

CO1: Analyse the mechanism of coordination polymerization. (Analyse)
CO 2: Describe the mechanism and kinetics of copolymerisation (Understand)
CO 3: Design the synthesis strategy for specialty polymers. (Analyse)
CO 4: Explain the properties of specialty polymers. (Understand)
CO 5: Understand the concept of average molecular weight. (Understand)
CO 6: Understand the techniques of molecular weight determination. (Understand)
CO 7: Comprehend on the degradation of polymers under different environments. (Understand)
CO 8: Understand the the mechanism of degradation and stabilisation. (Understand)

	Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) and High (3)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1							1		1
CO2	1		1	1	1	1					1	
CO3	3	1	1	2		1			1			1
CO4	1	1		1	1				1		1	
CO5	2	1	1						1			
CO6	2	1	2	1	1						1	1
CO7	2		1	1			1	1		1		
CO8	1	1	1				1	1				1

Unit 1. Coordination polymerization: basics, stereo regular polymers, tacticity in polymers. Mechanism of coordination polymerization: coordination catalysts, monometallic, bimetallic. Copolymerisation: types of copolymers, mechanism of copolymerization, addition and condensation copolymerization. Kinetics of copolymerization: reactivity ratios, copolymer equation.

Unit 2. Specialty polymers: synthesis and properties of polyimides, poly (ether ether ketone), polyphenyleneoxide, polysulphones, polysiloxanes, liquid crystalline polymers – main-chain rigid rod, containing flexible spacers, and side-chain polymeric liquid crystals, conducting polymers-polyacetylene, polypyrrole, polythiophene, polyaniline, poly(p-phenylenesulphide); and photoconducting polymers.

Unit 3. Molecular characterization of polymers– average molecular weight, molecular weight distribution, determination of molecular weight – end group analysis, colligative property measurement – ebulliometry, cryometry and osmometry; light scattering, ultra-centrifugation, solution viscosity and gel permeation chromatography.

Unit 4. Polymer degradation and stabilization –Thermal, oxidative, photochemical and ozone degradation, degradation under special environments – polluted atmosphere, high temperatures, mechanical and ultrasonic, high-energy radiation, and hydrolytic degradation; commonly used anti- degradants, mechanism of degradation and stabilization.

References

1. F.W. Billmeyer, A Text Book of Polymer Science, 3rd Edn., Wiley & Sons (2009).
2. R.B. Seymour, C.F.Carrher, Polymer Chemistry, 6th Edn., Marcel Dekker Publications(2003).
3. Hans – George-Elias, Macromolecules, Vol.1, Springer (1986).
4. G. Odian, Principles of Polymerization, 4th Edn., Wiley-Interscience (2007).
5. V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Polymer science, John Wiley & Sons 6. (2010).
6. Andrew Peacock, Allison Calhoun, Polymer Chemistry – Properties and Applications, Hanser Publishers (2006).
7. Hans R. Kricheldorf, Handbook of Polymer Synthesis Part B, Marcel Dekker, Inc.(1992)

Revised -50 %

24-214-0404 Science and Technology of Rubbers

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Explain the importance and functions of different rubber compounding additives and their normal dosages. (Understand)

CO 2: Design formulations based on different rubbers and additives. (Apply)

CO 3: Understand the chemistry of vulcanization process (Understand)

CO 4: Describe vulcanisation process, techniques to assess the state of cure. (Understand)

CO5: Compare different cure systems and vulcanizate properties. (Analyse)

CO 6: Explain the classification of elastomers, preparation, properties, processing and applications of various general purpose elastomers. (Understand)

CO 7: Understand the structure, properties and applications of specialty rubbers. (Understand)

CO8: Understand the properties and applications of thermoplastic elastomers and ionomers. (Understand)

	Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) and High (3)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1		1							1
CO2	3	1	2		1	1						1
CO3	1	1	1									1
CO4	2		1	1	1	1				1		1
CO5	1	2	1	1								1
CO6	2	2	1	1	1						1	
CO7	2	1	1	1	1				1			
CO8	1	1	1	1	1				1			1

Unit 1. Compounding ingredients – Preparation, properties and uses of carbon black. Structure and properties: non-black fillers, plasticizers, antidegradants, accelerators, activators, cross linking agents, reclaimed rubber, factice and special purpose additives.

Unit 2. Rubber vulcanization – Chemistry and technology of vulcanization, sulphur vulcanisation systems: conventional, semi- efficient, efficient, Nonsulphur curing systems: peroxides, metal oxides, sulphur donors, amines, quinone dioxime curing, resins, sulphur chloride, radiation. Analysis of cure characteristics using rheometers, Effect of state of cure and cure systems on properties of rubbers, crosslink density of vulcanisates, cross link density measurement.

Unit 3. Synthetic Rubbers – General purpose rubbers: Manufacture, structure, vulcanization, properties and applications of SBR, polybutadiene and polyisoprene rubber. Special purpose rubbers: Manufacture, structure, properties and applications of Neoprene rubber, EPDM, butyl rubber, nitrile rubber, Modified rubbers: ENR, Halo butyl rubbers, H-NBR, X-NBR.

Unit 4. Specialty rubbers – Manufacture, properties, vulcanization and applications of EVA, polyurethanes, hypalon rubber, silicone rubber and Fluorocarbon rubber. Thermoplastic elastomers: classification, preparation, properties and applications of thermoplastic elastomers based on polyurethane and polyesters. Ionomers: different types, preparation and properties.

References

1. Werner Hofmann, Rubber Technology Handbook, Hanser Gardner Publications (1990).
2. C. M. Blow, C. Hepburn, Rubber Technology and Manufacture, 2nd Edn., Butterworth Scientific (1982)
3. Maurice Morton, Rubber Technology, 3rd Edn., Springer Science Business (1999).
4. Frederick R Eirich, James E. Mark, BurakErman, (Eds.), Science and Technology of Rubber,2nd Edn., Elsevier (2014).

5. J. M. Martin, W. K. Smith, S. C. Bhatia, Handbook of Rubber Technology, Volume 1- Natural, Synthetic Rubber and Technology of Vulcanisation, CBS Publishers and Distributers (2007).
6. Steven Blow, Handbook of Rubber Technology, Galgotia Publications Pvt. Ltd. (1998).

Revised – 10 %

24-214-0405 Plastic Materials

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the advantages, disadvantages and general classification of polymers. (Understand)
CO 2: Understand the various types of additives and their uses in plastic, (Understand)
CO 3: Summarise the production, properties and uses of various general purpose thermoplastics. (Understand)
CO 4: Know the manufacture, properties and uses of various engineering thermoplastics (Understand)
CO 5: Know the manufacture, properties and uses of thermosetting resins based on. phenol, urea and melamine (Understand)
CO 6: Know the manufacture, properties and uses of thermosetting resins based on polyester, epoxy, silicone and PU. (Understand)
CO 7: Know the manufacture, properties and uses of PS and styrene containing polymers and copolymers. (Understand)
CO 8: Know the manufacture, properties and uses of fluorocarbon polymers, vinyl polymers and cellulose derivatives. (Understand)

Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1								1
CO2	3	1	2	1								1
CO3	2	2	2		1	1					1	
CO4	2	1	1	1	1	1	1			1	1	
CO5	2	1	1	1	1	1	1			1	1	
CO6	2	1	1	1	1	1	1			1	1	
CO7	2	1	1	1	1	1	1				1	
CO8		1	1	1	1	1	1			1	1	

Unit 1. Introduction to Plastics – Brief history of plastics, advantages and disadvantages, thermoplastic and thermosetting behaviour, amorphous and crystalline plastics , linear, branched and cross-linked structures. Additives for plastics: antioxidants, fillers, plasticisers, lubricants, fire retardants, blowing agents. General purpose thermoplastics: manufacture,

structure, properties and applications of polyethylene -LDPE, HDPE, LLDPE, cross-linked PE, chlorinated PE, polypropylene, polyvinyl chloride- compounding, formulation.

Unit 2. Engineering thermoplastics – Aliphatic polyamides: manufacture, structure, properties and uses of Nylon6, Nylon66. Polyesters: manufacture, structure, properties and uses of PET, PBT. Manufacture, structure, properties and uses of Polycarbonates, acetal resins, PMMA.

Unit 3. Thermosetting Plastics – Manufacture, curing reaction, moulding powder-ingredients, processes, laminates, properties and uses of phenol formaldehyde resins, urea formaldehyde, melamine formaldehyde, unsaturated polyester resin, epoxy resin, silicone resins.

Unit 4. Miscellaneous - Manufacture, properties and uses of polystyrene, HIPS, ABS, SAN, poly(tetrafluoroethylene) (PTFE), PVA, poly(vinyl acetate), cellulose acetate, polyurethane - flexible and rigid foams.

.

References

1. Marianne Gilbert (Ed.), Brydson's Plastics Materials, 8th Edn., Elsevier (2017).
2. J.A.Brydson, Plastics Materials, 7th Edn., Butterworth Heinemann (1999).
3. Manas Chanda, Salil K. Roy, Plastics Technology Handbook, 4th Edn., CRC press (2006).
4. A. Brent Strong, Plastics: Materials and Processing, 3rd Edn., Pearson Prentice Hall (2006).
5. Olagoke Olabisi, Kolapo Adewale (Eds.), Handbook of Thermoplastics 2nd Edn., CRC press (2016).

Revised- 15 %

24-214-0406: Universal Human Values

Course Outcomes:

At the completion of the course, the students will be able to:

CO 1: Recognize needs, basic guidelines, content and process of value education, explore the meaning of happiness and prosperity (Understand).

CO 2: Understand human being as the co-existence of two realities, self and body and harmony in the individual level (Understand).

CO 3: Verify the possibility of ensuring within the naturally acceptable feelings and express those to the others with an expectation of mutual happiness and mutual prosperity (Apply).

CO 4: Identify the harmony in society, nature and existence and ensuring them through the effort to fulfil the human goal (Apply).

CO 5: Apply the understanding of ethical human conduct to formulate strategies for ethical life and profession (Apply).

Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1			2	2	1	2	2	2	2
CO2			1			2	3	1	3	1	2	2
CO3			1			2	2	3	3	3	2	2
CO4			1			3	3	3	3	3	3	3
CO5			2			3	3	3	3	3	3	3

Unit I: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education. Self- Exploration–Its content and process; 'Natural Acceptance' and experiential Validation as the process for self-exploration. Continuous Happiness and Prosperity – A look at basic Human Aspirations. Right understanding, Relationship and Physical Facility – the basic requirements for the fulfilment of aspirations of every human being with their priority. Understanding Happiness and Prosperity rightly, a critical appraisal of the current Scenario. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Unit II: Understanding Harmony in the Human Being Harmony in Myself. Understanding human beings as a co-existence of the sentient 'I' and the material 'Body'. Understanding the needs of Self ('I') and 'Body' happiness and physical facility. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer). Understanding the characteristics and activities of 'I' and harmony in 'I'.

Unit III: Understanding Harmony in the Family and Society Harmony in Human Relationship. Understanding values in a human relationship; the meaning of Justice (nine universal values in relationships) and the program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship. Understanding the meaning of Trust; Difference between intention and competence. Understanding the meaning of Respect, the difference between respect and differentiation; the other salient values in a relationship. Understanding the harmony in the society (society being an extension of the family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals. Visualizing a universal harmonious order in society Undivided Society, Universal Order from family to world family.

Unit IV: Understanding Harmony in Nature and Existence – Whole existence as Coexistence. Understanding the Harmony in Nature. Interconnectedness and mutual fulfilment among the four orders of nature – recyclability and self-regulation in nature. Understanding Existence as co-existence of mutually interacting units in all pervasive space. Holistic perception of harmony at all levels of existence. Holistic Understanding of Harmony on Professional Ethics: Natural acceptance of human values, Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order. Competence in professional ethics: Ability to utilize professional competence for augmenting universal human order, Ability to identify the scope and characteristics of people friendly and ecofriendly production systems, Ability to identify and develop appropriate technologies and management patterns for the above production systems.

Reference

1. Human Values and Professional Ethics (3rd revised edition) by R. R. Gaur, R Asthana, G P Bageria, Excel Books, New Delhi, 2022.
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 3rd Edition, (2022).
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 5th Edition, (2022).

Revision 0%

24-214-0411 Polymer Synthesis, Modification and Characterisation (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Estimate molecular weight of polymers by different techniques.

CO 2: Modify natural rubber.

CO 3: Prepare specialty polymers.

Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) and High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										1
CO2	2	1	1		1	1	1	1	1			2
CO3	2	1	1		1	1	1	1	1			2

1.Estimation of polymer molecular weights

a) Viscometry

b) Gel permeation chromatography

c) End group analysis

2**. Polymer modification**

a) Cyclised natural rubber

b) Chlorinated natural rubber

c) Liquid natural rubber

3. Preparation of Specialty polymers

a) Preparation of cured epoxy resins.

b) Preparation of cured unsaturated polyester resin.

c) Prepration of polyaniline and its conductivity studies

d) Grafting of NR

References

1. Rabek, Experimental methods in Polymer Chemistry, John Wilely& sons (1998)

2. Stanley R. Sandler, Wolf Karo, Joanne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization: A Laboratory Manual, Elsevier (1998)

3. D. Braun, H. Cherdron, H. Ritter, Polymer Synthesis: Theory and Practice, Springer Science and Business Media (2001)

4. Stanley R. Sandler, Wolf Karo, Joanne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization: A Laboratory Manual, Elsevier (1998)

5. Stanley R. Sandler, Wolf Karo, Joanne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization: A Laboratory Manual, Elsevier (1998)

SEMESTER V

24-214-0501 Plastic Processing

Course outcome

On successful completion of the course the student will be able to

- CO 1: Acquire knowledge on additives for plastic compounding and methods employed for the same. (Understand)
- CO 2: Understand major processing techniques employed for plastics by moulding (injection, blow, compression and transfer), extrusion, thermoforming and casting. (Understand)
- CO 3: Familiarize the machinery and ancillary equipment related to different plastic processing techniques. (Understand)
- CO 4: Predict suitable additives for plastics for the intended application. (Apply)
- CO 5: Choose appropriate processing technique for the manufacture of a plastic product. (Apply)
- CO 6: Establish correlation between various processing techniques with product properties. (Apply)
- CO 7: Evaluate process variables against functional properties of the plastic products. (Evaluate)
- CO 8: Propose troubleshooting mechanisms for defects found in plastics products manufactured by various processing techniques. (Create)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1					1	1		1
CO2	3	1	1		2	2			1		1	
CO3	2	1	1	1	1	1					1	
CO4	2	1	1	1								1
CO5	2	1	1		1	2			1		1	
CO6	1	1	1	1	1	1						1
CO7	3	1	2	1	2	2					1	1
CO8	2		1	1	1	1						1

Unit 1: Introduction to plastic processing – Principles of plastic processing: processing of plastics vs metals and ceramics. Factors determining efficiency of plastics processing: molecular weight, viscosity and rheology, plastic machining techniques. Difference in approach for thermoplastic and thermoset processing. Additives for plastics: antioxidants, light stabilizers, UV stabilizers, lubricants, relative auxiliaries, processing aids, impact modifiers, flame retardants, antistatic

agents, stabilizers and plasticizers. Compounding: plastic compounding techniques, plasticization pelletization.

Unit 2: Extrusion – Principles of extrusion. Features of extruder: barrel, screw, types of screws, drive mechanism, specifications, heating & cooling systems, types of extruders. Flow mechanism: process variables, die entry effects, exit instabilities. Defects: melt fracture, shark skin, bambooing. Factors determining efficiency of an extruder. Extrusion of films: blown and cast films. Tube/pipe extrusion.
Extrusion coating: wire & cable. Twin screw extruder and its applications. Dies and take off equipment. Latest developments in extrusion assisted plastic processing.

Unit 3: Injection molding – Principles, machinery, accessories and functions, process outline, process variables, mould cycle. Types of clamping: hydraulic and toggle mechanisms. Cylinder nozzles. Basic mould types. Reciprocating vs plunger type injection moulding. Thermoplastic vs thermosetting injection moulding. Injection moulding vs other plastic processing techniques. State-of-the art injection moulding techniques.

Unit 4: Compression moulding: Working principles, bulk factor, flow properties, moulding materials, process cycle. Moulding parameters: cure time, temperature and pressure. Preforms and preheating. Types of moulds: positive, semi-positive and flash. Transfer moulding: working principle, equipment, moulding cycle, pot transfer, plunger transfer and screw transfer moulding techniques, advantages over compression moulding.
Blow moulding: principles and terminologies. Injection blow moulding. Extrusion blow moulding. Design guidelines for optimum product performance and appearance. Rotational moulding: process, optimization of moulding cycles, processing parameters, advantages and disadvantages. Thermoforming: principle, vacuum forming, pressure forming, mechanical forming. Casting: working principle, types and applications. Advanced processing methods: 3D printing and 4D printing, types of printing, advantages and disadvantages.

References

1 S. S. Schwart, S. H. Goodman, Plastics Materials and Processes, Van Nostrad Reinhold Company Inc. (1982).
2 W. S. Allen and P. N. Baker, Hand Book of Plastic Technology, Volume-1, Plastic Processing Operations [Injection, Compression, Transfer, Blow Molding], CBS Publishers
and Distributors (2004).
3 M. Chanda, S. K. Roy, Plastic Technology handbook, 4th Edn., CRC Press (2007).
4 I. I. Rubin, Injection Molding Theory & Practice, Society of Plastic Engineers, Wiley (1973).
5 D.V. Rosato, M. G. Rosato, Injection Molding Hand Book, Springer (2012).
6 M. L. Berins (Ed.), SPI Plastic Engineering Hand Book of Society of Plastic Industry Inc., Springer (2012).
7 B. Strong, Plastics: Material & Processing, A, Pearson Prentice hall (2005).
8 D.V Rosato, Blow Molding Hand Book, Carl HanserVerlag GmbH & Co (2003).
9 F. Hensen (Ed.), Plastic Extrusion Technology, Hanser Gardner (1997).

Revision 10%

24-214-0502 Polymer Physics

Course Outcome

On successful completion of the course, the students will be able to:

CO 1:	Correlate the molecular and structural aspects of polymers in predicting crystallinity in polymers and thereby its influence on the functional properties. (Apply)
CO 2:	Understand theories of crystallisation and methods of estimating degree of crystallisation. (Understand)
CO 3:	Acquire the concepts of glass transition process and the theories, other thermal properties. (Understand)
CO 4:	Understand theories of glass transition and factors affecting Tg. (Understand)
CO 5:	To define and calculate size of polymer chain in solution- ideal case and real polymers. (Understand)
CO 6:	Understand theories of polymer solutions and its application in osmotic pressure calculations(Apply)
CO 7:	Understand structure- property relationship in polymers. (Understand)
CO 8:	Understand influence of structural and environmental factors on mechanical properties. (Understand)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1						1		1
CO2	3	1	1	2						1	1	
CO3	3	1	1	2						1	1	
CO4	2		1	1						1		1
CO5	2	1	2	1							1	
CO6	2	1	1	1			1					1
CO7	2	1	1	1			1				1	1
CO8	1	1	1	1			1					1

Unit 1. Crystalline and amorphous structure of polymers – crystallization tendency, structural regularity, chain flexibility, polarity, bulky substituents. Crystal structure of polymers: theories of crystallization, kinetics of crystallization, degree of crystallinity, determination of crystal structure by X-Ray diffraction, crystallinity Vs polymer properties.

Unit 2. Thermal transitions in polymers – glass transition temperature and its measurement. Factors affecting glass transition temperature: chain flexibility, geometric factor, inter-chain attractive forces, co-polymerization, crosslinking, branching, crystallization, plasticization. Theories of glass transition: kinetic, equilibrium and free volume. Melting – Intermolecular bonding, effect of structure and chain flexibility

Unit 3. Solution properties of polymers – End – to – end dimensions, freely jointed chain, real polymer chain, thermodynamics of polymer solutions and blends: Flory-Huggins theory. Flory-Krigbaum theory, osmotic pressure of polymer solutions. Phase diagrams, theta solvents, solubility parameter.

Unit 4. Structure-property relationships: Stress-strain behaviour, creep, stress relaxation, dynamic mechanical analysis, impact, elastic stress-strain relation, deformation of solid polymers. Effect of structural and environmental factors in mechanical properties: molecular weight, cross-linking, crystallinity, co-polymerization, plasticizers, polarity, steric factors, temperature, strain rate, pressure. Mechanical tests: compression vs. tensile

References

1 Robert O. Ebewele, Polymer Science and Technology, CRC Press (2002)
2 Paul C. Hiemenz, Timothy P. Lodge, Polymer Chemistry, 2nd Edn., CRC Press (2007)
3 J.M.G Cowie, Ploymers: Chemistry and Physics of Modern Material, 2nd Edn., Chapman & Hall (1991).
4 L.H. Sperling, Introduction to Physical Polymer Sciences, John Wiley (1993).
5 Manas Chanda, Introduction to Polymer Science and Chemistry – A Problem Solving Approach, CRC Press (2006)
6 Joel Fried, Polymer Science and Technology, CRC Press (2006)
7 Alfred Rudin, The Elements of Polymer Science & Engineering, 2nd Edn., Academic Press (1999)
8 Herman S. Kaufman, Joseph J. Falcetta (Eds), Introduction to Polymer Science and Technology, John Wiley & Sons (1999)
9 Ulf W. Gedde, Polymer Physics, Chapman & Hall (1995)
10 Ulrich Eisele, Introduction to Polymer Physics, Springer-Verlag (1990)

Revision 0%

24-214-0503 Rubber Processing and Product Manufacture

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the machineries used for rubber compound preparation. (Understand)

CO 2: Understand the process of calendering and the machineries used. (Understand)

CO 3: Understand the process of moulding and the machineries used. (Understand)

CO 4: Understand the process of extrusion and the machineries used. (Understand)

CO 5: Appreciate recent status and future prospects of rubber product industries in India. (Understand)

CO 6: Learn the manufacture of foot wears, belts, hoses cables etc (Understand)

CO 7: Learn the manufacturing process of various rubber products such as tyres,seals, sports goods and surgical products. (Understand)

CO 8: Learn the manufacturing process of various rubber products such as bonded articles, rubber covered rollers, tank lining etc . (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO1	2	1	1	1	1							1
CO2	2	1	1	1	2	1			1			1
CO3	2	1	1	1	2	1			1			1
CO4	2	1	1	1	2	1			1			1
CO5	2	2				1		1	1	1		
CO6	3	2	1	1	2	2					1	1
CO7	3	2	1		2	1					1	
CO8	2	1	1									1

Reference

1. C. M. Blow, C. Hepburn, Rubber Technology and Manufacture, 2nd Edn., Butterworth Scientific (1982).
2. Werner Hofmann, Rubber Technology Handbook, Hanser Gardner Publications (1990).
3. P. K. Freakly, Rubber Processing and Production Organisation, Springer Science & Business Media (2012).
4. M.M.Patel, S.B.Rath, R.M.Sambandam, D.Joseph Francis (Eds.), Rubber Engineering by Indian Rubber Institute, Tata McGraw-Hill (1998).

5. J. M. Martin, W. K. Smith, S. C. Bhatia, Handbook of Rubber Technology, Volume 1- Natural, Synthetic Rubber and Technology of Vulcanisation, CBS Publishers and Distributers (2007).
6. J. M. Martin, W. K. Smith, S. C. Bhatia, Handbook of Rubber Technology, Volume 2- Processing, Compounding, Manufacturing and Uses of Rubber, CBS Publishers and Distributers (2007).
7. Steven Blow, Handbook of Rubber Technology, 1st Edn., Galgotia Publications Pvt. Ltd (1998).
8. Robert F. Ohm (Ed.), The Vanderbilt Rubber Handbook, 13th Edn., R. T. Vanderbilt Company, Inc. (1990).

Revision 10 %

24-214-0504 Fibre Science and Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Describe the structural principles of fibres. (Understand)
CO2: Explain the different types of spinning processes and post-processing techniques. (Understand)
CO 3: Summarise the production and properties of general purpose fibers. (Understand)
CO 4: Summarise the production and properties of high performance fibers. (Understand)
CO 5: Understand different types of tests done on fibers (Understand)
CO 6: Understand different post processing of fibers including dyeing. (Understand)
CO7: Learn different chemical treatments for modifying surface chemistry. (Understand)
CO 8: Identify the fibres suitable for reinforcing rubber products. (Analyse

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1								1
CO2	2	1	1	1	1	1	1					1
CO3	2	1	2	1	1	1			1			1
CO4	2	1	2	1	1	1			1			1
CO5	3	2	1	1			1		1			1
CO6	1	1	1						1			1
CO7	2	1		1		1	1				1	1
CO8	3	1	1			1					1	

Unit 1. Fibre basics – Definition of textile terms, use of fibres in rubber and plastic industries, classification of fibres. Structural principles of polymeric fibres: orientation, crystallinity, methods of measurement. Spinning processes: melt, dry and wet spinning, spin finishes, drawing process. Natural fibres: chemical composition, production- cotton, coir, flax, jute, sisal,

hemp, wool, silk, properties and uses.

Unit 2. Synthetic fibres – Manufacture, properties and application areas of viscose rayon, nylon 6, nylon 66, PET, acrylics, Spandex fibres,. High performance fibres: Manufacture, properties and application areas of aramid, carbonand glass fibres

Unit 3. Testing of fibres – Man-made fibres: crimp, fineness, tensile properties, eveness, shrinkage, entanglement, frictional properties. Post processing of fibres: fibre-to-fabric formation, weaving-operation, plain, twill and satin weaves, knitting- operation, warp and weft knits, non-woven fabrics. Bleaching methods, Dyeing of fabrics and types of dyes.

Unit 4. Surface modification of fibres and matrix: chemical treatments-mercerization, acetylation, benzoylation, grafting, coupling agents, maleation. Fibre- rubber matrix adhesion: adhesive treatments for rayon, nylon, polyester, aramid, in-situ bonding system, mechanism of adhesion. Requirements of textile for reinforcement of rubber products. Application of man-made fibres: textile, agriculture, biomedical applications.

References

1. V.B. Gupta, V.K. Kothari (Eds.), Manufactured Fibre Technology, Chapman & Hall (1997).
2. Premamoy Ghosh, Fibre Science and Technology, Tata McGraw-Hill (2004).
3. JorgMussig (Ed.), Industrial Applications of Natural Fibres, John Wiley & Sons (2010).
4. J. W. S. Hearle (Ed.), High-performance Fibres, 1st Edn.,Woodhead Publishing Limited (2001).
5. Bernard P. Corbman, Textiles: Fiber to Fabric, 6th Edn., McGraw-Hill (1985).
6. David B.Wootton, The Application of Textiles in Rubber, RAPRA Technology Ltd. (2001).
7. S.P. Mishra, A Text Book of FibreScience and Technology, New Age International (2000).
8. H.V.Sreenivasa Murthy, Introduction to Textile Fibres, Taylor & Francis (2015).

Revision – 10 %

24-214-0511 Polymer Characterisation and properties (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO1:	Demonstrate the working of equipments used for polymer testing and haracterization.
CO 2:	Understand the characteristic behaviour of polymer raw materials.
CO 3:	Prepare samples for testing.
CO 4:	Determine the mechanical and thermal properties of polymers.

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3								1	1		1
CO2	2	2							1			1
CO3	2	1							1			1
CO4	3	1	1						1			1

Experiments

1. Demonstration of equipment like UTM, TGA, DSC, ODR, UV etc.
2. Determination of MFI of plastic materials
3. Determination of viscosity using Brookfield viscometer
4. Determination of MST, HST, and ZST of latex.
5. Preparation of test pieces
6. Determination of tensile strength and tear strength of rubber and plastic samples.
7. Determination of Resilience, Abrasion Resistance, Flex, Crack Resistance, Compression set, Heat build up, Heat deflection temperature, Hardness.

References

1 BIS, ASTM, ISO Standards

24-214-0512 Analysis of Rubber Compounds and Ingredients (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Analyze the raw materials used for dry rubber compounding.

CO 2: Analyze the filler and sulphur content in rubber compounds / vulcanizates.

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2				1			1			1
CO2	1	2	2			1			1			1

Experiments

1. Estimation of percentage purity of MBT, DPG, ZnO
2. Determination of acid value of stearic acid
3. Determination of Iodine Adsorption number of Carbon black.
4. Analysis of rubber compounds – Carbon black content, Free sulphur content, Total inorganic filler and silica content, Total sulphur content, Bound rubber content, Determination of mooney viscosity, scorch time and cure time
5. Estimation of flash point and fire point of oils.
7. Estimation of Aniline point of oils.
8. Estimation of pour point of wax.

Factory visits: Visit to rubber factories producing extruded and mouldedarticles. Visit to units manufacturing FRP products

References

1 BIS, ASTM, ISO Standards

2 C. M. Blow, C. Hepburn, Rubber Technology and Manufacture, 2nd Edn, Butterworth Scientific (1982).

24-214-0521 Paints and Surface Coatings

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the different components of paint. (Understand)
CO 2: Explain the various resins used in paints. (Understand)
CO 3: Summaries the various types of pigments and its properties. (Understand)
CO 4: Generate appropriate paint formulations. (Apply)

Mapping of course outcomes with program outcomes:Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1			1			1		1	
CO2	3	2	1			1	1		1		1	1
CO3	2	1	1			1	1		1		1	1
CO4	1	1	1	1		1	1	1	1		1	1

Unit 1. Paint basics – Significance of paint, Components of paint: binders, pigments, solvents, various additives. Binders: covertible and non-convertible binders, Alkyd, polyester, silicone, epoxy, acrylic, hydrocarbon, vinyl, formaldehyde based polymers, chlorinated rubber, polyurethanes, fluoro polymers. . Bio-source materials for binders, pigments and other additives

Unit 2. Ingredients – inorganic and organic pigments. Pigment dispersion: properties of pigments, factors affecting dispersions, preparation of pigment dispersion, solvents, extenders, other additives. -Paint manufacturing machinery for pigment dispersion (Ball and pebble mills Roll mills Sand, bead or pearl mills Cavitation mixers Attritors Heavy-duty paste mixers Microflow mills). Formulating Principles, significance of PVC in basic formulation

Unit 3. Painting processes – Surface preparation: mechanical cleaning, solvent cleaning, , common industrial chemical cleaners. Chemical conversion treatment. Paint application: mechanism of film formation. Applying processes: brushing, dip coating and flow coating, curtain coating, roller coating and spray painting. Curing- Physical, chemical and oxidative curing.

Unit 4. Properties of Paints – mechanical, optical, rheological, flammability and environmental properties, paint film defects, Applications.

References

1. R.Lambourne, T.A.Strivens, Paint and Surface Coating: Theory and Practice, 2nd Edn., William Andrew Publishing (1993).
2. Rodger Talbert, Paint Application Handbook (2008)
3. Oil and Colour Chemists' Association, Surface Coatings Vol 2-Paints And Their Applications (1974)
4. Arthur A.Traction, Coatings materials and surface coatings, CRC Press (2007).
5. Rodger Talbert, Paint Technology Handbook, CRC Press (2008).
6. Swaraj Paul, Surface coatings: Science & Technology, 2nd Edn, Wiley(1996).
7. Philip A. Schweitzer, P.E. Paints and coating: Applications and Corrosion Resistance, CRC Press (2005).

Revision - 45 %

24-214-0522 Adhesives Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the basics and theories of adhesion. (Understand)
CO 2: Summarise the different types of resins used as adhesives. (Understand)
CO 3: Design different adhesive joints (Analyse)
CO 4: Identify suitable adhesive formulation for various applications. (Analyse)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					1			1		1	
CO2	3	2	2			1	1		1		1	
CO3		2	2			1			1		1	
CO4		1	2			1	1		1			

Unit 1. Introduction to Adhesives – Adhesive bonding technology, characteristics and functions of adhesives. Adhesive and cohesive failure. Structural and non-structural adhesives. Classification of adhesives. Theories of adhesion: Mechanical interlocking, Electronic theory, Theory of boundary layers and interphases, Adsorption (thermodynamic) theory, Diffusion theory, Chemical bonding theory - Wettability. Surface energy. Contact angle.

Unit 2. Performance of adhesives – Types of stresses acting on adhesive joints: Tension/compression, shear, cleavage and peel stresses. Factors affecting stress distribution. Factors affecting adhesive performance.. Design of adhesive joints. Testing of adhesives and adhesive joints.

Unit 3. Classification and types of adhesives – Classification based on origin, function, chemical composition, and method of reaction: single-part, multi-part, hot-melt, pressure sensitive etc. Thermoplastic and thermosetting resins for adhesives - Epoxy, urethane, acrylic, phenolic, cyanoacrylate, silicone, and water based adhesives ~~etc~~.

Unit 4. Adhesive compositions and applications – Adhesive compounding additives: binders, hardeners, solvents, fillers, plasticizers etc. Formulations. Adhesives for special environments high/low temperature, thermal cycling, vacuum, UV, ozone and corrosive atmosphere. Adhesives for specific substrates. Applications- automotive, aerospace, marine, electrical industry, etc.

References

1. Edward M. Petrie, Handbook of Adhesives and Sealants, McGraw Hill Handbook, 2nd Edn. (2007).
2. Pizzi, K.L. Mittal, Handbook of Adhesive Technology, Marcel and Dekker Inc., 2nd Edn. (2003).

3. Skeist (Ed.), Handbook of Adhesives,Chapman and Hall, 3rd Edn. (1990).
4. Lucas F. M. da Silva, Andreas Ochsner, Robert D. Adams, Handbook of Adhesion Technology (2018)

Revised – 30 %

24-214-0523 Disaster Management

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Differentiate the types of disasters, causes and their impact on environment and society. (Understand)

CO 2: Tell the Do's and Don'ts during various types of disasters. (Apply)

CO 3: Assess vulnerability and various methods of risk reduction measures as well as mitigation. (Analyse)

CO 4: Understand the relationship between disaster and development. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			2			1	1	1	1	1	1	
CO2			2			2	2	1	2	3		
CO3		2				2	2	1	1	1	1	
CO4			1			1	1	1	1	1		

Unit 1. Introduction to Disasters – Definitions: disaster, hazard, vulnerability, resilience, risks. Types of disasters: earthquake, landslide, flood, drought, fire. Classification and causes of impacts including social, economic, political, environmental, health, psychosocial. Differential impacts- in terms of caste, class, gender, age, location, disability. Global trends in disasters: urban disasters, pandemics, complex emergencies, climate change. Dos and Don'ts during various types of disasters.

Unit 2. Approaches to Disaster Risk Reduction (DRR) – Disaster cycle, phases, culture of safety, prevention, mitigation. Preparedness for community based DRR: structural and nonstructural measures. Roles and responsibilities of community, Panchayati Raj Institutions / Urban Local Bodies (PRIs/ULBs), State Government, Central Government, and other stake-holders.Institutional processes and framework at State and Central Level: State Disaster Management Authority (SDMA), Early warning system, Advisories from appropriate agencies.

Unit 3. Inter-Relationship between Disasters and Development – Factors affecting vulnerabilities, differential impacts, impact of development projects such as dams, embankments, changes in land-use. Climate change adaptation: IPCC scenario and scenarios in the context of India. Relevance of indigenous knowledge, appropriate technology and local resources.

Unit 4. Disaster Risk Management in India – hazard and vulnerability profile of India, components of disaster relief: water, food, sanitation, shelter, health, waste management, institutional arrangements (mitigation, response and preparedness). Disaster Management Act

and Policy: other related policies, plans, programmes and legislation. Role of GIS and Information technology components in preparedness, risk assessment, response and recovery, phases of disaster. Disaster damage assessment. Management of industrial disasters.

References

1 J. P. Singhal, Disaster Management, Laxmi Publications (2019).
2 Tushar Bhattacharya, Disaster Science and Management, McGraw Hill India Education Pvt. Ltd. (2012).
3 K.Gupta Anil, Sreeja S. Nair, Environmental Knowledge for Disaster Risk Management, NIDM (2011).
4 Kapur Anu, Vulnerable India: A Geographical Study of Disasters, IIAS and Sage Publishers (2010).
5 Govt. of India: Disaster Management Act , Government of India (2005).
6 Government of India, National Disaster Management Policy (2009).

Revision 0%

24-214-0524 Biodegradable Polymers

Course Outcome

On successful completion of the course, the students will be able to:

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2	2			1	1	1	1	1	1	2
CO 2	3	2	1						1			2
CO 3	1	1	1			1	1	1	1			1
CO 4	2	2	2	1		1	1	1	1			1

Unit 1: Biodegradation of Polymers- Biochemical and Environmental factors, Biodegradability definition, criteria, Biodegradable polymers: Classification based on origin, structure, Physical, mechanical and chemical variations in properties, Surface and bulk erosion, Environmental cues: microorganisms and their role, Microbial degradation, Enzymes: enzyme nomenclature, specificity, factors affecting activity, mechanism of enzymatic degradation, Chemical degradation, Chemically initiated biodegradation: Hydrolysis of natural and synthetic biodegradable polymers. Biodegradation Mechanisms

Unit 2: Biodegradable Plastics - Biodegradable plastics: Natural and Synthetic and Modified Naturally Biodegradable polymers, polysacrides: starch, Starch-Filled Plastics, Thermoplastic Starch, Alternatives for starch based biodegradable plastic films Starch-Based Materials on the Market, cellulose, nanocellulose, plant based and microbial nanocellulose, extraction of cellulose and its derivatives, nanocellulose, hemicellulose, chitin and chitosan, Alginate,Carrageen, protein based and lipid based polymers, PLA, polyhydroxy alkanoates, PEG, PCL, Polyglycolic acid, biodegradable polyurethane. Biodegradable composites- Types, preparation, properties of starch; starch- polymer films: fabrication, properties and testing. Biodegradable plastics and composites for packaging applications: pre-requisite properties and challenges, Evaluation of biodegradation by laboratory, environmental and accelerated test methods,

Unit 3: Biodegradable polyesters- Introduction, History, Bio degradable Polyesters by Radical Ring-Opening Polymerization, Microbial Synthesis of Biodegradable Polyesters: Processes, Products, Applications, Biodegradable Aliphatic Polyesters, Biosynthesis properties and applications of synthetic and bacterial polyesters: crystal structure, morphology, Biodegradable shape-memory polymers, Classes of degradable SMPs, Applications of Biodegradable SMPs, Shape Memory Systems with Biodegradable Polyesters, biodegradation: thermal, hydrolytic, environmental and in vivo degradation. Recycling of Bioplastics: Methods and Challenges, Routes and Benefits. Bioplastics from renewable resources.

Unit 4: Standards and test methods: Standards for evaluation of biodegradability, Criteria for selecting appropriate test standard, screening tests for ready biodegradability, tests for inherent biodegradability, tests for simulation studies, environmental tests, soil burial tests. Aquatic, Aerobic Biodegradation Tests, Compost Biodegradation Tests, Soil Biodegradation Tests, Aquatic, Anaerobic Biodegradation Tests, High-Solids, Anaerobic Biodegradation Tests, Marine Biodegradation Tests

References

1	Catia Bastioli (Editor) Handbook of Biodegradable Polymers ISBN: 1-85957-389-4, ile Rapra Technology Limited, United Kingdom, 2005
2	Andreas Lendlein and Adam Sisson (Editor), Handbook of Biodegradable Polymers: Isolation, Synthesis, Characterization and Applications, ISBN: 978-3-527-63582-5, Wiley-VCH Verlag GmbH & Co. KGaA , 2011.
3	Stoyko Fakirov (Editor), Biodegradable Polyesters, ISBN:9783527330867, Wiley-VCH Verlag GmbH & Co. KGaA 2015.
4	G.J.L Griffin Blackie (Ed.), Chemistry & Technology of Biodegradable Polymers, Academic & Professional London (1994).
5	Yoshiharu Doi, Kazuhiko Fukuda (Ed.), Biodegradable Plastics & Polymers Elsevier (1994).
6	Abraham J.Donb& Others (Ed.), Handbook of Biodegradable polymers.
7	Harvard Academic Publishers Australia (1997).

Revision: 50%

24-214-0525 Polymers and Environment

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Acquire in depth knowledge on the environmental issues related with polymeric materials. (Understand)
CO 2: Understand the polymers used in agriculture and packaging applications. (Understand)
CO 3: Dispose or reuse or recycle the polymeric materials. (Apply)
CO 4: Identify the carcinogenic and noncarcinogenic polymeric materials and chemicals used in polymer industries. (Analyse)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1	1		1	1	1	1	1	1	2
CO 2	2	2	1			2	2	2	2			2
CO 3	3	2	2	1		2	2	2	2	1	1	3
CO 4	3	2	2	1	1	1	1	1	1	1		2

Unit 1. Polymers and Environment – Environmental issues related to polymer industries, design for environment life cycle approach, contribution to energy, feed stock, transport, gross and net calorific value. Effect of plastic waste on wild life, aquatic life and water pollution, positive impact of plastic on environment. Microplastic pollution.

Unit 2. Polymers in agriculture – Greenhouse films, Plastics in mulch films, plastics in silage, drip irrigation system. Polymers in packaging – Common packaging plastics. Biodegradable polymers for agriculture and packaging.

Unit 3. Recycling – PET bottles and thermocol, disposal of waste plastics films. Energy recovery from waste polymer products. Disposal of plastics goods, recycling of e-waste, disposal and recycling of biodegradable plastics and food waste, biogas production, production of cooking gas from waste plastics. Tyre recycling, recycling of dipped goods and non-tyre products.

Unit 4. Flammability of polymers – Release of polymer vapours, ignition, combustion of polymer vapours. Fire propagation, fire resistant polymers. Methods to improve the fire resistance of polymers. Carcinogenic polymers and rubber chemicals.

References

1. Anthony L. Andrady, Plastics and environment, Wiley Inter Science (2003).
2. Prasanth Raghavan, Recycling of Natural Rubber based Waste Tyres – A Green Environment for the Future Recycled Polymers, Chemistry and Processing, Volume 1, Smithers RAPRA (2015).
3. Ian Hamerton, Polymers, the environment and sustainable, JohnWley and Sons (2003).

Revision – 10 %

24-214-0526 Polymers for Packaging

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Compare various bioplastics suitable for packaging. (Understand)
CO 2: Discuss various processing techniques and fundamental properties of packaging materials. (Understand)
CO 3: Explain different methods of packaging (Understand)
CO 4: Identify various packaging for raw as well as cooked food materials to increase shelf life. (Apply)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	1			1	1	1	1	1		2
CO 2	2	1	1			1	1		1			1
CO 3	2	1	1			1	1	1	1	1		1
CO 4	3	2	1		1	1	1	1	1	1		2

Unit 1. Edible and biobased food packaging materials – introduction, advantages & disadvantages. Edible films and coatings : polysaccharide based coatings, lipid based coatings, ~~and~~ protein based coatings, composite materials. Film additives: plasticizers, emulsifiers, antimicrobials and antioxidants. Biobased and Biodegradable packaging materials :first, second and third categories.,~~.~~

Unit 2. Processing and properties of packages – extrusion, calendaring, coating and laminating, stretch blow molding, foamed plastics, closures and sealing systems, vapour deposition, orientation and micro perforation. Optical, tensile, bursting strength, impact strength, crease or flex resistance, coefficient of friction, blocking, orientation and shrinkage. Permeability: single and multilayer materials, gas permeability, water vapour permeability, factors affecting the diffusion & solubility coefficients.

Unit 3. Methods of packaging. Aseptic packaging of foods: Sterilization of Packaging Material Food Contact Surfaces. Active packaging: Active packaging systems and packaging materials, Intelligent packaging. Modified atmospheric packaging: principle, Gases used, methods of creation of MA conditions, applications.

Unit 4. Food packaging – Packaging materials: microwaveable foods, flesh foods, dairy products, cereals, snack foods & confectionary, beverages. Comparison of polymer packaging with paper, metal and glass materials.

References

1. Gordon.L Robertson, Food Packaging: Principles and Practices, CRC Press (2012).
2. R.J. Hernandez, Susan E. M. Selke, John D. Culter, Plastics packaging, Hanser Publishers (2000).
3. Stanley Sacharow, Roger C. Griffin, Jr., Basic Guide to Plastics Packaging, MassachusettsCahners (1973).
4. S. Athalye, Plastics in Packaging, Tata McGraw Hill Publishing Company Ltd. (1992)

Revision – 40 %

SEMESTER VI
24-214-0601 Latex Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Describe the characteristics of NR latex. (Understand)

CO 2: Explain the significance and methods of latex specification tests. (Understand)

CO 3: Explain the basic principles of latex stability and destabilization. (Understand)

CO 4: Get an insight on the various ingredients used for latex compounding. (Understand)

CO 5: Summarise the different types of dipping techniques. (Understand)

CO 6: Identify the role of latex in miscellaneous applications. (Analyse)

CO 7: Design suitable formulations for different latex based products. (Apply)

CO 8: Illustrate and compare various latex product manufacture methods. (Understand)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO 2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO1 0	PO1 1	PO12
CO1	3	1	1			1						1
CO2	3	2	2			1	1			2		2
CO3	2	2	1	1			1			1		1
CO4	3	2	1			1	1		1	1		1
CO5	2	1	2						1		1	1
CO6	1	1	1			1	1		1	1	1	1
CO7	2	2	2	1		2	2	1	1	1	2	1
CO8	2	1	1			1	1		1	1	1	1

Unit 1. Introduction to Natural rubber latex – fundamentals, comparison of natural and synthetic latices, comparative study of rubber goods manufactured from latices and solid elastomers, polymer solution vs polymer latices, viscosity-concentration relationship, latex stability and destabilization.

Unit 2. Latex test methods and compounding – Total solids, dry rubber content, total alkalinity, coagulum content, sludge content, KOH number, mechanical and chemical stability, VFA number, zinc oxide stability. Latex compounding: Principles of latex compounding, de-ammoniating of latex, functions and dosages of vulcanising agents, accelerators, antioxidants, fillers, dispersing and emulsifying agents, stabilisers, thickening agents, special ingredients- Method of preparation of ZnO-sulphur-ZMBT-dispersion with typical formulations, working and parts of ball mill - solutions, dispersions and emulsions, compounding and vulcanisation, pre-vulcanised latex, radiation vulcanisation.

Unit 3. Dipping technology – principle of dipping process - straight dipping, coagulant dipping, different types of formers, dipping process, after treatments. Manufacture of dipped goods: rubber band, medical, household, and industrial gloves, dipped fabric gloves, balloon, nipples, prophylactics, defects in dipped goods. Latex impregnation and spreading. Latex cement and adhesives. Latex based surface coatings. Latex in road rubberisation. Rubber-fibre composite products: coir foam, latex treated rugs and carpet backing.

Unit 4. Latex foam, thread and mouldings – compounding, mechanical frothing by beating, processing methods, vulcanisation, washing and drying. Gelling: merits and demerits. Continuous foam production.. Latex castings and mouldings: principles and production of hollow articles, solid articles, use of porous moulds in casting. Latex extrusion-principle –formulation-equipments-

process- products-quality control - latex thread, latex tubing

References

1 D.C. Blackley, Polymer Latices: Science and Technology, Vol 1, 2 and 3, Springer Science (1997).
2 D. C. Blackley, High Polymer Latices, Vol 1 and 2, Maclaren (1966).
3 Rani Joseph, Practical Guide to Latex Technology, Smithers Rapra (2013).
4 R. F.Mausser (Ed.), The Vanderbilt Latex Handbook, R.T. Vanderbilt Company (1987).
5 David Eaves, Handbook of Polymer Foams, Smithers Rapra Publishing (2004).

Revision – 15 %

24-214-0602 Characterization and Testing Methods

Course Outcome

On successful completion of the course, the students will be able to:

CO 1 Explain the relevance of standards and specifications. (Understand)
CO 2 Distinguish the processability tests used for thermoplastics, thermosets and elastomers. (Analyse)
CO 3 Discuss the thermal, electrical & optical properties of plastics and rubbers. (Understand)
CO4 Summarise the various test methods for evaluating the mechanical properties of the polymers. (Understand)
CO 5 Outline various techniques used for charactersing polymers. (Understand)
CO 6 Distinguish polymer, blends & composites using the test results of characterisation. (Analyse)
CO 7 Explain the test procedures for latex and dry rubber products. (Understand)
CO 8 Summarise the specification test methods of various plastics products. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	1					1						
CO 2	3	2	1			1	1			1	1	1
CO 3	2	2	1	1		1	1		1	1	1	1
CO 4	3	2	2	2			1		1	1	1	1
CO 5	2	2	1	1					1			1
CO 6	2	2	1	1		1			1			1
CO	3	2	2	1		1	1		1			1

7												
CO 8	2	1	1			1	1		2	1	1	1

Unit 1. Introduction – Standard organizations: BIS, ASTM, ISO, BS, DIN etc. Standards and specifications. Importance of standards in the quality control of polymers and polymer products. Preparation of test pieces, conditioning and test atmospheres. Tests on dry rubber: processability parameters of rubbers - plasticity, Mooney viscosity, scorch time, cure time, cure rate index Processability tests carried out on thermoplastics and thermosets: MFI, cup flow index, gel time, bulk density, bulk factor.

Unit 2. Mechanical properties of plastics and rubber: Tensile, compressive, flexural, tear strength, dynamic stress-strain, hardness, impact strength, resilience, abrasion resistance, creep and stress relaxation, compression set, dynamic fatigue, ageing properties.Thermal properties: specific heat, thermal conductivity, thermal expansion, heat deflection temperature, Vicat softening point.Electrical properties: resistivity, dielectric strength, dielectric constant.Optical properties: transparency, refractive index, haze, gloss.Tests for chemical resistance. acids, alkalies. Flammability tests- oxygen index test. Tests for weather resistance. Gas permeability.

Unit 3. Characterisation of polymers, blends and composites – X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Ultraviolet-Visible Spectroscopy, Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), Scanning Electron Microscopy (SEM), and Transmission Electron Spectroscopy (TEM), Atomic Force Microscopy (AFM).

Unit 4. Testing of latex products: dipped goods - gloves (surgical, examination, household, industrial), prophylactics, balloons, foam, latex thread. Testing of dry rubber products: footwear, hose, belts (conveyor & power transmission).Testing of plastic products: containers, pipes, films, laminates.

References

1. ISO, BIS, ASTM, BS and DIN standards.
2. R.P.Brown, Plastic test methods, 2nd Edn., Harlond, Longman Scientific, (1981).
3. Vishu Shah, Handbook of Plastic Testing Technology, 3rd Edn., John Wiley & Sons (2007).
4. R.P.Brown, Physical Testing of Rubbers, 4th Edn., Chapman Hall (2006).
5. J.F.Rabek, Experimental Methods in Polymer Chemistry, John Wiley and Sons (1980).
6. M.M.Woolfson, An Introduction to X-Ray Crystallography, 2nd Edn., Cambridge University Press, Vikas Publishing House (1997).
7. F.Majewska, H.Zowall, Handbook of analysis of synthetic polymers and plastics, Ellis Horwood Limited Publisher (1977).

Revision 10%

24-214-0603 Polymer Products Design

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the various steps involved in plastic products design process. (Understand)

CO 2: Understand general relationships between polymer structure and properties. (Understand)

CO 3: Understand the fundamentals of designing plastic beam and plates. (Understand)

CO 4: Analyse the stress on plastic beams and plates. (Analyse)

CO 5: Understand the fundamentals of various plastic products design features. (Understand)

CO 6: Understand the principles of designing walls, tapers, blind holes, gate and undercuts. (Understand)

CO 7: Understand the theory of damping and types of dampers. (Understand)

CO 8: Understand the candidate materials and various design features of vibration dampers. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1				1					
CO2	2	1									1	
CO3	2	1	1			1				1		1
CO4	1	3	2						1			1
CO5	3	1	1						1		1	1
CO6	2	1	1			1			1		1	1
CO7	2	1										1
CO8	2	1	1						1		1	1

Unit 1. Product design – Principles, functional design, aesthetic design, plastics structure, physical and chemical properties, effect of fillers on properties and performance.

Unit 2. Beams and plates – Structural design, dynamic load response, cyclic loading, design for stiffness, processing limitations, design of products for static and dynamic loads, cost estimation, cost reduction methods.

Unit 3. Design features – Inside sharp corners, ribs, tapers or draft angles, weld lines, gate size and location, wall thickness, tolerance, internal plastic threads, blind holes, undercuts, thermoplastic hinge and snap fitting.

Unit 4. Vibration dampers: basic vibration damping relations, octave rule for damped systems, estimating damping in structures, controlling resonant peaks with damping, response of damped structures to shock.

References

1 E. Miller, Plastics Products Design Handbook (Part A and B), Marcel Dekker (1983).

2 Paul F. Mastro, Plastics Product Design, Scrivener Publishing (2016)

3 C. Hepburn, Elastomers: Criteria for Engineering Design, Applied Science Publishers (1979).

4 J.B. Dym, Product Design with Plastics - Industrial Press Inc. (1983).

5 D. Beck Ronald, Plastic Product Design, Van Nostrand Reinhold Company (1980).

Revision – 25 %

24-214-0604 Polymer Rheology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the different models used to represent viscoelastic materials. (Understand)
CO 2: Analyse the models mathematically to derive appropriate governing equations and predict the behaviour of the system. (Analyse)
CO 3: Understand the effect of time and temperature on viscoelastic materials. (Understand)
CO 4: Summarise the effect of temperature and frequency on the dynamic mechanical properties of polymers. (Understand)
CO 5: Understand the different types of non-Newtonian fluids. (Understand)
CO 6: Analyse the factors that affect the flow behaviour. (Understand)
CO 7: Understand the flow behaviour of fluids through simple geometries. (Understand)
CO 8: Understand the principles of different types of viscometers. (Understand)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1										1
CO2	2	3										1
CO3	2	1							1			1
CO4	1	2	1						1	1		
CO5	3	1	1						1	1		1
CO6	1	2	1			1					1	1
CO7	2	1	1		1	1		1	1		1	1
CO8	3	2	1			1			1		1	1

Unit 1. Polymer viscoelasticity – Response of Ideal elastic solid, pure viscous flow, viscoelastic solids and fluids, mechanical models for linear viscoelastic response: Max well and Voigt-Kelvin models, four parameter model; material response time-Deborah number, relaxation and retardation time, generalized Maxwell-Weichert model, generalized Voight element, Problems.

Unit 2. Superposition principles: Boltzmann superposition, time temperature superposition, WLF equation, shift factor, Problems. Dynamic measurements: storage, loss modulus, loss tangent and complex modulus, effect of frequency, temperature, molecular weight, cross-linking, crystallinity;

fatigue, hysteresis, rebound resilience; Rubber elasticity: ideal rubber, entropic elasticity..

Unit 3. Polymer flow behaviour – Newtonian flow, non – Newtonian flow, pseudoplastic, Bingham, dilatant, thixotropic and rheopectic behaviour. Factors influencing flow behaviour: molecular weight and distribution, chain branching, temperature, plasticizers and fillers. Flow of Newtonian fluids in simple geometries – circular cross-section, parallel plates.

Unit 4. Flow properties – Power-law fluids, Rabinowitsch correction, entry and exit effects, Bagley correction factor- estimation, Carreau equation. Measurement techniques: capillary viscometers, coaxial cylinder viscometer, cone and plate viscometer, advantages and disadvantages. Flow defects: melt fracture, shark-skin, die swell. Problems.

References

1. Robert O. Ebewele, Polymer Science and Technology, 1st Edn., CRC Press (2000).
2. R. J. Crawford, P. J. Martin, Plastics Engineering, 4th Edn., Butterworth-Heinemann (2020).
3. R.P. Chhabra, J.F. Richardson, Non-Newtonian Flow and Applied Rheology: Engineering Applications, 2nd Edn., Butterworth-Heinemann (2008).
4. J. A. Brydson, Flow properties of polymer melts, 2nd Edn., Godwin (1981).
5. B.R. Gupta, Applied Rheology in Polymer Processing, Asian Books Private Limited (2006).
6. John M. Dealy, Kurft F. Wissbrun, Melt Rheology and its Role in Plastics Processing, Springer (1999).
7. F. N. Cogswell, Polymer Melt Rheology – A guide for Industrial Practice, Woodhead Publishing (1981).
8. Lawrence E. Nielsen, Robert F. Landel, Mechanical properties of Polymers and Composites, 2nd Edn., Marcel Dekker, Inc. (1994).

Revision – 30 %

24-214-0611 Latex Technology and Dry Rubber (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Test natural rubber (dry & latex) as per the specification.
CO 2: Prepare different natural rubber products (dry and latex).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1								1		
CO2	3		1						1		1	1

1. Preparation of dispersions and emulsions.
2. Dry Rubber Testing – Homogenization, volatile matter, ash content, initial plasticity and PRI, dirt content, nitrogen content.
3. Latex Testing – DRC, TSC, total alkalinity, VFA number, MST, coagulum content, Magnesium content, sludge content, KOH number, Cu content, Manganese content.
4. Determination of Mooney viscosity and cure time of natural rubber compound.
5. Creaming of natural rubber field latex.
6. Effect of viscosity modifier on thickness of latex deposits.
7. Preparation of rubber bands, balloons, finger caps, household and surgeons gloves, latex foam, latex based adhesives.
8. Preparation of rubber products like play balls, injection bottle caps, teats, tea-mats, M.C.Sheet, Vstraps, sponge.

Factory visits:

Visit to units producing dipped goods, latex foam, carpet backing, latex thread and other latex products.

References

1. BIS, ASTM, ISO Standards

2. D.C.Blackely, High Polymer Latices, Vol. I & II, Applied Science Publishing

24-214-0621 Polymers for Electrical and Electronics Applications

Course Outcome

On successful completion of the course, the students will be able to:

CO 1:	Describe the structure, theory and properties of organic and inorganic semiconductors. (Understand)
CO 2:	Explain the different preparation methods of conducting polymers. (Understand)
CO 3:	Outline the properties and processing of conducting polymers. (Understand)
CO 4:	Identify the application and device fabrication of conducting polymers. (Analyse)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12
CO1	3				2		1					1
CO2	2	1		2								1
CO3	3	1				1				1		1
CO4	2	1	1	1			1				1	1

Unit 1: Introduction to semiconductors, Semiconductor Theory: Definition and Fundamentals, Organic and inorganic semiconductors, Classification of materials based on electrical conductivity. Basic laws on electrical conductivity: Ohms law and Coulomb's law. Valance band theory-basic concept of band model. Conducting polymers, Classification of conducting polymer, Concept of doping, n-Type and p-Type doiping, Electrochemistry of electronically conducting polymers-source of electronic conduction in polymers, polaron, bipolaron, conduction mechanism. p-n junctions. Oxidative and reductive dopants. Inorganic and organic dopants. Type of doping technique. Charge carriers polarons, bipolarons and solitons. Effect of doping on the properties of organic and organic semiconductors. Effect of temperature on conductivity of inorganic and organic semiconductors.

Unit 2: Discovery and synthesis of important conducting polymers – Discovery of organic conductors. Discovery of polyacetylene and polyanilene. Properties of conducting polymers Structure-property relationship. Synthesis of intrinsically conducting polymers and extrinsically conducting polymers, chemical oxidative polymerization and electrochemical synthesis of organic conductors: Polyaniline (PANI), Polypyrrole (PPy), Polythiophene (PTh), Poly-para – phenylene etc. Step growth polymerization and chain growth polymerization of conducting polymers, Fabrication of conducting polymer blends and composites. Preparation of conducting polymer nanocomposites. Synthesis of intrinsically conducting and extrinsically conducting nanofibers. Preparation of elastomeric conducting polymers and fiber reinforced thermosetting conducting polymers. Production of conducting polymer waterborne latex. Pros and cons of conducting polymers

Unit 3: Properties and Processing of conducting polymers – Important properties of conducting polymers: thermal properties, electrical and mechanical properties. Charge storage and electronic properties. Processing of conducting polymers. Solution processing, melt processing, latex stage processing, in-situ polymerization and in-situ synthesis. Methods to enhance the processability of conducting polymers.

Unit 4: Analytical Techniques for Characterization and testing of conducting polymers: Impedance spectroscopy, Thermo gravimetric analysis, Scanning Electron microscopy (SEM), Transmission electron microscopy (TEM), Electrical and ionic conductivity measurement. Temperature dependant ionic transportation in polymers. Applications of conducting polymers: Rechargeable batteries, supercapacitors, optical applications, display systems, o-LED, antistatic coating, Telecommunication system, Electromagnetic screening material, aerospace applications.

References

1	Tony Blythe, David Bloor, Electrical Properties of Polymers, 2nd Edn, Cambridge University Press. (2005).
2	H.S. Naiwa, Organic conductive molecules and polymers, John wiley and sons; vol. 2,

	(1977).
3	Prasanth Raghavan, Jabeen Fatima (Eds.), Polymer and ceramic electrolytes for energy storage devices, First Edition, Taylor and Francis, CRC Press (2020).
4	Neethu T. M. Balakrishnan, Prasanth Raghavan (Eds.), Electrospinning for advanced energy storage applications, Springer-Nature (2020).
5	J. L. Bredas, R. Silbey, Conjugated polymers, Kluwer, Dordrecht (1991).
6	Pradip Kar, Doping in Conjugated Polymers, Scivener Publishing (2013).
7	J. Margolis, Conducting Polymers and Plastics, Chapman and Hal (1993).
8	M.E.O.Lyons (Ed.), Electroactive polymers, Plenum Press (1994).

Revision: 30%

24-214-0622 Footwear Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the operations involved in footwear manufacture. (Understand)

CO 2: Select required adhesives and synthetic fabrics for footwear. (Analyse)

CO 3: Identify various footwear components and processes. (Apply)

CO 4: Understand the process of specialty footwear manufacture. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		1		1	1					1	1
CO2	3	1	2		1	1						1
CO3	2		1		1	1				1		1
CO4	2				1	2		1		1	1	2

Unit 1. Introduction of foot wear, types, and parts of foot wears, structure of safety footwear, Benefits of synthetic midsole and Fussbett in foot wears**.** Production of Footwear- unit operations involved in making footwear. 'Built-up' footwear: DVP/DIP (Direct Vulcanising / Direct injection Moulding) process. Non-rubber materials used for footwear manufacture: leather, thermoplastics and textiles. Environmental impact of footwear and footwear materials, recycling of footwear.

Unit 2. Adhesives and Synthetic Fabrics in Footwear – Adhesive formulations involving starch, glue, latex rubber solutions, chloroprene, polyurethane (PU) etc. Properties of adhesives & their choice for different purposes and in construction as in DIP, DVP, cemented etc. Mechanism of adhesion. Fabrics used: cotton, rayon, nylon, polyester. Treatment of textiles for combining with rubber. Textiles for Protective Military Footwear, Textiles and other Materials for Orthopaedic Footwear Insoles,

Unit 3. Cellular and Microcellular Materials – Natural and synthetic rubber based microcellular materials: PU, polyvinyl acetate, PVC, ethylene vinyl acetate (EVA), thermoplastic elastomers in microcellular soling; Mixing and moulding, Direct vulcanizing / injection processes. Designing of

MC sheets, Recent innovations in footwear manufacturing, high performance materials, smart materials and Sustainable Materials for footwears.

Unit 4. Specialty and moulded footwears – Footwear's for sports: parts of sport wears, Relation between surface, activity and footwear, materials and method of construction, role of textile materials in sports footwears, preparation of uppers, sequence of operations. Sponge rubber moulded on slippers. Orthopaedic footwear: components, materials and construction. Soled rubber moulded on footwear. Thermoplastic injection moulded on footwear. Cellular PU moulded on footwear. Mountaineering / hiking shoes, fireman, and oil refinery shoes. Materials for fire fighting, mining and oil fileds. Footwear for Cold Weather Conditions, Green footwear, 3D printed foot wears and their market forecast.

References

1. J.H. Thornton, Text Book of Footwear Manufacture, National Trade Press Ltd., 3rd E Edition. (1970).
2. A. Luximon (Editor), Handbook of Footwear Design and Manufacture, ISBN: 9780128216064, 2nd Edition, Elsevier, UK (2021)
3. J. Blakeman, An Introduction to Applied Science for Boot and Shoe Manufacture, The Anglo American Technical Co.Ltd. (1935).
4. Ravindra S. Goonetilleke, Science of Footwear, ISBN 9781138077843, Taylor & Francis Group, CRC Press, (2013).
5. I.A. Skoggard, Modern Shoe Making– Lasting, SATRA Publication, (1996)
6. A. J. Harvey, Footwear Materials and Process Technology, LASRA Publications, 2nd Edition (1982).

Revision 50%

24-214-0623 Polymer Recycling

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Explain the need and benefits of polymer recycling. (Understand)
CO 2: Describe primary and secondary recycling aspects. (Understand)
CO 3: Explain tertiary and quaternary recycling routes. (Understand)
CO 4: Understand the recycling of commingled plastic and rubber wastes (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1				2					
CO2	3	2	1			2	2					1
CO3	3	2	1			2	2					1
CO4	2	1	1			2	1	1			1	1

Unit 1. Introduction to polymer recycling – Need, benefits. Micro plastics and their health hazards. Sorting and Separation Techniques: manual, density based, optical, advanced

spectroscopic based, electrostatic. Recycling methods: primary, secondary, tertiary and quarternary.

Unit 2. Primary/secondary recycling (mechanical recycling) – Stages of recycling: pre-sorting, size reduction separation - separation of non-plastics, light contaminants, plastic-plastic separation. Cleaning and conversion into products. Recycling of Polyolefins, PVC, Polystyrene,. Recycling of Engineering Thermoplastics: Nylons, polycarbonate. Recycling of polyesters and polyurethanes. Recycling of biodegradable polymers and polymer composites. Generation of micro plastic in polymer recycling. Recycling of micro plastics and their challenges

Unit 3. Tertiary recycling – Modes of decomposition. wet process : PET - glycolysis, methanolysis, hydrolysis, PMMA - catalytic cracking, PU - glycolysis, hydrolysis and alcoholysis, Nylon - hydrolysis. Dry process -pyrolysis and gasification. Catalytic cracking of polyolefins. Feedstock recycling of plastic wastes: chemical depolymerisation, gasification and partial oxidation, thermal process, catalytic cracking and reforming, hydrogenation. Quarternary recycling: energy recovery from plastic waste, incineration.

Unit 4. Recycling of commingled plastics, thermosets and rubber – Commingled plastics recycling: problems methods, applications. Recycling of thermoset waste: problems, recycling technologies - mechanical, thermal & chemical recycling process, and uses of recyclates. Rubber recycling: crumb rubber, reclaimed rubber devulcanization techniques, compounding with devulcanized rubber, properties and applications. Tyre recycling: Energy recovery from waste tires- Pyrolysis of waste rubber and plasma me- conversion of used tire to carbon black and oil. Recycling of dipped goods: gloves and contraception condoms. Polymer recycling and circular economy.

References

1 John Scheirs, Polymer Recycling: Science, Technology and applications, John Wiley and Sons Ltd (2001)
2 G. Akovali, C. Bernardo, J. Leidner, L. A. Utracki, M. Xantho (Eds.), Frontiers in the Science and Technology of Polymer Recycling, 2nd Edn., Spriger Science and Business media (2013).
3 R. J. Ehirg (Ed.), Plastics Recycling: Products and Processes, Hanser Publications (1992).
4 Sadhan K. De, AvraamIsayev, KlementinaKhait (Eds.), Rubber Recycling, CRC Press (2005).
5 J. Aguado, D. Serrano, James H. Clark (Ed.), Feedstock Recycling of Plastic Wastes, The Royal Society of Chemistry (1999)
6 A. L. Andrady, Plastics and the Environment, John Wiley and Sons (2003).
7 J. Brandrup, M. Bittner, W. Michacli, G. Menges, Recycling and Recovery of plastics, Hanser Publications (1996).

Revision 50%

24-214-0624 Specialty Polymers

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Summarise the different types of high temperature resistant polymers. (Understand)

CO 2: Understand the synthesis and properties of ionic polymers. (Understand)

CO 3: Develop polymers possessing novel properties. (Apply)

CO 4: Get an insight of the polymers used in concretes, propellants and explosives. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		1			1					1	1
CO2	2	3			1	1						1
CO3	2	1	1	2	1							1
CO4	1	1		1	1		2				1	1

Unit 1. High temperature and fire resistant polymers – fluoropolymers, aromatic polymers, hydrocarbon polymers, polyphenylene sulphide, polysulphones, polyesters, aromatic polyamides, polyketones, heterocyclic polymers, fire resistant polymers: Inorganic and semiorganic polymers. Intrinsically fire-resistant polymers- Linear, single-stranded polymers with cyclic aromatic components (Polyimides, polybenzoxazoles (PBOs), polybenzimidazoles, and polybenzthiazoles (PBTs), Ladder polymers, flame retardant additives and fillers.

Unit 2. Ionic polymers – Synthesis and physical properties: Ion-exchange, hydrophilicity, applications, single ion conductors, Electron and proton conducting polymers, ionomers based on polyethylene, elastomeric ionomers, ionomers based on polystyrene, PTFE, ionomers with polyaromatic backbones. Polyelectrolytes: ion exchangers, polyelectrolytes based on carboxylates, polyelectrolyte complexes. Water soluble polymers, edible polymers, Poloxamers and their applications.

Unit 3. Polymers with novel properties – Liquid crystalline polymers (LCPs): concept of liquid crystalline (LC) phase, liquid crystalline polymers and their classification, main chain LCPs and side chain LCPs, structure-property relationship, applications of LCPs. Conducting polymers: charge carriers, doping, synthesis of polyacetylene, polyaniline, polypyrrole, polythiophene. Photoconducting polymers. Polymers with, pyroelectric and ferroelectric properties.

Unit 4. Polymers for special applications – Polymer concretes, polymer binders for propellants, polymer-bonded explosives, polymer binders for energy storage devices. Speciality polymeric materials used in telecommunication, space applications and power transmission. Polymers in agricultural applications: green houses, mulches, control release of agricultural chemicals and micronutrients .

References

1 Manas Chanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, CRC Press (2009).

2 Faiz Mohammad (Ed.), Specialty Polymers: Materials and Applications, I.K. International

Pvt. Ltd, (2008).
3 Manas Chanda, Salil K.Roy, Plastics Technology Hand book, 5th Edn., CRC press (2018).
4 Jiri George Drobny, Polymers for Electricity and Electronics – Materials, Properties and Applications, 1st Edn., John Wiley & Sons (2012).
5 Pardip Kar, Doping in Conjugated Polymers, John Wiley & Sons (2013).
6 Robert William Dyson (Ed.), Specialty Polymers, Springer (2012).

Revision 25%

24-214-0625 Materials Science

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand classification, crystallography, and fundamentals of thermodynamics and kinetics of materials. (Understand)
CO 2: Understand the mechanical behaviour and testing of materials. (Understand)
CO 3: Outline the processing and properties of materials. (Understand)
CO 4: Describe the characterization techniques and applications of materials. (Understand)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1								1	1
CO2	2	2	1	1			1				1	1
CO3	2	1		1		1	1					1
CO4	1	1	1	1		1	1					1

UNIT 1: Basics of Materials Science: Introduction to materials science, Classification and properties of materials- metals, ceramics, polymers, carbon materials, metal oxides, magnetic materials and composites. Classification based on electronic properties: conductors, insulators and semiconductors. Bonding in materials: metallic, ionic, covalent and mixed bonding, Band theory of materials. Structure of materials: fundamentals of crystallography, symmetry operations, crystal systems, Bravais lattices, unit cells, primitive cells, crystallographic planes and directions; structures of metals, ceramics, polymers, amorphous materials and glasses. Defects in crystalline materials: 0-D, 1-D and 2-D defects; vacancies, interstitials, solid solutions in metals and ceramics, Frenkel and Schottky defects; dislocations; grain boundaries, twins, stacking faults; surfaces and interfaces.

UNIT 2: Thermodynamics and properties of materials: Extensive and intensive thermodynamic properties, laws of thermodynamics, phase equilibria, phase rule, phase diagrams (unary and binary), Reaction kinetics, fundamentals of diffusion, Fick's laws, their solutions and applications. Solidification of pure metals and alloys, nucleation and growth, diffusional solid-state phase transformations (precipitation and eutectoid), martensitic transformation.
Properties of Materials. Mechanical properties: Mechanical properties of metals, ceramics, polymers, carbon materials and composites; stress-strain response (elastic, anelastic and plastic deformation).

Electronic properties: electronic conductivity, ionic conductivity, Hall effect, dielectric properties of materials, piezo- and ferro-electric behaviour.
Magnetic properties: Origin of magnetism in materials, para-, dia-, ferro- and ferrimagnetism.
Thermal properties: Specific heat, heat conduction, thermal diffusivity, thermal expansion, and thermoelectricity.
Optical properties: Refractive index, Dispersion, Transmittance and Transmission coefficient, Absorption, Scattering, Turbidity, Reflectance and Reflectivity (reflection coefficient), Albedo.

UNIT 3: Synthesis and Processing of materials: Synthesis of materials: bulk materials, thin films, nanomaterials and composites. thin film deposition: evaporation and sputtering techniques, and chemical and physical vapour deposition, pulsed laser deposition, arc discharge, laser ablation, Molecular Beam Epitaxy (MBE), solid state synthesis, water assisted synthesis, electrochemical synthesis, sol-gel synthesis of metal oxides. Synthesis of colloids and magnetic fluids. Preparation of carbon materials. Processing of materials: melt processing and solution processing. Processing of metals: Casting, Forging, Rolling, Bulk deformation and Extrusion. Processing of polymers and ceramic. 3D and 4D printing, Electrospinning and Electro forestic deposition.

UNIT 4: Characterization and applications of materials: X-ray diffraction; spectroscopic techniques such as UV-Vis, IR and Raman; optical microscopy, electron microscopy. Tensile and modulus test, hardness measurement. Impedance analysis, Electrical conductivity, carrier mobility and concentrations. Thermal analysis techniques: thermogravimetry and calorimetry. Applications of materials: Materials for energy storage: batteries, super capacitors, fuel cells Optical applications: optical fibers, lenses and display systems, data storage, solar cell, and electronic applications, Medical, Biomedical and aerospace application.

Reference

1. William D. Callister Jr., David G. Rethwisch, Materials Science and Engineering: An Introduction, 10th Edn., Wiley & Sons, (2018).
2. Pradeep P. Fulay, Donald R. Askeland, Essentials of Materials Science and Engineering 2nd Edn., Cengage (2013).
3. I P Singh, Materials Science And Engineering 13th Edn., Jain Brothers, (2010).
4. R. Balasubramaniam, Callister'S Materials Science And Engineering: Indian Adaptation, IND-W, (2007).
5. Prasanth Raghavan, Jabeen Fatima (Eds.), Polymer and ceramic electrolytes for energy storage devices, First Edition, Taylor and Francis, CRC Press (2020).
6. Neethu T. M. Balakrishnan, Prasanth Raghavan (Eds.), Electrospinning for advanced energy storage applications, Springer-Nature (2020).

Revision 50%

24-214-0626 Introduction to Biomaterials and Medical Devices

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Obtain a comprehensive knowledge on fundamentals of biomaterials and its real demand in medical field (Understand)

CO 2: Apply the know-how as a criterion to predict tissue – biomaterial interactions and associated inflammatory reactions in our body (Apply)

CO 3: Validate the performance of a biomaterial in vitro as per the international standards based on the in vitro results (Evaluate)

CO 4: Design of simple biomaterials for biomedical applications (Create)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1		1		2					1
CO2	2	1	2				1	1				1
CO3	1	1	1	1	2		1	1				1
CO4	1		1	1	3	2						1

Unit 1. Biomaterials – Definition, Contemporary demand and clinical implications, Classification: based on origin, material, functionality, degradation and duration of implantation. Biological systems, Prerequisites of a biomaterial, Concept of biocompatibility, Classifications and Behavior of biomaterials - Natural and synthetic biomaterials, Bioactive, Bioinert and Bioresorbable biomaterial, Biodegradation and its mechanisms, Design Factors for Biomaterials, Typical examples for polymers used as biomaterials: Cellulosic materials, nanocellulose and bacterialcellulose, hemicellulose, lignin and tannin, ultrahigh molecular weight polyethylene, poly(methyl methacrylate), silicone, Polydimethylsiloxane (PDMS), polyurethanes, polylactic acid, polyglycolic acid and its copolymers, polycaprolactone, chitin and chitosan, ceramic and metals, bioceramic and advanced bioceramic and carbon materials, foams, hydrogels and aerogels

Unit 2. Tissue Engineering (TE) – Principles of TE, Biomimetics: Concept and its role in the advancement of tissue engineering, polymeric tissue engineering scaffolds, Design Challenges in Polymeric Scaffolds for tissue engineering, tuning of degradation and biosorbale properties of implantable 3D scaffolds, Surface functionalization of polymers and techniques employed, Tissue-biomaterial interactions, Inflammatory responses associated with implantation of a biomaterial. Sterilization of biomaterials, classification- physical and chemical sterilization methods, Different methods of sterilization: dry heat, UV irradiation, autoclave, ethylene oxide, gamma radiation, selection of suitable sterilization method for biomaterials. Sterilization of Sensitive Biomaterials with Supercritical Carbon Dioxide at Low Temperature. Mechanical properties of sterilized biomaterialsmaterials

Unit 3. Biomaterials Characterizations – Physicochemical Characterizations, *In vitro* cytocompatibility tests: trypan blue dye exclusion, MTT, live/dead assay, *In vitro* biofunctional assays, *In vivo* assays: importance and evaluation in animal models, Requirement of standards for validation of biomaterials: ISO and ASTM standards followed for biomaterials and medical devices. Pre-clinical evaluation.

Unit 4. Biomedical Devices – Definition, design of a typical medical device, Medical devices: extracorporeal devices (hemodialysis, apheresis, ultrafiltration), Oxygenators, Vascular grafts, blood bag, Implants: soft tissue implants and hard tissue implants, Bone cement, Advanced drug delivery devices, Polymeric prosthetic heart valves

References

1 Joon Park, R. S. Lakes, Biomaterials: An Introduction , 3rd Edn, Springer Science, New

York (2007)
2 Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science: An Introduction to Materials Science, 3rd Edn, Elsevier Academic Press (2004)
3 Medical Biomaterials by Prof. Mukesh Doble, IIT Madras, https://nptel.ac.in/courses/102106057/, available from 13/03/2017
4 Biomaterial for Bone Tissue Engineering Applications, Coordinated by IISc Bangalore https://nptel.ac.in/courses/113108071/#, available from 22/08/2016
5 Biomedical Nanotechnology, Coordinated by IIT Roorkee https://nptel.ac.in/courses/102107058/ available from 08/06/2016
6 Introduction to Biomaterials, Coordinated by IIT Kanpur https://nptel.ac.in/courses/113104009/#, available from 04/07/2012
7 Biomaterial-Tissue Interactions Instructors - Prof.IoannisYannas and Prof. Myron Spector MIT Course Number 20.441J / 2.79J / 3.96J / HST.522J
8 J. C. L. Schuh, K. A. Funk, Compilation of International Standards and Regulatory Guidance Documents for Evaluation of Biomaterials, Medical Devices, and 3-D Printed and Regenerative Medicine Products. ToxicolPathol. 2019; 47(3):344-357. Doi: 10.1177/0192623318804121.

Revision 25%

SEMESTER VII

24-214-0701 Polymer Composites and Blends

Course Outcome

On completion of the course, the students will be able to

CO1: Summarize the resins used in the manufacture of FRP. (Understand)
CO2: Understand the manufacture and properties of fibres used for FRPs. (Understand)
CO3: Derive the properties of the continuous and short fibre composites theoretically. (Understand)
CO4: Understand the mechanism of failure of composites (Understand)
CO5: Summarise the various techniques used for the manufacture of FRPs. (Understand)
CO 6: Compare the advantages and limitations of the different manufacturing process of FRPs. (Analyse)
CO 7: Outline the basic concepts and preparation of different types of blends. (Understand)
CO 8: Interpret the polymer blends based on its characterisation. (Apply)

Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1			1	1		1	1		1
CO2	3	1	1			1	1		1	1		1
CO3	2	2	1			1			1		1	1
CO4	1	2	2						1			1
CO5	2	1	1			2	1		1	1		1
CO6	1	2	1			1	1		1			
CO7	2					1	1			1		
CO8	1	2	1						1		1	1

Unit 1 Introduction to composite materials, classification – particulate, flake, fibrous, laminates; Micro composite and nanocomposite, advantages and disadvantages. Reinforcement fibres - glass, carbon (PAN & Pitch-based), Kevlar, boron, silicon carbide – composition, manufacture, properties and applications; surface treatment, coupling agents. Matrix materials: unsaturated polyester resins, epoxy, vinyl esters, phenolics – production, properties, their composites and applications.

Unit 2 Theory and calculations of composite materials: prediction of composite properties- weight fraction, volume fraction, rule of mixtures, density, void content. Continuous fibre composites: estimation of longitudinal strength and modulus, transverse strength and stiffness, shear modulus, Poisson's ratio; Halpin -Tsai equation, Stress-strain curve of composites, Failure of composites-minimum and critical fibre content. Factors affecting the strength of composites- orientation, strength, short fibres, interfacial bond, residual stresses. Short fibre composites - mechanism of load transfer, load transfer length, critical fibre length, stress distribution in short fibres, average strength of composites.

Unit 3 FRP processing : machinery, operation, advantages and disadvantages- hand lay-up, spray up, centrifugal casting, Bag moulding- vacuum bag, pressure bag, autoclave; resin transfer moulding (RTM), vacuum assisted resin transfer moulding (VARTM), reinforced reaction injection moulding (RRIM), compression moulding, injection moulding, filament winding, pultrusion.

Unit 4 Polymer blends – classification, criteria for miscibility, factors contributing to miscibility/immiscibility, advantages of blending; preparation techniques- melt blending, solution blending, latex blending, in-situ polymerization, solid state blending; compatibilising agents- types, methods of determining miscibility/compatibility-dynamic mechanical analysis (DMA), differential scanning calorimetry (DSC); TGA, Fox equation. Types of blends: plastic- plastic, rubber-rubber, plastic-rubber blends, elastomeric alloys, dynamic vulcanization.

Text/Reference Books:

1. P. K. Mallick, Composites Engineering Handbook Part-1&2, CRC Press (2016)
2. Ever J. Barbero, Introduction to Composite Materials Design, CRC Press (2011)
3. Bhagwan D. Agarwal, Lawrence J. Broutman, K. Chandrashekhara, Analysis and Performance of Fiber Composites, Wiley India (2006)
4. F.L. Matthews, R.D. Rawlings, Composite Materials: Engineering and Science, Chapman & Hall (1994)

5. Autar K. Kaw, Mechanics of Composite Materials, CRC Press (1997)
6. D. Hull, T. W. Clyne, An Introduction to Composite Materials, Cambridge University press (1996)
7. Leonard Hollaway, Handbook of Polymer Composites for Engineers, Jaico Publishing (1995)
8. F. R. Jones, Handbook of Polymer-Fibre Composites, Longman Scientific & Technical (1994)
9. Polymer Composites – from Nano to Macro scale, Friedrich K., Fakirov S. and Zhang Z.(Eds.), Springer Science + Business Media, Inc., 233 Spring Street, New York, NY 10013, USA (2005).
10. R. P. Singh, C. K. Das, S. K. Mustafi, Polymer Blends and Alloys, Asian Books Private Limited (2002)
11. M.J.Folkes, P.S.Hope, Polymer Blends and Alloys, Chapman & Hall (1993)
12. D.R. Paul, C. B. Bucknall, Polymer blends Vol. 1 & 2, john Wiley & Sons (2000)
13. Gabriel O. Shonaike, George P. Simon, Polymer Blends and Alloys, CRC Press (2006)

Revision: 30%

24-214-0702 Introduction to Mould and Die Design

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Get an insight into the materials used for the manufacture of the various components of moulds and dies. (Understand)
CO 2: Identify the right materials for the components of moulds and dies. (Analyse)

CO 3: Gain knowledge about the conventional & advanced machinery and techniques used for machinining and production of the components of moulds and dies. (Understand)
CO 4: Learn the modern computer based systems for the design, production and quality assurance of moulds and dies. (Understand)
CO 5: Comprehend and envisage the processes involved in the design and production of various types of injection moulds. (Analyse)
CO 6: Understand the basic designs used for feed and ejection system. (Understand)

CO 7: Get an insight into the design and manufacture of moulds for compression and transfer moulding processes. (Understand)
CO 8: Learn the design and manufacture of various types of dies and extrudate calibration systems. (Understand)

Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) High (3)

	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO8	PO 9	PO 10	PO1 1	PO 12
CO 1	2					1	1					
CO 2	1	1				1	1					1
CO 3	3	1	1		1				1	1		
CO	2	1	1						1	1		

4												
CO 5	2	1	1		1	1	1		1	1		1
CO 6	2	1			2	1	1		1	1	1	1
CO 7	2	1	1		2	1	1		1			
CO 8	3	1			2	1			1			1

Unit 1. Materials for moulds and dies – Selection, steels-hardening, nitriding, corrosion resistant steels, aluminium alloys-surface treatment and coating, bronzes, zinc alloys. Materials for prototype moulds: natural materials, metals, synthetic materials.

Unit 2. Mould manufacturing processes – Machineries used: cutting, turning, milling, grinding and welding. Electrical discharge machining (EDM). Electroforming. Hobbing. Polishing. Surface structuring. Design: Introduction to computer aided mould design (CAD), computer aided manufacturing (CAM), computer integrated manufacturing (CIM) and computer integrated quality assurance (CAQ).

Unit 3. Injection mould design – Basic injection mould construction, feed system in injection moulds -design of sprue, runners and gates. Non solidifying runners. Ejection system. Mould venting, cooling, guiding and locking. Stack moulds. Moulds for threaded products. Moulds for thermosets and rubbers.

Unit 4. Compression moulds: general types, components of compression moulds and design. Transfer moulds : types of moulds, components of transfer moulds, advantages and design. Extrusion dies: General rules for die design, extrusion dies for discharge of single melt. Types of dies: basic, pipe, sheet, blown film and wire coating . Automatically adjustable dies. Profile dies. Dies for extruding nets. Dies for co-extrusion. Systems for sizing and calibration of extrudates.

References

1 Gunter Mennig, KlausStoeckhert (Editors.), Mould- Making Handbook, 3rd Edn, Hanser Publishers (2012).

2 R.G.W. Pye, Injection Mould Design, 4th Edn, Affiliated East-West Press Pvt. Ltd. (2000).

3 Walter Michaeli, Extrusion Dies for Plastics and Rubber 3E: Design and Engineering

Computations, 3rd Edn, Hanser Publications (2003).

4 Gastrow, Injection Molds: 130 Proven Designs, Peter Unger (Ed), 4th Edn, Hanser Publications (2006).
5 Herbert Rees, MouldEngineering, 2nd Edn, Hanser Publishers (1995).
6 George Menges, Walter Michaeli, Paul Mohren, How to Make Injection Moulds, 3rd Edn, Hanser Publishers (2001).
7 E.G. Fisher, Extrusion of Plastics, 3rd Edn, Halsted Press (1976).
8 Chris Rauwendaal, Understanding Extrusion, 2nd Edn, Hanser Publications (2010).

Revision: 0%

24-214-0703 Failure Analysis of Polymers

On successful completion of the course, the students will be able to:

CO 1: Understand the different modes of failure occurring in polymers and composites. (Understand)
CO 2: Explain the fundamentals of fracture mechanics. (Understand)
CO 3: Understand the fracture mechanics during impact tests. (Understand)
CO 4: Explain fracture mechanics in long-term tests. (Understand)
CO 5: Summarise the effect of various environmental factors on the degradation behaviour of polymers. (Understand)
CO 6: Explain the strategic weakness leading to failure of polymers. (Understand)
CO 7: Outline the environmental stress cracking phenomenon in polymers. (Understand)
CO 8: Discuss degradation mechanisms in polymers. (Understand)

	PO 1	PO 2	PO 3	PO4	PO5	PO 6	PO 7	PO8	PO9	PO10	PO11	PO1 2
CO1	3	1							1			
CO2	2	1										
CO3	2	1										
CO4	2	1				1	1			1		
CO5	2	1				1	1			1		
CO6	2	1										
CO7	1	1				1	1		1			
CO8	1	1				1	1			1		1

Unit 1. Fundamentals of fracture – molecular failure process. Failure modes: brittle failure, ductile failure, Three modes of fracture. Fracture mechanics: Griffith theory, Irwin Theory, linear elastic

fracture mechanics (LEFM),Elasto-plastics Fracture Mechanics, fracture predictions based on stress concentration and stress intensity factor, fracture predictions based on an energy balance. J integral

Unit 2. Fracture predictions – Fracture predictions based on stress strain analysis of polymers: impact test creep test, fatigue and wear.

Unit 3. Failure analysis and degradation of polymers – Identification of strategic weakness, stability of polymer structures, environmental effect on polymer failure - weather, thermal, photo and oxidation.

Unit 4. Degradation mechanisms- Ionizing radiation, hydrolysis, environmental stress cracking-crazing and cracking, electrical treeing and water treeing, chemical degradation, electrochemical degradation, biodegradation, physical ageing.

References

1. David C. Wright, Failure of Plastics and Rubber Products, RAPRA Technology Ltd. (2001).
2. Tim A. Osswald, Georg Menges, Material Science of Polymers for Engineers, 3rd Edn., Hanser Publications (2012).
3. R. J. Young, P. A. Lovell, Introduction to Polymers, 3rd Edn., CRC Press (2011).
4. R.J. Crawford, Plastics Engineering, 3rd Edn., Elsevier Butterworth-Heinmann (2002)

Revision-25%

24-214-0704 Industrial Management

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Summarise the basic concepts of management. (Understand)

CO 2: Explain the theories and the functions of management. (Understand)

CO 3: Differentiate personnel management & human resource management and Recruitment & Selection. (Understand)

CO 4: Describe the various concepts in HRM (like absenteeism, transfers, promotions and T&D. (Understand)

CO 5: Describe different concepts in Production management and Materials management. (Understand)

CO 6: Outline the basic concepts of Quality management. (Understand)

CO 7: Describes Marketing management and consumer behaviour. (Understand)

CO 8: Analyse Accounting concepts and principles and financial accounting concepts. (Apply)

Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1								1	1	1		
CO 2						1		1	1	1	1	
CO 3						1		1	1	1		
CO 4						1		1	1	1		1
CO 5						1	1	1	1	1	1	
CO 6						1	1	1	1	1	1	
CO 7						1			1	1		
CO 8						1			1	1		

Unit 1. Introduction to management– Definition of management, characteristics of management, levels of management, management skills. Theories: evolution of management theory, scientific management, principles of scientific management, administrative management, modern management theories. Functions of management: planning, forecasting, organizing, staffing, directing, motivating, controlling, coordinating, communicating, decision making.

Unit 2. Personnel management /HR Management: – definitions, objectives, characteristics, functions, principles, recruitment and selection of manpower, scientific selection, transfers, promotion, absenteeism, labour turnover, training and development of manpower, need, objectives, benefits, methods

Unit 3. Production management: manufacturing systems, product design and development, plant location and layout, balancing production lines. Materials management: purchasing, stores and store-keeping - inventory control. Marketing management – Evolution of marketing, modern concept of marketing-marketing functions, marketing mix, consumer behaviour, products mix, product line, advertising, pricing, market research, sales forecasting.

Unit 4. Functions of financial management : Fundamentals of accounting, balance sheet, source of finance, profit/loss account, financial ratio, capital classification of capital, working capital, need for working capital, assessment of working capital, factors affecting working capital, sources of working capital. Breakeven analysis, depreciation, equipment replacement policy.

References

1. Lawrence L. Bethel, Franklin S. Atwater, George H.E. Smith, Harvey A. Stackman Jr., James L. Riggs (Ed.), Industrial Organisation and Management, 6th Edn., Mc Graw Hill Inc. (1979).
2. Harold Koontz, Cyril O'Donneli, Principles of management : An Analysis of Managerial Functions, 2nd Edn., McGraw-Hill (1959).
3. Prasanna Chandra, Financial Management, 8th Edn., Tata Mc Graw Hill Education Pvt. Ltd. (2011).
4. W J Reddin, Denis Ryan, Handbook of management by objectives, Tata Mcgraw-Hill (1988).
5. Prasanna Chandra, Projects, Tata Mc Graw Hill Education (2013).
6. S.K.Basu , Industrial Finance in India: A Study in Investment Banking and State-Aid to Industry, University of Calcutta (1961).
7. Mary Jo Hatch, Organization Theory: Modern, Symbolic, and Postmodern Perspectives, Oxford University Press (2018).
8. N.L. Hingorani, A.R. Ramanathan,Management Accounting, Sultan Chand & Sons (2012).
9. Richard B. Chase, Nicholas J. Aquilano, F. Robert Jacobs, Production and operations management: manufacturing and services, Volume 1, 8th Edn., Irwin/McGraw-Hill (1998).
10. Jack R Meredith, Scott M. Shafer, Samuel.J.Mantel.Jr., Project Management : A strategic managerial Approach, 10th Edn., John Wiley & Sons (2017).
11. Dennis Lock, The essentials of Project Management, Ashgate Publishing Ltd. (2014).

Revision :20%

24-214-0711 Polymer Products Testing (Lab)

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Test latex products, dry rubber products and plastic products as per specification.

Mapping of Course Outcomes with Programme Outcomes: Level – Low (1), Medium (2) High (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2							1	1		1

Experiments

1. Testing of Latex products – gloves, thread, foam
2. Testing of Dry Rubber Products – sponge, MC sheet, cycle tyres and tubes, rubber to metal bonded products, hoses, belting
3. Testing of Plastic Products – films, sheets, pipes, laminates, blow moulded containers

References

1 BIBIS, ASTM, ISO Standards

24-214-0721 Tyre Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Gain familiarity with the design of various types of tyres and their functions. (Understand)

CO 2: Get an insight into the materials used for the manufacture of tyres and tubes. (Understand)

CO 3: Comprehend and envisage the processes involved in the design and production of the components of various types of tyres and tubes.(Apply)

CO 4: Learn the non-destructive and destructive tests done on tyres and tubes. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1			1						1
CO2	2	1			1	1	1			1	1	1
CO3	1	1	2	1	1	1					1	1
CO4	2	1	1	1	1		1					1

Unit 1. Introduction to the history and development of tyres. Indian and global status of tyre industry. Pneumatic tyres – comparison of tubed and tubeless tyres, tread pattern, basic functions and performance comparison, advantages. Basic functions of pneumatic tyres. Components of bias and radial tyres. Construction of bicycle tyres, Aircraft tyres. Tweel, Tyres for electric vehicles. Benefits of filling nitrogen in tyres. Role of Indian Tyre Technical Advisory Committee. Tyre size designation. Winter tyres.

Unit 2. Introduction to the materials used in tyre manufacture–Ingredients of rubber compounds for tyres, tubes and tyre curing bladders. Tyre reinforcing materials. Advantages and the disadvantages of cotton, rayon, polyester, nylon, glass, steel and aramid fibers. Typical formulations for tyre components. Compounding for radial tyres. Textiles used in tyre manufacture. Treatment of textiles – RFL dipping.
Manufacture of tyres: two wheelers, cars, trucks, OTR, farm and aircrafts. Calendaring process. Bias cutting. Extrusion of tread, side wall and other components. Dual extrusion of cap and base. Bead construction

Unit 3. Tyre building: machines for bias and radial tyres, components of tyre building machines. Inputs for tyre building: inner liner, plies, bead assemblies, tread, breakers, belts and side walls. Sequence of building. Green tyre preparation. Awling, shaping and curing in Bag-O-matic press. Typical cure cycle. Post cure inflation. Determination of optimum cure time by thermocouple studies. Cured tyre inspection. Tyre finishing. Design and manufacture of bicycle and automobile

tubes.

Unit 4. Evaluation of tyres – Raw materials analysis, in-process tests and tests on finished products. Various tyre testing systems. Noise measurements, tyre balancing, mileage evaluation. Non-destructive tests such as X-ray and holography. Tyre maintenance. Retreading of tyres. Need for tyre re-treading. Hot and cold retreads. Tyre design: Tyre structure, tyre shape. Tread design. Tyre performance analysis: tyre stresses and deformations, tyre noise, rolling resistance, aqua-planning, tyre wear. Features and operations of tyre building machines: bead winding machines, wire belt processing machines, bias cutters and curing presses. Valves used in tyres. Recent developments in tyre technology.

References

1 John F. Purdy, Mathematics Underlying the Design of Pneumatic Tires, University of
2 Michigan (1963 – Digitized on 25 Jul 2011).
3 ITTAC Standards Manual, Indian Tyre Technical Advisory Committee, New Delhi (2018).
4 L. J. K. Setright, AutomobileTyres, Chapman and Hall (1972).
5 Tom French, Tyre Technology, Taylor & Francis (1989).
6 Dr. S.N. Chakravarthy, Introduction to Tyretechnology, Polym Consultants- New Delhi (2012).
7 Samuel Kelly Clark, Mechanics of Pneumatic Tires, U.S. Department of Transportation,
8 National Highway Traffic Safety Administration (1981 - Digitized on 17 Dec 2007).
9 F.J. Kovac, Tyre Technology, Goodyear Tyre& Rubber Company (1973).
10 Tyre Condition Guides, Indian Tyre Technical Advisory Committee, New Delhi (2018).

Revision: 25%

24-214-0722 Polymer Process Modelling and Simulation

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the mechanism of flow and leakage in film blowing process. (Understand)

CO2 Analyse the flow pattern in injection moulding and estimate mould cooling time and flow length.(Analyse)

CO 3: Analyse the flow in compression moulding, rotational moulding and calendaring.(Analyse)

CO 4: Model the polymer melt flow through various channels of uniform cross section. (Create)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1			1						
CO2	2	1	2	1	1						1	
CO3	1	1	2	1	1						1	
CO4	1	1	1		1	1		1	1			1

Unit 1. Extrusion – General features: mechanism and analysis of flow, leakage power requirements, analysis of film blowing and blow moulding.

Unit 2. Injection moulding – General features: screws, nozzles and moulds, mould clamping force, heat transfer in polymers. Estimation of mold cooling time and flow length.

Unit 3. Analysis – Compression moulding, thermoforming, rotational moulding and calendering.

Unit 4. Modelling of polymer melt flow – Isothermal flow of Newtonian and power law fluids through different channels of uniform cross-section.

References

1 J. R. A. Pearson, S. M. Richardson (Eds.), Computational Analysis of Polymer Processing, Applied Science publisherrs (1983).

2 D. H. Morton-Jones, Polymer processing, Chapman and Hall (1989).

3 Tim A. Osswald, Polymer Processing: Modeling and Simulation, Hanser Publications (2006).

24-214-0723 Smart and Intelligent Polymers

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Explain the basic concepts of smart materials and its working principles. (Understand)

CO 2: Outline the concept of various shape memory systems. (Understand)

CO 3: Explain the principles of various chromogenic materials. (Understand)

CO 4: Describe the properties of various smart polymers. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	1	1								1	3
CO2	2	2	1	1			1				1	2
CO3	2	1		1		1	1					2
CO4	1	1	1	1		1	1					1

Unit 1. Smart materials and structures – System intelligence : components, classification of smart structures, common smart materials and associated stimulus-response, applications. Ferroelectric materials. Piezoelectric materials : piezoelectric effect, direct and converse, parameter definitions, piezopolymers, piezoelectric materials as sensors and actuators.

Unit 2. Shape memory materials – Shape memory effect (SME), Martensitic transformation, one way and two-way SME, rubber like effect. Shape memory alloys (SMAs), binary and ternary alloy systems, functional properties of SMAs. General applications of SMAs and smart materials. Chromogenic materials: thermochromic, photochromic, electrochromic, chemochromic, mechanochromic- principle and applications.

Unit 3. Smart polymers – thermoresponsive, pH-responsive, photo-responsive, magnetically responsive polymers, synthesis, properties and applications. Smart hydrogels: types-thermoresponsive, pH responsive, light responsive, electroresponsive, synthesis, properties and application.

Unit 4.Self healing polymer systems: principle, types and applications. Smart polymers in medical devices, texiles and optical storage devices- applications.

References

1. D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley (2007). .
2. M. Addington, D.L. Schodek, Smart Materials and New Technologies in Architecture, Elsevier(2005).
3. K. Otsuka, C.M. Wayman (Eds.), Shape Memory Materials, Cambridge University Press(1998).
4. Maria Rosa Aguilar, Julio San Román (Eds.), Smart Polymers and their Applications, Elsevier (2014)
5. M.V. Gandhi, B. S. Thompson, Smart Materials and Structures, Chapman & Hall (1992).
6. M. Schwartz, New Materials, Processes, and Methods Technology, CRC Press (2006).

7 P. Ball, Made to Measure: Materials for the 21stCentury, Princeton University Press, (1997).

8 N. Yui, R. J. Mrsny, K. Park (Eds.), Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems, CRC Press (2004).

9 Marinella Ferrara, Murat Bengisu, Materials that change Colour - Smart materials, Intelligent Design, Springer Science & Business Media (2013)

24-214-0724 Polymers for Space Applications

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Synthesise high temperature polymers used for space applications. (Understand)
CO 2: Understand the polymers used for thermal protection systems in space research. (Understand)
CO 3: Explain the properties of composites for satellites and launch vehicles. (Understand)
CO 4: Understand the types and properties of polymers used for launch vehicles and Human in Space programme. (Remember)

Mapping of course outcomes with program outcomes:
Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1				1	1				1
CO2	1	1	2		1		1	1				1
CO3	2	1	1		1	1		1	1			1
CO4	2	1	1	1		1		1	1		1	1

Unit 1. High temperature polymers for space research – Synthesis, properties and processing of advanced thermoplastics, polyethers, poly (ether sulphones), poly (ether ether ketones) (PEEK), aromatic liquid crystalline polyesters, bismaleimide, polycarbonates.

Unit 2. Polymers for thermal protection systems – Synthesis and processing, high temperature resistant resins-epoxy, phenolic and polyimides. High temperature resistant polymers with metals in their back bone - boron, silicon and phosphorous containing polymers.

Unit 3. Composites for satellites and launch vehicles – Types: fibre composites, particulate composites, foam composites. Polymer matrix :desired properties of a matrix, thermosets, thermoplastics. Fiber reinforced polymer (FRP): types of fibers-glass, carbon, aramid, metal, alumina, boron, silicon carbide and silica.

Unit 4. Propellant binders – Classification of propellants: solids, liquids, hybrids. Solid propellants: homogeneous-single base and double base propellantspropellants. Composite propellants: preparation of oxidiser, fuel, mixing of ingredients, curing and testing of solid composite propellants. Materials for space environment (HIS): Space radiation environment, Radiation effects, radiation shielding materials, atomic oxygen resistant materials, space suit materials and materials for life support systems. Ultra high molecular weight polyethylene (UHMWPE): fundamentals, processing of UHMWPE-ram extrusion, Screw extrusion, Radiation shielding

properties of polymers. Materials for cryogenic applications: cryo insulation materials, polymers and adhesive for cryo temperature applications.

References

1. S-C Lin, E.M. Pearce, High Performance Thermosets, Chemistry, Properties and Applications, HanserPublictions (1993).
2. C. A. Dostaletal, Engineered Materials Handbook, vol 3, Adhesives and sealants, ASM international (1990).
3. S.K. Mazundar, Composites manufacturing materials, product and process engineering,
4. CRC press (2002).
5. K. Friedrich,Polymer composite-from nano to macro scale, Springer (2005).
6. Urbensky, Chemistry and Technology of Explosives, Vol.2, Vol.3 and Vol.4, Pergamon Press (1985).

Revision: 15 %

24-214-0725 Polymer Nanocomposites

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the structural features and modification of nanomaterials. (Understand)

CO 2: Explain the various preparation methods for the synthesis of nanomaterials and nanocomposites. (Understand)

CO 3: Explain the various processing techniques of nanomaterials. (Understand)

CO 4: Explain the applications of polymer nanocomposites. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1				1					1
CO2	2	1	2	1		1						1
CO3	3	2	1				1					1
CO4	21		1	1	1				1		1	1

Unit 1. Introduction to nanomaterials–History of nanomaterials, size and shape dependent properties, their uniqueness. Quantum confinement : zero dimensional, one dimensional, two dimensional nanostructures. Carbon based nano materials: fullerene, carbon nanotube, single walled and multi walled CNT, graphene, carbon onion, nanodiamond and films, modification with carbon nanotubes. Inorganic nanomaterials: nano silica, nano clay, organically modified layered clays, LDH, nanoZnO, nano TiO_2. Hybrid nanomaterials : core-shells, nanoshells, self-assembled nanostructures, POSS.

Unit 2. Nanoparticle synthesis – Introduction to nanoparticle synthesis: topdown and bottom up approaches, wet chemical methods for metal nanoparticles, quantum dots, nanoclusters, nanowires and rods, thin films. Physical nanofabrication techniques: introduction to PVD, MBE, CVD, self-assembly, lithographic techniques.

Unit 3. Processing of nanomaterials – Various methods used for the incorporation of nano fillers in polymer matrix: solution mixing, latex stage mixing, melt mixing, in-situ polymerization and precipitation. Dispersion and nucleating effects: Intercalation, exfoliation. Modification of polymers: layered and non-layered nano and micro particles.

Unit 4. Applications of nanomaterials– healthcare, biosenors, coatings, environment, catalysis, agriculture, automotives, electronics, photonics, information technology, quantum computing, energy sector, and aerospace sector.

References

1 K. Friedrich, S.Fakirov, Z. Zhang (Eds.), Polymer Composites – from Nano to Macro scale, Springer Science and Business Media Inc. (2005).

2 R. Krishnamoorti, R.A. Vaia, Polymer nanocomposites: Synthesis characterization and modelling, Americal Chemical Society (2002).

3 T.J. Pinnavaia, G.W. Beall , Polymer Clay Nanocomposites, John Wiley (2000).
4 K. Friedrich,Polymer composite-from nano to macro scale, Springer (2005).
5 T. Pradeep, Nano: The Essentials, McGraw-Hill (India) Pvt Limited (2008).
6 Bharat Bhushan, (Ed.), Handbook of Nanotechnology, Springer (2007). Carl C. Koch (Ed.),
7 Anke Krueger, Carbon Materials and Nanotechnology, Wiley-VCH Verlag GmbH & Co. KGaA (2010).

24-214-0726 Professional Ethics in Engineering

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Get fundamental insights into diverse kinds of ethics to be practiced self and in society.
(Understand)

CO 2: Practice Self-ethics and professional ethics as an engineer (Apply)

CO 3: Realize the responsibilities and rights as an individual in the society (Analyze)

CO 4: Learn to be a good professional in corporate sector (Apply)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1			1		2		1		
CO2	2	1	1			1		2	1	1	1	
CO3	2	1	1			2		2	1	1		1
C04	2	1	1			1		2	1	1		1

Unit1 Human Qualities and values- Honesty, Integrity, Courage, Self-awareness and wholeheartedness. Character -Character traits, Self- respect and self-confidence, Caring and sharing, Respect for others. Morals and ethics- Morals, Work ethics, Environmental ethics and Computer ethics, Service learning, Respect for others. Societal values: Humanity, Caring, Sharing, Valueing time, Cooperation, Commitment and Empathy. Professional excellence and stress management.
Unit 2. Engineering Ethics- Senses of 'Engineers Ethics', Decision making: Black & white and grey areas, Emotional intelligence, Knowledge, experience and Wisdon Types of inquiry, Moral dilemmas, Moral Autonomy, Principles of obligation, Hierarchy of ethical obligations- primary secondary and tertiary. Professional competence: acquiring, maintaining. Confidentiality - significance and preservation, Misconduct and fraud, Fraud management.
Unit 3. Social Responsibilities and Rights- Engineers as responsible Experimenters, Codes of Ethics, Rights- Professional rights, employee Rights and intellectual Property Rights (IPR), Safety and Risk: Assessment, benefit analysis and methods for reducing risk, Respect for authority, Confidentiality, Conflicts of Interest, Occupational Crime, Discrimination.
Unit 4. Engineers as Leaders: Engineers as managers, consultants, experts and advisors: Eligibility and practices. Motivation- Gaining and giving, Leadership qualities for engineers. Professional excellence and human values. Social responsibilities- Principles and practices. Obeying law. Model Engineers for society

References

1. Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Tata McGraw Hill, NewDelhi, 2003.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004.

24-214-0727 Advanced Energy Harvesting and Storage Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1:	Explain the features of energy materials and devices. (Understand)
CO 2:	Explain the different energy storage devices and their fabrication. (Understand)
CO 3:	Outline the hydrogen production, storage and green energy. (Understand)
CO 4:	Identify energy harvesters and their applications. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1			1	1					1
CO2	2	1	1		1	1			1			1
CO3	3	1				1	1	1		1		1
CO4	2	1	1	1			1				1	1

Unit 1: Introduction to energy and its utilization.

Introduction to energy technology, Basic principles of energy conversion and storage, Energy units and measurements, Historical and current demand of Energy, Understanding energy Markets. Environmental impact of energy. Characteristics of energy-efficient materials, Environmental and economic benefits of energy-efficient materials. Introduction to advanced energy technologies, Importance and impact of advanced energy solutions on global energy systems. Advanced Battery Technologies: Air Batteries, Anode-less Batteries, Nuclear Batteries (Overview, Working principles and components, Emerging Trends in Energy Storage and Conversion

Unit 2: Energy storage devices

Introduction to Energy Storage; Overview of and need of energy storage systems and their importance, Types of energy storage (chemical, electrical, mechanical, thermal, etc.), Electrochemical energy storage-Principles of electrochemical energy storage, Basic principles of energy storage in batteries, capacitors and supercapacitors. Classification of batteries, battery materials and battery fabrication. Introduction to supercapacitors (electrochemical double-layer capacitor, pseudocapacitor and hybrid capacitors), Comparison of batteries and supercapacitors in terms of energy density, power density, and cycling stability.

Unit 3: Hydrogen Energy conversion and Storage

Introduction to hydrogen/oxygen evolution reactions (HER/OER), Mechanisms and kinetics of HER and OER, Catalysts and materials for enhancing HER/OER efficiency; Hydrogen production methods- electrolysis-Thermal Decomposition of Water-Chemical Reactions. Methods of hydrogen storage (compression, liquefaction, adsorption), Materials for hydrogen storage (metal hydrides, porous materials), Challenges and advancements in hydrogen storage technology. Transportation of Hydrogen and efficiency of different transportation techniques. Green energy and production.

Unit 4: Energy harvesters

Overview of energy harvesting principles and applications. Importance of energy harvesting in powering autonomous systems and IoT devices, Comparison of energy harvesting techniques with traditional energy sources (wind, solar), Environmental considerations and sustainability in energy

harvesting. Piezoelectric Energy Harvesting- Principles, piezoelectric materials, working mechanisms, design considerations and optimization techniques, Applications of piezoelectric energy harvesting in vibration and motion-powered devices. Thermoelectric Energy Harvesting; Thermoelectric effect and thermoelectric materials, Operating principles of thermoelectric generators, Factors affecting the efficiency of thermoelectric energy harvesters, Applications of thermoelectric energy harvesting in waste heat recovery and temperature gradient sensing. Triboelectric energy harvesting- introduction, design consideration, materials and applications.

Reference

1 Ahmed F Zobaa and Ramesh C Bansal Handbook of Renewable Energy Technology, 1st Edn., WorldScientific (2011)
2 Akhila Das, Prasanth Raghavan, Advanced Technologies for rechargeable batteries, 1st Edn., CRC Press (2024).
3 Mehmet Sankir, Nurdan Demirci Sankir, 1st Edn., Hydrogen Production Technologies Wiley, Scrivener Publishing LLC (2017).
4 Prasanth Raghavan, Jabeen Fatima, Polymer Electrolytes for Energy Storage Devices, Vol. 1, 1st Edn., CRC Press (2020).
5 Prasanth Raghavan, Jabeen Fatima, Ceramic and Speciality Electrolytes for Energy storage devices, Vol. 2, 1st Edn., CRC Press (2020).
6 Neethu T. M. Balakrishnan, Raghavan Prasanth, Electrospinning for Advanced Energy Storage Applications, Springer-Nature (2020).
7 S. Wazed Ali, Satyaranjan Bairagi, Shahid Ul Islam Hybrid Materials for Piezoelectric Energy Harvesting and Conversion, 1st edition Wiley; (2024)

Revision 100%

24-214-0801 Project Work Report and Viva Voce

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Perform literature survey and analyse the recent technology developments in the field of polymer engineering. (Analyse)

CO 2: Design experiments related to the development of polymer products (Create)

CO 3: Perform experiments related to a research problem. (Apply)

CO 4: Analyse and solve problems related to polymer industries. (Analyse)

CO 5: Assess the experimental data generated during the experimental work. (Analyse)

CO 6: Develop components, products, processes or technologies in the polymer engineering field. (Create)

CO 7: Interpret results and make reports based on the project work. (Analyse)

CO 8: Apply knowledge gained in solving real life engineering problems. (Apply)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	1	1	1	1	1	1	1
CO2	3	2	2	1	2	1	1	1	1	1	1	1
CO3	3	2	2	1	2	1	1	1	1	1	1	1
CO4	3	2	2	1	2	1	1	1	1	1	1	1
CO5	3	2	2	1	2	1	1	1	1	1	1	1
CO6	3	2	2	1	2	1	1	1	1	1	1	1
CO7	3	2		1	2	1	1	1		1	1	1
CO8	3	2	2	1	2	1		1	1	1	1	1

Project Plan:

Do through literature survey to aquireindepth knowledge on the research topic assigned by the company/ institution. Finalization of the objectives and methodology relating to the assigned topic, preparing a detailed work plan for conducting the project work, including team work. Detailed Analysis/ Modelling/ Simulation/ Design/ Problem Solving/ Experiment as needed. Final development of product/process, testing, results, conclusions and future directions. Preparing a paper for Conference presentation/Publication in Journals, if possible. Preparing a report in the standard format for being evaluated by the assessment board. Final project presentation and viva voce by the assessment board including external expert.

Evaluation

Exam	**Mark Distribution**		
	Report	presentation & viva	Total Marks
Internal Assessment	50	150	200
External Assessment	50	150	200
Total Marks	100	300	400

24-214-0802 Industrial Training

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Identify the vaious processes involved in the manufacture of polymer products. (Analyse)

CO 2: Understand various machineries used for the manufacture of polymer products. (Understand)

CO 3: Analyse and solve problems related to polymer industries. (Apply)

CO 4: Make reports based on the industrial training. (Understand)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6		PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	1	1	1	1	1	1	1
CO2	2	2	2	1	2	1	1	1	1	1		1
CO3	2	2	2	1	2	1	1	1	1	1	1	1
CO4	2	2	2	1	2	1	1	1	1	1	1	1

CURRICULUM FRAMEWORK AND SYLLABUS
(OUTCOME BASED EDUCATION)

M. TECH. (POLYMER TECHNOLOGY)

(with effect from the academic year 2024–25)

COCHIN UNIVERSITY OF SCIENCE & TECHNOLOGY

Kalamassery, Cochin - 682022 Kerala, India Phone: 0484 – 2575723

April 2024

Vision

The Department strives to develop a Centre of Excellence in Polymer Technology in the country by strengthening in-house infrastructure and taking up collaborative Research and Development in frontier areas.

Mission

As a Department we are committed to:

- Acquire state-of-the-art infrastructure and take up inter-disciplinary research in frontier areas.
- Achieve academic excellence in the field of Polymer Science and Rubber Technology through innovative teaching - learning processes.
- Prepare well-trained human resource in Polymer Science and Rubber Technology who can contribute positively to the developmental efforts of the Nation.
- Promote good academia - industry interaction.

Programme outcome

PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, techniques, skills, and modern tools of polymer Science and engineering to the solution of polymer engineering problems.

PO2.Problem Analysis: Identify, formulate, research literature, and analyze engineering problems related to Polymer Science and Engineering to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the needs of public health and safety, and the cultural, societal, and environmental considerations in the field of Polymer Science and Rubber Technology.

PO4. Conduct investigations of complex Problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the **information to provide valid conclusions for broadly defined polymer science and engineering problems.**

PO5. Modern Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to Polymer Science and Engineering activities with an understanding of the limitations.

PO6. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice related to Polymer Science and Engineering.

Admission and Regulations

The admissions to this programme is based on the GATE score. In case of non- availability of GATE qualified candidates, the selection will be done based on Departmental Admission Test (DAT). The notification for admission will be published during December/January.

The regulations in force is published by the University. The current regulation is available at https://cusat.ac.in/student/mtech-regulations.

M TECH POLYMER TECHNOLOGY

CURRICULUM

SEMESTER I

Course code	Subject	C/E	Hrs per week			Credit	Marks		
			L	T	P		CE	EE	Total
24–440–0101	Advanced Polymer Science	C	3	0	0	3	50	50	100
24–440–0102	Polymer Materials	C	3	0	0	3	50	50	100
24-440-0103	Advanced Polymer Product Design	C	3	0	0	3	50	50	100
24–440–0104	Research Methodology and IPR	C	2	0	0	2	50	50	100
24-440-012*	Prog. Elective I	E	3	0	0	3	50	50	100
24-440-013*	Audit course	A	2	0	0	0	–	100	100
24-440-011*	Lab 1 (Prog. Core based)	C	0	0	4	2	100	–	100
24-440-011*	Lab 2 (Elective based)	E	0	0	4	1	100	–	100
	Total					**17**	**450**	**350**	**800**

SEMESTER II

Course code	Subject	C/E	Hrs per week			Credit	Marks		
			L	T	P		CE	EE	Total
24–440–0201	Advanced Plastics processing	C	3	0	0	3	50	50	100
24–440–0202	Rubber Processing and Product Manufacture	C	3	0	0	3	50	50	100
24-440-0203	Advanced Tyre Technology	C	3	0	0	3	50	50	100
24-440-022*	Prog. Elective II	E	3	0	0	3	50	50	100
24-440-022*	Prog. Elective III	E	3	0	0	3	50	50	100
24-440-021*	Lab 3 (Prog. Core based)	C	0	0	4	2	100	–	100
24-440-021*	Lab 4 (Elective based)	E	0	0	4	1	100	–	100
24–440–0251	Minor Project with Seminar	C	0	0	2	2	100	–	100

	Total					**20**	**550**	**250**	**800**

SEMESTER III									
Course code	**Subject**	**C/E**	**Hrs per week**			**Credit**	**Marks**		
			L	**T**	**P**		**CE**	**EE**	**Total**
24-440-032*	Prog. Elective IV	E	3	0	0	3	50	50	100
24-440-036*	Open Elective	E	3	0	0	3	–	100	100
24–440–0341	Dissertation - I	C	0	0	20	10	–	100	100
	Total					**16**	**50**	**250**	**300**

SEMESTER IV									
Course code	**Subject**	**C/E**	**Hrs per week**			**Credit**	**Marks**		
			L	**T**	**P**		**CE**	**EE**	**Total**
24–440–0441	**Dissertation - II**	C	0	0	35	19		300	300
	Total					**19**		**300**	**300**
	GRAND TOTAL					**72**	**1050**	**1150**	**2200**

Programme Elective I	
24–440–0121	Polymers for packaging
24–440–0122	Advanced Polymer Rheology
24–440–0123	Characterisation and Testing Methods
Programme Elective II	
24–440–0221	Specialty polymers (I.E.)
24–440–0223	Advanced Polymer Nanocomposites (I.E.)
Programme Elective III	
24–440–0224	Mould and Die Design
24–440–0225	Polymers for Advanced Electrical and Electronics Applications
24–440–0226	Materials in Space Applications
Programme Elective IV	
24–440–0321	Adhesives and Surface Coatings
24–440–0322	Advanced Biomaterials for Medical Applications (I.E.)
24–440–0323	Modelling and Simulation
Lab 1: Labs - Core based (Sem I)	
24-440-0111	Advanced Polymer Science
Lab 2: Labs - Elective based (Sem I)	
24-440-0112	Polymers for packaging
24-440-0113	Advanced Polymer Rheology
24-440-0114	Characterisation and Testing Methods
Lab 3: Labs - Core based (Sem II)	
24-440-0211	Plastics and Rubber Processing
Lab 4: Labs - Elective based (Sem II)	
24-440-0212	Specialty polymers
24-440-0213	Advanced Polymer Nanocomposites
24-440-0214	Mould and Die Design
24-440-0215	Polymers for Advanced Electrical and Electronics Applications
24-440-0216	Materials in Space Applications

The **open elective** is to be taken from the courses offered **by NPTEL/ SWAYAM.**

Tentative list of online courses approved by DC. Further courses may be selected by students which need to be approved by the Department.

Open Elective Courses	
24-440-0361	Properties of Materials
24-440-0362	Biomedical Nanotechnology
24-440-0363	Technologies For Clean And Renewable Energy Production
24-440-0364	Environmental Quality modelling and Analysis
24-440-0365	Membrane Technology
24-440-0366	Chemical Process Safety
24-440-0367	Chemical Reaction Engineering
24-440-0368	Soft Nanotechnology
24-440-0369	Waste to Energy Conversion
24-440-0370	Environmental Degradation of Materials
24-440-0371	Rheology of Complex materials
24-440-0372	Environmental Engineering
24-440-0373	Municipal solid waste management
24-440-0374	Fundamentals of combustion for propulsion
24-440-0375	Medical Biomaterials
24-440-0376	Biomass Conversion and Biorefinery
24-440-0377	Materials Science and Engineering
24-440-0378	Organometallic Chemistry
24-440-0379	Polymer Reaction Engineering
24-440-0380	Pericyclic Reactions and Organic Photochemistry
24-440-0381	Physical and Electrochemical Characterizations in Chemical Engineering
24-440-0382	Nature and Properties of Materials
24-440-0383	Fundamentals of Materials Processing - Part 2

Audit courses	
24–440–0131	Constitution of India and environmental governance: administrative and adjudicatory process
24–440–0132	Principles of management
24–440–0133	Technical English for engineers
24–440–0134	Entrepreneurship and IP strategy
24–440–0135	Exploring Human Values: Visions of Happiness and Perfect Society
24–440–0136	Speaking Effectively
24–440–0137	Enhancing Soft Skill and Personality
24–440–0138	Plastic Waste Management
24–440–0139	Scanning Electron / Ion / Probe Microscopy in Materials Characterization
24–440–0140	Chemical Process control
24–440–0141	Introduction to programming
24–440–0142	Managing Intellectual Property in Universities
24–440–0143	Patent drafting for beginners
24–440–0144	Development Research Methods
24–440–0145	Entrepreneurs
24–440–0146	Polymer Assisted Abrasive Finishing Processes
24–440–0147	Science and Technology of Weft and Warp Knitting

YLLABUS

SEMESTER I

20-440-0101 Advanced Polymer Science

Course Outcome

On successful completion of the course, the students will be able to:

CO1:	Explain fundamentals of polymerisation reactions and predict composition of copolymers. (Analyse)
CO 2:	Understand the special synthesis routes for polymerisation.(Understand)
CO 3:	Comprehend the molecular motions based on kinetic and thermodynamic considerations.(Analyse)
CO 4:	Analyze polymer structure and properties based on molecular weight determination, spectroscopic, thermal and X-ray scattering techniques.(Analyze)
CO 5:	Get an insight in to the degradation of commercial polymers and the management of polymer wastes. (Analyse)

Mapping of course outcomes with program outcomes:
Level - Low (1), medium (2) and high (3)

Unit 1. Mechanistic aspects of polymerization–Basics of Polymerisation: Addition polymerisation: Free radical, Cationic and Anionic polymerisation; condensation polymerisation, Stereoregular polymerisation-monometallic and bimetallic; Copolymerisation: general characteristics, mechanisms, kinetics of copolymerization, composition of copolymers, block and graft copolymers.

Unit 2. Special synthesis routes– Cyclopolymerisation: general features, mechanism. Ring-opening polymerization, , Metathesis polymerisation: ring -opening metathesis polymerisation (ROMP). Living polymerization: atom -transfer-radical-polymerization (ATRP), reversible addition fragmentation chain transfer (RAFT).

Unit 3. Polymer Solutions–Thermodynamics of polymer solutions: dissolution of polymers, factors affecting dissolution and swelling, Flory - Huggins theory, enthalpy of mixing, cohesive energy density, solubility parameter,. Kinetic and thermodynamic considerations: step growth and chain growth mechanism under ideal and real conditions.

Unit 4. Characterization techniques– Molecular characterization of polymers– average molecular weight, molecular weight distribution, determination of molecular weight – end group analysis, colligative property measurement –Osmometry; light scattering, solution viscosity and gel permeation chromatography.

Spectroscopy techniques: Infra red, NMR, UV-visible. Thermal properties: differential scanning calorimetry, differential thermal analysis, thermogravimetry, dynamic mechanical analyzer. Microscopic techniques: optical and electron microscopy Crystallinity studies: density measurements, XRD.

Unit 5. Polymer Degradation and Stabilization–Principles of thermal, photo, oxidative and biodegradation in polymers. Methods/equipments used for monitoring the degradation in polymers. Mechanism of degradation of some commercial polymers. Biodegradation of polymers. Waste Management.

References

1 F.W. Billmeyer, A Text Book of Polymer Science, 3rd Edn., Wiley & Sons (2009).

2 Herman F. Mark (Ed.),Encyclopedia of Polymer Science and Engg., Vol 15, 4th Edn., Wiley & Sons (2014).

3 P.J.Flory, Principle of Polymer Chemistry, Cornell University Press (1986).

4 V. R. Gowariker, N. V. Viswanathan and J. Sreedhar,Polymer science, John Wiley & Sons (2010).

5 J.F.Rabek, Experimental methods in polymer chemistry, Wiley & Sons, Imprint:Academic Press (2012).

6 Hans-George-Elias, Macromolecules Vol.1, Plenum press, Springer (1986).

7 George Odion, Principles of Polymerization, 4th Edn., Wiley & Sons (2007).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	3	3	2	2
CO 2	3	2	3	3	2	2
CO 3	2	2	2	2	2	2
CO 4	2	3	3	3	2	2
CO 5	3	3	3	2	2	2

References

1 F.W. Billmeyer, A Text Book of Polymer Science, 3rd Edn., Wiley & Sons (2009).

2 Herman F. Mark (Ed.),Encyclopedia of Polymer Science and Engg., Vol 15, 4th Edn., Wiley & Sons (2014).

3 P.J.Flory, Principle of Polymer Chemistry, Cornell University Press (1986).

4 V. R. Gowariker, N. V. Viswanathan and J. Sreedhar,Polymer science, John Wiley & Sons (2010).
5 J.F.Rabek, Experimental methods in polymer chemistry, Wiley & Sons, Imprint:Academic Press (2012).
6 Hans-George-Elias, Macromolecules Vol.1, Plenum press, Springer (1986).
7 George Odion, Principles of Polymerization, 4th Edn., Wiley & Sons (2007).

Revision- 40%

24-440-0102 Polymer Materials

Course outcome

On successful completion of the course, the students will be able to:

CO 1: Acquire in depth knowledge on different types of polymeric materials and general purpose rubbers. (Understand)

CO 2: Understand the structural property relations of different special purpose elastomeric materials and their applications. (Understand)
CO 3: Understand the structural property relations of different thermoplastic materials and their applications. (Understand)
CO 4: Acquire in depth knowledge on polyamides, polyesters and polyurethanes and their applications. (Understand)
CO 5: Understand the preparation and structural property relations of different thermoset materials and their applications. (Understand)

Unit 1. General Purpose Elastomeric materials – Introduction to manufacture, structure, properties and applications of styrene butadiene rubber (SBR), Natural rubber (NR), poly isoprene rubber (PIR), acrylonitrile-butadiene rubber (NBR) and polychloroprene rubber (CR). Comparison of different unsaturated rubbers (SBR, PIR, NBR, NR and CR).

Unit 2. Special Purpose Elastomeric Materials – Comparison with general purpose elastomeric materials, Introduction to manufacture, structure, properties and applications of butyl rubber (IIR), EPDM, EPM, hypalon, silicone and polyurethane rubbers. Comparison of these rubbers with unsaturated elastomers SBR, PIR, NBR, CR and NR with respect to structure and properties.

Unit 3. Thermoplastic and thermosetting behaviour of plastics. Thermoplastic Materials (poly olefins and Vinyl polymers) – Introduction to preparation, general properties and uses of important thermoplastics: polyethylenes (PE), polypropylene (PP), polyvinyl chloride (PVC), polyvinylidene chloride, polystyrene (PS).

Unit 4. Engineering thermoplastics and conducting polymers: Poly Amides and Polyesters Based Polymer Materials – Preparation, properties and uses of Nylon-6 and Nylon-66 and Kevlar. Important polyesters and polyurethanes in commercial applications. Manufacture, structure, properties and uses of polycarbonates, acetals resins, polyimides, PMMA. Introduction to

conducting polymers: Polyacetylene, Polyaniline, Polypyrrole, Polythiophene.

Unit 5. Thermosets – Manufacture, structure, curing, moulding powder, laminates, general properties and applications of phenolic resins (PF), urea formaldehyde (UF) and melamine formaldehyde (MF) resins and epoxy resins.

Reference

1. **Maurice Morton, Rubber Technology, 3rd Edn., Kluwer Academic Publishers (1999).**
2. **C.M. Blow, Rubber Technology and Manufacture, Butterworths (1982).**
3. **J. A Brydson, Plastic Materials: 7th Edn., Oxford Butterworths (1999).**
4. **Gilbert Marianne, Brydson's Plastics Materials, Edited: 8th Edn., Elsevier (2017).**
5. **D. C Blackly, Synthetic Rubbers, Applied Science Publishers (1983).**
6. **Ehrenstein Gottfried, Polymeric materials, Hanser Publishers (2001).**
7. **Natural Rubber and Agromanagement, Rubber Research institute of India (2000)**

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	2
CO 2	2	3	3	2	3	2
CO 3	2	2	3	2	3	2
CO 4	3	3	2	2	3	2
CO 5	2	2	2	2	2	2

Revision – 30%

24–440–0103 Advanced Polymer Products Design

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Structure – property relationship and role of fillers in polymers. (Understand)
CO 2: Design polymeric gears, bearings and PVC piping.(Apply)
CO 3: Design O-ring and vibration dampers.(Apply)
CO 4: Joining of plastics using ultrasound and snap fits (Understand)
CO 5: Design of thermosets, metal plating of plastics, design of self-hinges. (Apply)

Unit 1. Structure and properties of polymers – Stress- strain behaviour, effect of fillers on properties of polymers. Creep and stress relaxation. Pseudoelastic design approach. Design of plastic beams.

Unit 2. Design of products I – Gears: materials, strength and durability, moulded v/s cut plastic gearing, inspection assembly and operation. Bearings: self-lubricated plastic materials, rubber bearing, type of bearings, designers check list. PVC piping: raw materials, pipe design, specification and test procedure, manufacturing process.

Unit 3. Design of products II – Elastomeric ring seals: basic configurations, design method, design consideration, static and dynamic seals. Vibration dampers: basic vibration damping relations, octave rule for damped systems, estimating damping in structures, controlling resonant peaks with damping, response of damped structures to shock.

Unit 4. Ultrasonic assembly of thermoplastics- theory, equipment, type of assembly, joint design for assembly, materials for ultrasonic welding. Snap fits and hinges: Design of cantilever snaps, assembly and disassembly, annular snap fits. Plastic hinges- design and production.

Unit 5. Thermoset part design- materials, general design recommendations for parting line, straight draw, undercuts, sharp corners, cross sectional areas, wall sections, taper, ribs, bosses, holes, threaded holes, surface flatness. Plating on plastics, the plating process, preparation for plating, electroless plating, electroplating, testing of electroplate, typical formulation of electroless plating and electroplating solutions.

References

1 Edward Miller, Plastics Products Design Handbook-Materials and Components, Part A, Marcel Dekker (1981).

2 Edward Miller, Plastics Products Design Handbook-Materials and Components, Part B, CRC Press (1983).

3 Paul F. Mastro, Plastics Product Design, Scrivener Publishing (2016)

4 P. K. Freekly, A.R. Payne, Theory and Practice of Engineering with Rubber, Applied Science (1978).

5 S. Levy, J. H. Dubois, Plastic Product Design Engineering Hand Book, 2nd Edn., Springer science (2012).

6 A.N. Gent (Ed.), Engineering with Rubber: How to Design Rubber Components, Hanser Pub. Inc.(2001).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	3	2	2	2
CO 2	3	3	3	2	3	2
CO 3	3	3	2	2	3	2
CO 4	1	2	1	1	2	1
CO 5	1	1	1	1	1	1

Revision- 40%

24-440-0104 Research Methodology and IPR

Course Outcome
On successful completion of the course, the students will be able to:

CO1: Explain research process and research problem. (Understand)

CO 2: Understand the design of research. (Understand)

CO 3: Discuss the methods and techniques of data collection. (Understand)

CO 4: Explain the field work in research and data processing. (Understand)

CO 5: Understand different forms of IPR. (Understand)

Unit 1. Research – Definition, meaning, research as the application of scientific method. Importance of research. The Research Process and types of Research. Defining the Research Problem. Problem Formulation and Statement of Research.

Unit 2. Research Design – Details and applications of exploratory, descriptive, diagnostic/conclusive and experimental researches. Operational and Administrative structure for research. Sampling and Sampling Designs.

Unit 3. Methods & Techniques of data collection – Observational and other survey methods, development and designing of tools of data collection, measurement scales. Levels of measurement and questions of validity and reliability. Mean, Standard deviation, Normal distribution.

Unit 4. Fieldwork in research and data processing – Analysis and Interpretation of Data: univariate analysis, bivariate analysis of data-Correlation and Regression. Testing of hypothesis, parametric and non-parametric tests. Mathematical models.

Unit 5. Reporting of research – Graphical presentatation of data, types of reports, substance of reports, format of Report. Presentation of Reports.
IPR – Analysing and understanding the Interpretation of IP laws , need for protecting IP. Forms of IPR: copyright ,trademark ,patents, industrial designs, trade secrets , geographical

indications, application of different forms of IPR

References

1 Roger Bennett, Nitish De, Management Research: Guide for Institutions and Professionals, 3rd Edn., International Labour Office (1983).

2 Claire Selltiz,Marie Jahoda,Morton Deutsch,Stuart W. Cook. (Ed.) , Research methods in social relations,Methuen (1977).

3 Neil J.Salkind, Exploring Research, 9th Edn., Pearson Education (2016).

4 C.R.Kothari, Research Methodology: Methods and Techniques, New Age International (2004).

5 Taro Yamane, Statistics: an Introductory Analysis, 3rd Edn., Harper & Row (1973).

6 Richard I Levin, Statistics for Management, Pearson Education India (2011)

7 V. K. Ahuja, Law Relating to Intellectual Property Rights, 2nd Edn.,Lexis Nexis (2013).

8 Craig Allen Nard, Law of Intellectual Property, 2nd Edn., Aspen publishers(2008).

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	3
CO 2	2	2	3	2	2	3
CO 3	1	2	3	3	3	2
CO 4	2	3	2	2	2	3
CO 5	2	2	2	2	2	3

24-440-0111 Advanced Polymer Science

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Identify the plastics and rubbers used in various unknown polymeric products.

CO2: Estimate molecular weight of polymers by different techniques.

CO3: Understand the various synthesis methods for the preparation of polymers

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	1	2
CO2	2	1	1	2	1	2
CO3	2	2	1	1	1	2

1. Identification of rubbers, plastics and thermoplastic elastomers -NR, SBR, PB, IR, IIR, EPDM, Hypalon, Thiokol, Silicone, CR, NBR, PE, PP, PS, PVC, PVA, PF, UF, MF, Polyester, SIS, SBS, SEBS, Hytrel.

2. Estimation of polymer molecular weights

   a) Viscometry

   b) Gel permeation chromatography

   c) End group analysis

3. Determination of effect of free radical intiators on molecular weight

4. Preparation of Polymers

   a) Preparation of plystyrene/PMMA through various sythesis techniques such as bulk, solution, suspension and emulsion polymerisation techniques

   b) Grafting of NR

   c) Preparation of cured epoxy resins.

   d) Preparation of cured unsaturated polyester resin.

References

1. Rabek, Experimental methods in Polymer Chemistry, John Wilely & sons (1998)

2. D. Braun, H. Cherdron, H. Ritter, Polymer Synthesis: Theory and Practice, Springer Science and Business Media (2001)
3. Stanley R. Sandler, Wolf Karo, Joanne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization: A Laboratory Manual, Elsevier (1998)
4. K.J. Saunders , Identification of Plastics and Rubber, Chapman and Hall

24-440-0112 Polymers for packaging

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Determine various physical, mechanical and barrier properties of plastic packaging films

CO2: Analyse the gas barrier properties of packaging films

CO3: Assess the capability of film and packaging materials to withstand wear, pressure and damage

1. Determination of tensile stregth and tear strength of packaging films using UTM
2. Determination of Impact resistance of films
3. Determination of puncture resistance of packaging films
4. Determination of bond strength and peel strength of poymer films
5. Determination of gas barrier properties of pckagaing films using various gases like O_2, N_2, CO_2 etc.

References

1 ASTM standards, ISO standards

Mapping of course outcomes with program outcomes: Level - Low (1), Medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	1	2
CO2	2	1	1	2	1	2
CO3	1	1	1	1	1	2

24-440-0113 Advanced Polymer Rheology

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Analyse the viscosity of polymers based on the experiments

CO 2: Analyse the dynamic mechanical properties of polymers

CO 3: Understand the effect of strain rates on mechanical properties

1. Determination of melt viscosity using capillary rheometer
2. Determination of die swell
3. Determination of Brookfield viscosity.
4. Determination of MFI
5. Determination of post moulding shrinkage
6. Determination of creep
7. Determination of stress relaxation
8. Determination of storage modulus, loss modulus and loss tangent
9. Determination of effect of frequency on dynamic mechanical properties
10. Determination of strain rate on mechanical properties

References

1. ASTM, BIS, ISO standards

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	1	1	1	1	1	2
CO3	1	1	1	1	1	2

24-440-0114 Characterisation and Testing Methods

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Understand the modelling of various parts of polymers by using CAD

CO 2: Understand the principle and working of 3D printers

1. Determination of melt viscosity using capillary rheometer
2. Determination of die swell
3. Determination of Brookfield viscosity.
4. Determination of MFI
5. Determination of post moulding shrinkage
6. Determination of creep
7. Determination of stress relaxation
8. Determination of storage modulus, loss modulus and loss tangent
9. Determination of effect of frequency on dynamic mechanical properties
10. Determination of strain rate on mechanical properties

References

1. ASTM, BIS, ISO standards

2. CAD software tutorial

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	1
CO2	1	1	1	1	1	1

24-440-0121 Polymers for Packaging

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Explain fundamental properties of packaging materials. (Understand)
CO 2: Compare various bioplastics suitable for packaging. (Understand)
CO 3: Identify chemical and physical changes after packaging. (Analyse)
CO 4: Discuss packaging methods for food materials. (Understand)
CO 5: Identify specific waste management methods , safety and legislative aspect of packaging materials. (Analyse)

Unit 1. Food packaging materials– Conventional, edible and biobased, advantages and disadvantages. Edible films and coatings : polysaccharide, lipid and protein based coatings. Biodegradable packaging materials: first, second and third category.

Unit 2. Properties of packaging materials – optical, tensile, bursting strength, impact strength, tear strength, stiffness, crease or flex resistance, coefficient of friction, blocking, orientation & shrinkage and barrier properties.

Unit 3. Selection of packaging materials – deteriorative reaction in foods: enzyme reactions, chemical reactions, physical change, biological change. Shelf life of foods, factors controlling shelf life.

Unit 4. Food packaging materials – microwavable foods, flesh foods, horticultural products, dairy products, packaging of cereals, snack foods & confectionary and beverages. Aseptic packaging of foods. Sterilization of packaging materials. Active packaging: active packaging systems, sachets and pads, active packaging materials, self-heating and self-cooling packages, widgets. Intelligent packaging. Modified atmospheric packaging: principle, gases used, passive and active MA. Sealing methods. Printing processes.

Unit 5. Waste management – recycling, composting, thermal treatment, landfill. Life cycle assessment. Safety and legislative aspect of packaging: Regulatory considerations, plastics packaging, metal packaging, paper packaging and glass packaging.

References:

1. Gordon L. Robertson, Food Packaging Principles and Practices, CRC press (2012).
2. R.J. Hernandez, Susan E. M. Selke, John D. Culter, Plastics packaging, Hanser Publishers (2000).
3. Stanley Sacharow, Roger C. Griffin, Jr., Basic Guide to Plastics Packaging, Massachusetts Cahners (1973).
4. S. Athalye, Plastics in Flexibles Packaging, Multi- Tech Publishing (1992).
5. S. Athalye, Plastics in Packaging, Tata McGraw Hill Publishing Company Ltd. (1992).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	2
CO 2	2	2	2	2	2	2
CO 3	2	2	3	2	3	2
CO 4	2	3	3	2	2	2
CO 5	1	2	1	2	2	1

Revision 15%

24-440-0122 Advanced Polymer Rheology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Analyse the viscoelastic behaviour using various models and superposition principles. (Analyse)
CO 2: Explain the failure behaviour of polymers. (Understand)
CO 3: Interpret the flow behavior of polymer melts. (Apply)
CO 4: Describe the flow of polymer melts through different cross-sections. (Understand)
CO 5: Examine the rheological behaviour in different processing equipment. (Analyse)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

Unit 1. Viscoelastic behaviour– Response of Ideal elastic solid, pure viscous flow, viscoelastic solids and fluids. Mechanical models: Maxwell and Voigt-Kelvin models, four parameter model, Deborah number, relaxation and retardation time, generalized Maxwell-Weichert model, generalized Voigt model, Boltzmann superposition principle. Dynamic mechanical properties: storage and loss modulus, loss tangent, effect of temperature and frequency, effect of molecular weight, branching, crosslinking, crystallinity, blending. Time-temperature superposition: WLF equation. Rubber elasticity, entropic elasticity, Thermodynamics: force-temperature relations.
Unit 2. Fracture mechanics –Yielding and cold drawing, yield criteria, temperature and strain rate dependence, crazing, fracture, ductile-brittle transition temperature, brittle fracture- Griffith's theory, linear elastic fracture mechanics- fracture toughness, elastic - plastic fracture mechanics, rubber toughening, fatigue

Unit 3. Polymer melts – Time independent fluids: Newtonian fluids, non-Newtonian fluids, pseudoplastic, Bingham, dilatants. Time dependent fluids-thixotropic and rheopectic behavior. Models: two parameter models, three-parameter models. Factors influencing flow behavior: temperature, pressure, molecular weight and distribution, chain branching, shear rate,

fillers,plasticizers . Flow of Newtonian fluids through circular cross-sections, parallel plate and annulus.

Unit 4. Flow properties – Power-law fluids, Rabinowitsch correction, Entry and exit effects, Bagley correction factor-estimation, wall slip, Carreau equation. Measurement of flow properties: capillary viscometers, coaxial cylinder viscometer, cone and plate viscometer- advantages and disadvantages. Defects: Melt fracture, shark skin, frozen-in orientation, draw-down, die swell-effect-L/D ratio, shear rate, temperature, fillers, molecular weight. Extensional flow- simple extension, biaxial extension, planar extension.

Unit 5. Rheology in extruders: analysis of pressure, drag and leakage flow. Rheology in injection moulding, Rheology in blow moulding, Rheology in compression, Rheology in transfer moulding.

References

1. Robert O. Ebewele, Polymer Science and Technology, 1st Edn., CRC Press (2000).
2. N. G. McCrum, C. P. Buckley, C. B. Bucknall, Principles of Polymer Engineering, 2nd Edn., Oxford University Press (1997).
3. Robert. J. Young , Peter. A. Lovell, Introduction to Polymers, 3rd Edn., CRC Press (2011). 4 R. J. Crawford, P. J. Martin, Plastics Engineering, 4th Edn., Butterworth-Heinemann (2020).
4. R.P. Chhabra, J.F. Richardson, Non-Newtonian Flow and Applied Rheology: Engineering Applications, 2nd Edn., Butterworth-Heinemann (2008).
5. J. A. Brydson, Flow properties of polymer melts, 2nd Edn., Godwin (1981).
6. B.R. Gupta, Applied Rheology in Polymer Processing, Asian Books Private Limited (2006). 8 John M. Dealy, Kurft F. Wissbrun, Melt Rheology and its Role in Plastics Processing,
7. Springer (1999).
8. F. N. Cogswell, Polymer Melt Rheology – A guide for Industrial Practice, Woodhead Publishing (1981).
9. Lawrence E. Nielsen, Robert F. Landel, Mechanical properties of Polymers and Composites, 2nd Edn., Marcel Dekker, Inc. (1994).
10. Montgomery T. Shaw, William J. McKnight, Introduction to Polymer Viscoelasticity, 4th Edn John Wiley and Sons (2018.,

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	3	3	2	2
CO 2	3	3	3	3	3	2
CO 3	3	3	2	2	3	2
CO 4	2	3	2	1	2	1
CO 5	3	2	2	1	2	1

Revision – 10%

24-440-0123 Characterisation and Testing Methods

Course Outcome

On successful completion of the course, the students will be able to:

CO 1 Explain the relevance of standards and specifications. (Understand)

CO 2 Distinguish the processability parameters of thermoplastics and thermosets. (Understand)

CO 3 Discuss the mechanical and dynamic mechanical properties of plastics and elastomers. (Understand)

CO 4 Analyze the characterization and test results of polymers. (Analyse)

CO 5 Interpret the test results obtained from polymer product testing. (Analyse)

Unit 1. Introduction – Specifications and standards. Importance of standards in the quality control of polymers and polymer products. Standards organizations. Preparation of test pieces, conditioning and test atmospheres. Testing of dry rubber: Determination of dirt, volatile matter, ash, nitrogen, plasticity retention index (PRI), acetone extract. Latex testing: total solids content (TSC), dry rubber content (DRC), total alkalinity, coagulum content, sludge content, KOH number, mechanical and chemical stability, volatile fatty acid (VFA) number.

Unit 2. Tests for processability parameters of rubbers – Mooney viscosity, scorch time, cure time, cure rate index - Rubber process analyzer (RPA). Processability tests for thermoplastics: MFI, cone and plate rheometer, capillary rheometer. Processability tests for thermosets: gel time, cup flow test.

Unit 3. Properties of plastics and rubbers – Mechanical : tension, compression, flexural, tear strength, dynamic stress- strain, hardness, impact strength, resilience, abrasion resistance, creep and stress relaxation, compression set, dynamic fatigue, ageing properties. Thermal: specific heat, thermal expansion, thermal conductivity, heat deflection temperature (HDT), Vicat softening point (VST). Electrical : resistivity, dielectric strength, dielectric constant**.**

Unit 4. Characterisation of polymers, blends and composites – Differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), electron spectroscopy for chemical analysis (ESCA), scanning electron microscopy (SEM), transmission electron spectroscopy (TEM), atomic force microscopy (AFM).

Unit 5. Quality control tests – Rubber products: latex dipped goods, foam, thread, hose, belts. Plastic products: laminates, films, pipes and cables.

References

1 ISO, BIS, ASTM, BS and DIN standards.

2 R.P. Brown, Plastic test methods, 2nd Edn., Harlond, Longman Scientific (1981).

3 Vishu Shah, Handbook of Plastic Testing Technology, 3rd Edn., John Wiley & Sons (2007).

4 R.P. Brown, Physical Testing of Rubbers, 4th Edn., Chapman Hall (2006).

5 J.F. Rabek, Experimental methods in Polymer Chemistry, John Wiley & Sons (1980).

6 F. Majewska, H. Zowall, Handbook of analysis of synthetic polymers and plastics, Ellis Horwood Limited Publisher (1977).

7 H.H. Williard, L.L. Merrit, J.A. Den, F.A. Settle, Instrumental method of Analysis, CBS Publishers and distributors (1986).

8 Douglas A. Skoog, F.J. Holler, Stanley R. Crouch, Principles of Instrumental Analysis, 7th Edn., Cengage Learning (2018).

9 C.A. Harper, Handbook of Plastics Elastomers & Composites, 2nd Edn., McGraw Hill Inc. (1992).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**3**	**3**	**2**	**2**	**2**
CO2	**3**	**3**	**3**	**2**	**3**	**2**
CO3	**3**	**3**	**2**	**2**	**3**	**2**
CO4	**2**	**3**	**2**	**1**	**2**	**1**
CO5	**2**	**2**	**2**	**1**	**1**	**1**

SEMESTER II

24-440-0201 ADVANCED PLASTIC PROCESSING

Course Outcome
On successful completion of the course, the students will be able to:

CO 1 Acquire fundamental understanding on the selection of appropriate additives and techniques for plastic processing. (Understand)
CO 2 Recommend a preferred plastic production process based on requirement. (Apply)
CO 3 Analyze merits and demerits from product design perspective. (Analyze)
CO 4 Develop skill to critically evaluate design of product vs performance. (Evaluate)
CO 5 Modulate processing parameters and compounding additives towards product requirement. (Evaluate)

UNIT 1. Applied Principles of Plastics Processing: Functional characteristics of polymer melts: rheological aspects of plastic processing, evaluation of mechanism of action of additives in plastic compounds, criteria for selection of processing techniques, selection criteria vs performance. Compounding and mixing: methods of incorporation of additives., mixing equipment-batch, continuous, high-speed mixers, two roll mill, Banbury, ribbon blender, planetary mixers and extruders.

UNIT 2. Extrusion: Process cycle. Factors governing efficiency. Extruder screw design vs efficiency. Special extruders: vented, reverse flow, twin screw, intermeshing and non–intermeshing, counter rotating and co-rotating. Extrudate defects and troubleshooting: shark skin, melt fracture & bambooing. Product Manufacture: co-extruded sheets, corrugated pipes, coating, lamination, profiles. Screw design for special applications of extruders. Dies and take off equipment. Post-extrusion techniques.

UNIT 3. Injection Moulding: Reciprocating screw injection moulding machines, process variables, effects on moulding quality, factors affecting moulding. Common moulding defects: causes and remedies. Thermoset injection moulding: machine description, parts and their functions, process parameters, merits and de-merits. Reaction injection moulding (RIM): features and variables, flow

diagram, merits and demerits. Injection foam moulding-types, microcellular injection foam moulding. Specialized processes: reinforced pipes, fishing net, heat shrink film, cling film, corrugated sheets and pipes Nonconventional injection moulding processes: gas-assisted, sandwich moulding, structural foam, metal filled, multicolour moulding, injection moulding of reinforced thermoplastics.

UNIT 4. Special Plastic Processing Techniques: Compression moulding: materials for compression moulding, process parameters and specifications, influence of process variables. Transfer moulding: pot and plunger types, advancements, screw transfer moulding techniques, design parameters. Advantages and disadvantages of compression and transfer moulding. Thermoforming: advancements, materials and modulations in processing. Calendaring: principle, roll configuration vs products. Defects vs trouble shooting: finishing operations, product vs material/mould designs. Rotational moulding, Rotational moulding process analysis, multilayer rotational moulding, rotational moulding of thermosets.

UNIT 5. Blow Moulding and Advanced Plastic Processing Techniques: Blow moulding: stretch, co-extrusion, miscellaneous blow moulding processes, blow moulding of irregular parts. 3D printing and Additive Manufacturing Systems: Fused Deposition Modelling, Shape Deposition Manufacturing (SDM), Ballistic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting. Artificial Intelligence (AI) assisted plastic processing.

References

1. Seymour S. Schwartz, Sidney H. Goodman, Plastics Materials and Processes., Van Nostrand Reinhold Company Inc. (1982).
2. D. V. Rosato, Plastic processing data Handbook, Springer (1997).
3. Norman Lee, Plastic Blow Moulding Handbook, Rapra Technology Ltd. (2006). 4 R.J. Crawford, Plastics Engineering, Butterworth – Heinemann (1998).
4. D.H. Morton Jones, Polymer Processing, Chapman and Hall (1989).
5. Joel Fradas, Plastics Engineering Handbook, Van Nostrand Reinhold Company (1978). 7 George Matthews, Polymer Mixing Technology, Elsevier Science Ltd. (1982).
6. Chris Rouwendaal, Polymer Extrusion, 5th Edn., Hanser Publishers (2013).
7. John R. Wagner, Jr. Eldridge M. Mount, Harold F. Giles, Extrusion – The definitive Processing Guide and Handbook, Elsevier. Inc. (2013).
8. Walter E. Becker, Reaction Injection moulding Van Nostrand Reinhold Company (1979). 11 I.I. Rubbin, Injection moulding theory and practice, Wiley (1973).

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	**2**	**3**	**3**	**3**	**2**	**2**
CO 2	**3**	**2**	**3**	**3**	**3**	**2**
CO 3	**3**	**2**	**3**	**2**	**3**	**2**
CO 4	**3**	**3**	**3**	**3**	**3**	**2**
CO 5	**3**	**3**	**3**	**2**	**3**	**2**

Revision-30%

24–440–0202 Rubber Processing and Product Manufacture

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Explain the basics of NR latex preservation, processing and dry rubber production. (Understand)

CO 2: Explain the principle and operation of compounding machineries. (Understand)

CO 3: Design rubber compounds based on end-use requirements. (Apply)

CO 4: Explain various rubber processing techniques used to manufacture rubber products. (Understand)

CO 5: Identify different unit operations for rubber product manufacturing. (Analyse)

Unit 1. Natural rubber – Preserved field latex, latex concentrates – centrifuging and creaming, ribbed smoked sheets, crepe rubber, technically specified solid block forms (crumb rubber), superior processing rubbers and other modified forms of natural rubber.

Unit 2. Vulcanisation – Curatives: Sulphur, sulphur donors, accelerators, activators, non-sulphur curatives- peroxides, metal oxides, resin, high energy radiation, microwave. Mechanism of cure, estimation of cure using rheometers and swelling studies.

Other compounding ingredients: fillers- black and non black, filler characteristics such as surface area, structure and surface activity, role of filler on properties, anti-degradants, mechanism of protection, plasticisers, special purpose additives- blowing agents, antistatic agents, conducting fillers, anti-fungal agents. Design of rubber compounds to meet specific needs.

Unit 3. Rubber Processing – Machinery used for: mixing- two roll mill, internal mixers and continuous mixers, extrusion, calendering, fabric coating and spreading process.

Unit 4. Moulding techniques – Compression moulding- types of mould, the process, the hydraulic press, types of press, transfer moulding and injection moulding and autoclave curing. Continuous curing methods: rotocure, hot air, fluidized bed, LCM, molten salt bath and high energy radiation curing.

Unit 5. Rubber products – Dry rubber products: footwear, belts, hoses and tubes, wire and cables, rubber to metal bonded articles, mechanical seals, cellular products, sports goods, tank, pipe and valve linings, shock absorbers and anti-vibration mountings. Latex products: foam, gloves, balloons, prophylactics, thread. Rubber waste disposal: recycling-size reduction methods, reclaimed rubber. Pyrolysis of waste rubber.

References

1. C. M. Blow, C. Hepburn, Rubber Technology and Manufacture, 2nd Edn., Butterworth Scientific (1982).
2. Werner Hofmann, Rubber Technology Handbook, Hanser Gardner Publications (1990).
3. P. K. Freakly, Rubber Processing and Production Organisation, Springer Science & Business Media (2012).
4. Anil K. Bhowmick, Howard L. Stephens, Handbook of Elastomers, 2nd Edn., CRC Press (2000).
5. Anil K Bhowmick, Malcolm M. Hall Henry A. Benarey (Eds.), Rubber Products
6. Manufacturing Technology, Marcel Dekker Inc. (1994).
7. Robert F. Ohm (Ed.), The Vanderbilt Rubber Handbook, 13th Edn., R. T. Vanderbilt Company, Inc. (1990).

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	1	2
CO 2	3	2	2	2	3	2
CO 3	3	2	3	2	3	2
CO 4	2	2	2	2	3	2
CO 5	3	3	3	2	3	2

Revision 10%

24-440-0203 Advanced Tyre Technology

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Gain knowledge about the various types of tyres and their functions.(Understand)
CO 2: Learn the mathematics underlying the design of pneumatic tyres.(Understand)
CO 3: Comprehend and envisage the processes involved in the design and production of rubber compounds and the components of various types of tyres and tubes.(Apply)
CO 4: Understand the standard practices followed in tyre retreading, tyre & tube maintenance and service. (Understand)
CO 5: Learn the non-destructive and destructive tests done on tyres and tubes. (Understand)

Unit 1. History of design and development of tyres– Current status of global and Indian tyre industry. Pneumatic tyres – tubed and tubeless tyres, basic functions and performance comparison. Components of a tyre: geometry and basic functions. Functions of pneumatic tyres: load carrying capacity, vibration and noise reduction, tyre function as a spring, contribution to driving control and road holding. Other functions of tyres. Cornering and self-aligning torque.

Unit 2. Raw materials used for tyre manufacturing– Tyre cords - reinforcing materials- their advantages and disadvantages- compounding ingredientsconstruction of different types of cords, Modification of the tyre cords and adhesion.- . Mechanics of tyre pavement interaction. Tyre forces on dry and wet road surfaces. Tractive forces on dry surface, wet surface, snow and irregular pavements. Braking and traction of tyres.

Unit 3. Production of bead unit, tyre tread, inner liner side wall - significance of retreading process. Tyre wear–Rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed, etc. on noise. Recent developments in tyre technology.

Unit 4. Manufacturing process for various tyres– Two wheeler and car tyres, truck tyres, OTR, farm tyres, aircraft tyres and solid tyres. Principles of compounding for various tyre components. Compounding for winter tyres. Tyre reinforcement materials (Textile, steel, glass, etcTyre curing methods, post cure inflation, quality control tests. Design and manufacturing techniques for tyre related products: tubes, valves, flaps, bladders. Different types, features and operation of tyre building machines, bead winding machine, wire belt processing machines, bias cutters, curing presses. Recent advance in tyre technology: Tweel , and green tyre technology, Tyre design for the

electric vehicle

Unit 5. Measurement of tyre properties – Static & loaded dimension and size. Tyre construction analysis, Various tyre testing systems. Force and moment characteristics, cornering coefficient, aligning torque coefficient, load sensitivity and load transfer sensitivity. Rolling resistance, non-uniformity, dimensional variations, force variations, radial force variation, lateral force variation, conicity and ply steer. Tyre balancing. Tyre flaws and separations (X- ray, holography, etc.). Standards (BIS) for tyres, tubes and flaps. Role of Indian Tyre Technical Advisory Committee.

References

1. L.J.K. Setright, Automobile Tyres, Chapman and Hall (1972).
2. Tom French, Tyre Technology, Taylor &Francis (1989).
3. Dr. S.N. Chakravarthy, Introduction to Tyre technology, Polym Consultants - New Delhi (2012).
4. Samuel Kelly Clark, Mechanics of Pneumatic Tires, National Highway Traffic Safety Administration, U.S. Department of Transportation (1981 - Digitized on 17 Dec 2007).
5. F.J. Kovac, Tyre Technology, Goodyear Tyre & Rubber Company (1973).
6. ITTAC Standards Manual, Indian Tyre Technical Advisory Committee, New Delhi (2018).
7. Tyre Condition Guides, Indian Tyre Technical Advisory Committee, New Delhi (2018).
8. John F. Purdy, Mathematics Underlying the Design of Pneumatic Tires, University of Michigan (1963 – Digitized on 25 Jul 2011).

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	2
CO 2	2	2	2	2	2	2
CO 3	2	3	2	2	3	2
CO 4	2	2	2	1	2	2
CO 5	1	1	2	1	2	2

Revision – 30%

24-440-0211 Plastics and Rubber Processing Lab

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Apply theoretical knowledge in formulation design and processing of Rubber products.

CO 2: understand plastic product manufacturing by diverse plastic processing techniques

1. Formulation design, compounding and manufacture of microcellular sheet.

2. Formulation design, compounding and manufacture of sponge.

3. Testing:

   a. Determination of Mechanical properties by UTM

   b. Determination of Hardness test –Shore A Durometer

   c. Density measurements– Liquid intrusion method

   d. Microstructure analysis – Scanning electron microscopy

4. Product manufacture by injection molding.

5. Product manufacture by extrusion.

6. Product manufacture by blow molding.

7. Testing:

   a. Determination of Mechanical properties by UTM

   b. Determination of Hardness

   c. Morphology assessment

   d. Trouble shooting – Typical illustrative examples

References

1 ISO, BIS, ASTM, BS and DIN standards.

2 C. M. Blow, C. Hepburn, Rubber Technology and Manufacture, 2nd Edn., Butterworth Scientific (1982).

3 R.P. Brown, Plastic test methods, 2nd Edn., Harlond, Longman Scientific (1981).

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	1	1	1	1	1	2

24-440-0212 Specialty Polymers Lab

Course Outcome

On completion of the course, the students will be able to:

CO1: To learn the synthesis of conducting polymers (Understand)

CO2: To learn the preparation of biomaterial substrates for medical applications. (Understand)

CO3: Analyse the prepared polymers by various characterisation techniques (Analyse)

Preparation of conducting polymers

a) Synthesis of Poly(aniline)
b) Synthesis of Poly(pyrrole)
c) Preparation of biodegradable polymer substrates for medical applications
d) Preparation of alginate microspheres for drug delivery applications
e) Preparation of porous biodegradable tissue engineering scaffolds from PLA

Characterization and Testing of Specialty Polymers

a) UV
b) FTIR
c) DC Electrical conductivity
d) Optical microscopy
e) Density measurement
f) Thermogravimetric analysis
g) vii) Biodegradation evaluation in phosphate buffer saline

References:

1. Stanley R. Sandler, Wolf Karo, Jo-Anne Bonesteel, Eli M. Pearce, Polymer synthesis and characterization: A laboratory Manuel, Elsevier Inc. (1998).

2. Rabek, Experimental methods in Polymer Chemistry, John Wilely & sons (1998)

3. D. Braun, H. Cherdron, H. Ritter, Polymer Synthesis: Theory and Practice, Springer Science and Business Media (2001)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	1	1	1	1	1	2
CO3	1	1	1	1	1	2

24-440-0213 Advanced Polymer Nanocomposites

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Synthesis of nanomaterials

CO 2: Understand the characterisation of nanomaterials

CO 3: Synthesis of polymer nanocomposites

CO 4: Understand the characterisation of polymer nanocomposites

1. Synthesis of nanomaterials (ZnO, TiO2, SnO2) by sol – gel method
2. Synthesis of nanomaterials by precipitation method (ZnO, MnO2, CuO, SiO2)
3. Characterization of nanomaterials (ZnO, TiO2, SnO2) by UV – Visible spectroscopy and FTIR
4. Characterization of nanomaterials by X- Ray Diffraction analysis (ZnO, MnO2, CuO)
5. Synthesis of Graphene via Hummer's Method
6. Liquid phase exfoliation of MoS2 and nanoclay
7. Characterization of Graphene, MOS2 and naoclay by FTIR, UV, SEM and TEM
8. Nanocomposite synthesis by solution mixing
9. Nanocomposite synthesis by In-situ polymerization
10. Nanocomposite synthesis by melt mixing of polymer (two roll mill and internal mixers)
11. Nanocomposite synthesis by latex stage mixing
12. Testing of polymer nanocomposite (Tensile strength, Tear strength, Hardness, Impact strength, Thermal properties, Chemical resistance and Gas barrier properties)

13. Comparison of physical properties of polymer nanocomposites and micro composite

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	1	1	1	1	1	2
CO3	1	1	1	1	1	1
CO4	1	1	1	1	1	1

24-440-0214 Mould and Die Design

Course Outcome

On completion of the course, the students will be able to:

CO1: Learn the use of CAD for mould design (Understand)

CO 2: Able to analyse the mould flow (Analyse)

1. Mould Design using CAD

   a) Injection Mould Design
   b) Compression Mould Design
   c) Transfer Mould Design
   d) Blow mould Design
   e) Extrusion Die Design

2. Mould Flow Analysis

References:

1. Herbert Rees, Mould Engineering, Hanser (2002)
2. Jay Shoemaker, Mould Flow Design Guide: A Resource for Plastic Engineers, Vol. 10 (2006)

Mapping of course outcomes with program outcomes: Level – Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	1	1	1	1	1	2

24-440-0215 Polymers for Electrical and Electronics Applications

Course Outcome

On successful completion of the course, the students will be able to:

CO1: Synthesize conducting polymers through various techniques.

CO2: Characterize conducting polymers

CO3: Estimate the conductivity properties of conducting polymers

1. Synthesis of conducting polymers through chemical route
   a) Synthesis of Polyailine
   b) Synthesis of Polypyrrole
   c) Synthesis of Poly (o-toluidiene)

2. Synthesis of conducting polymers through electrochemical route
   a) Synthesis of Polyailine
   b) Synthesis of Polypyrrole

3. Characterisation of conducting polymers using IR, UV, XRD, TGA,SEM and TE

4. Property evaluation of conducting polymers

   a) D.C. conductivity studies
   b) Dielectric property evaluation of conducting polymers

References

1 Rabek, Experimental methods in Polymer Chemistry, John Wilely & sons (1998)

2 D. Braun, H. Cherdron, H. Ritter, Polymer Synthesis: Theory and Practice, Springer Science and Business Media (2001)

3 Stanley R. Sandler, Wolf Karo, Joanne Bonesteel, Eli M. Pearce, Polymer Synthesis and Characterization: A Laboratory Manual, Elsevier (1998)

Mapping of course outcomes with program outcomes: Level - Low (1), Medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	1	1	1	1	1	2
CO3	1	1	1	1	1	2

24-440-0216 Materials in Space applications

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Synthesize adhesive

CO 2: Prepare composites

CO 3: Synthesize high-energy binder

1. Synthesis of epoxy resin.
2. Preparation of Epoxy/Clay Nanocomposites
3. Preparation of carbon-fibre reinforced epoxy composite by compression molding.
4. Evaluation of sress-strain properties of the composites
5. Preparation of Resorcinol-formaldehyde based carbon aerogel.
6. Synthesis of Glycidyl azide polymer

Mapping of course outcomes with program outcomes: Level - Low (1), Medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	2
CO2	1	1	1	1	1	2
CO3	1	1	1	1	1	2

24-440-0221 Specialty Polymers

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Summarize the different types of high temperature resistant polymers. (Understand)
CO 2: Outline the working principle of various devices made of conducting, photo-conducting, piezoelectric, pyroelectric polymers. (Analyse)
CO 3: Understand the rheology of liquid crystalline polymers. (Understand)
CO 4: Describe the types of ionic conducting polymers. (Understand)

CO 5: Identify the uses of polymeric materials for different medical devices. (Analyze)

Unit 1. High temperature and fire resistant polymers – fluoropolymers, aromatic polymers, hydrocarbon polymers, polyphenylene sulphide, polysulphones, polyesters, aromatic polyamides, polyketones, heterocyclic polymers, fire resistant polymers, flame retardants.

Unit 2. Polymers with electrical and electronic properties – conducting polymers, conducting mechanisms, charge carriers. Synthesis and properties of conducting polymers: polyacetylene, polyaniline, polypyrrole, polythiophene. Doping: dopants, doping techniques, applications. Photoconducting polymers. Polymers with piezoelectric, pyroelectric and ferroelectric properties. Polymers in photoresists for semiconductor fabrication: negative photoresists, positive photoresists, electron beam photoresists, plasma developable photoresists.

Unit 3. Liquid crystalline polymers (LCPs) – Concept of liquid crystalline (LC) phase, liquid crystalline polymers and their classification, main chain LCPs and side chain LCPs, structure-property relationship, applications of LCPs. Introduction to smart polymers, dendritic polymers and shape memory polymers.

Unit 4. Ionic polymers – Synthesis and physical properties: Ion-exchange, hydrophilicity, applications, ionomers based on polyethylene, elastomeric ionomers, ionomers based on polystyrene, PTFE, ionomers with polyaromatic backbones. Polyelectrolytes: ion exchangers, polyelectrolytes based on carboxylates, polymers with integral ions, polyelectrolyte complexes.

Unit 5. Polymers for biomedical applications – Biomaterials: definition and classifications. Biocompatibility: concept and validation, cell-biomaterial interactions, invitro- and invivo assessment. Biodegradation. Biocompatible polymers: silicones, polyurethanes, hydrogels. Biomedical applications of polymers: cardiovascular, dental, orthopaedic, ophthalmological, wound dressing, sutures and drug delivery.

References

1. Manas Chanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, CRC Press (2009).
2. Faiz Mohammad (Ed.), Specialty Polymers: Materials and Applications, I.K. International Pvt. Ltd, (2008).
3. Manas Chanda, Salil K. Roy, Plastics Technology Hand book, 5th Edn., CRC press (2018).
4. Jiri George Drobny, Polymers for Electricity and Electronics - Materials, Properties and Applications, 1st Edn., John Wiley & Sons (2012).
5. Pardip Kar, Doping in Conjugated Polymers, John Wiley & Sons (2013).
6. Bansi D. Malhotra, Handbook of Polymer in Electronics, Rapra Technology Limited, (2002). 7. Robert William Dyson (Ed.), Speciality Polymers, Springer (2012).
7. Buddy D., Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons (Eds.), Biomaterial Science: An Introduction To Materials In Medicine, Academic Press (2012).
8. J Park and R. S Lakes, Biomaterials An Introduction, 3rd Edn., Springer Science (2007).
9. Plastics for Electronics, Matrin. T. Goosey, Chapmann & Hall (1999).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6

CO1	2	2	3	2	2	2
CO2	3	3	3	2	3	2
CO3	2	2	2	2	2	1
CO4	2	2	2	1	2	1
CO5	1	1	2	1	3	1

Revision: 0 %

24-440-0223 Advanced Polymer Nanocomposites

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the basics of composites and carbon nanostructures. (Understand)

CO 2: Understand the structure and properties of ceramic nanomaterials. (Understand)

CO 3: Explain the synthesis and properties of polymer nanocomposites.(Apply)

CO 4: Properties of elastomeric nanocomposites and design nanoengineered polymers. (Analyze)

CO 5: Get an insight into the concepts of Nano Engineering and find the areas of pportunity in nanotechnology research. (Apply)

Unit 1. Introduction to composite materials and carbon nanostructures – Introduction to composite materials: Classification, different methods of preparation and applications. Classification based on the dimensionality:nanoparticles, nanoclustures, nanorods, nanotubes, nanowires, nanofibers and nanodots. Structure and properties of canrbon nanomaterials: CNT, fullerene, Graphene. Synthesis of graphene: Modified Hummer's method, electrochemical exfoliation and CVD method. Synthesis of CNT by CVD and arc discharge method.

Unit 2. Ceramic nanostructures and materials modifications – Introduction of ceramic nanomaterials: SiO2, ZnO, nanoclay, hBN, MoS2, and WS2. Structure and classification of nanoclay : 2:1 nanocly and 1:1 nanoclay. Modification of nanomaterials like CNT, Graphene and Clay for polymer nanocomposites.

Unit 3. Sythesis of polymer nancomposite – Introduction of synthesis of polymer nanocomposite: Solution process, Latex stage mixing, Melt mixing In-situ polymerization, Polymer nanocomposite preparation by emulsion and suspension polymerization. Electrospinning and production of polymer nanocomposite nanofibers. Electrospun nanofibers for energy storage (batteries and super capacitors), membrane, defense and biomedical applications.

Unit 4. Elastomeric nanocomposites and nanoengineered polymers – Nanocomposite with elastomeric matrix : NR, SBR and TPE. Reinforcement mechanism of nanocomposite with elastomeric matrix. Preparation of bucky paper and fiber spinning of CNT and Graphene for reinforcing polymer nanocomposite. Mechanical and thermal properties of elastomeric polymer nanocomposite. Advantages and disadvantages of nanosized fillers in polymer nanocomposite, 2D polymers: Synthesis and applications.

Unit 5: Design and applications of polymer nanocomposites – Design of high performance polymer nanocomposite, Factors affecting properties of polymer nanocomposite. Thermal and Physical properties of polymer nanocomposite. Mechanism of enhanced thermal, chemical and gass barier properties of polymer nanocomposites. Applications of polymer nanocomposites: energy, environment, defense and structural applications.

Reference

1 Stelbin Peter Figerez, Prasanth Raghavan, Graphene and Carbon Nanotube for Advanced Lithium Ion Batteries, CRC Press (2018).

2 Vijay Kumar Thakur, Manju Kumari Thakur, Chemical Functionalization of Carbon nanomaterials: Chemistry and Applications, Taylor & Francis Group (2015).

3 Yury Gogotsi, Nanomaterials Handbook, CRC Press (2006).

4 Suresh G Advani, Processing and Properties of Nanocomposites, World Scientific Publishing (2007).

5 Parag Diwan and Ashish Bharadwaj, Nanocomposites, Pentagon Press (2006).

6 The Graphene Handbook, A guide to the Graphene Technology, Industry and Market, Ron Mertens, lulu.com (2016).

7. Vijay Kumar Thakur, Manju Kumari Thakur, Eco-friendly Polymer Nanocomposite, Processing and Properties, Chemistry and Applications, Springer-Verlag GmbH (2015).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	2	2	2	2	2	2
CO3	2	3	2	2	3	1
CO4	2	3	2	1	2	1
CO5	1	2	2	2	3	1

Revision: 0 %

24-440-0224 Mould and Die Design

Course Outcome

On successful completion of the course, the students will be able to:

CO 1 Comprehend the mathematical calculations involved in the planning and design of moulds and dies. (Evaluate)

CO 2 Suggest the machinery required for the manufacture of various components of moulds and dies. (Analyse)

CO 3 Comprehend and envisage the processes involved in the design and production of various types of injection moulds. (Analyse)

CO 4 Get an insight into the design and manufacture of moulds for compression, transfer,

rotational and blow moulding processes. (Understand)

CO 5 Learn the maintenance, repair and storage of moulds and dies. (Remember)

Unit 1. Mould engineering – Introduction, basic functions of the mould, types of mould. Shrinkage of plastic materials. Calculation for the number of cavities based on available machine hour. Calculation of mould clamping force. General mould design guidelines and steps. Machine specifications. Product drawing and specifications.

Unit 2. Materials for mould manufacture – Specifications, composition, heat treating, stress relieving, carburizing, nitriding, mould finishing, polishing, mould fatigue. Screws in moulds. Rules and calculations for design. Machinery for mould manufacture : cutting, turning, milling, drilling, welding, hobbing, EDM and electro-deposition.

Unit 3. Moulds for injection moulding – Construction, design of split moulds, moulds for threaded products, stack moulds, runner-less moulds. Ejection system. Feed system. Parting surfaces. Mould cooling. Venting in injection moulds. Moulds for thermosets and rubbers. Methods of fitting moulds to the injection moulding machine platens.

Unit 4. Compression moulds –Types, components of compression moulds, mould design. Transfer moulds: general types, components, design. Moulds for thermoforming. Moulds for rotational moulding and slush moulding. Design of prototype and short-term moulds. Mould maintenance, repair and storage.

Unit 5. Introduction to the rheology of polymeric materials – Simple basic equations representing flow in extrusion dies, flow through circular tube, flow in an annulus. Extrusion dies: discharge of single melt, basic types, pipe, sheet and blown film, wire coating dies, profile dies. Automatically adjustable dies. Dies for extruding nets. Dies for co-extrusion. General rules for die design. Systems for sizing and calibration of extrudates.

References

1. Gunter Mennig, Klaus Stoeckhert (Eds.),3rd Edn., Mould- Making Handbook, Hanser Publishers (2012).

2. Chris Rauwendaal, Understanding Extrusion, 2nd Edn., Hanser Publications (2010).

3. R.G.W. Pye, Injection Mould Design, 4th Edn., Affiliated East-West Press Pvt. Ltd. (2000).

4. Walter Michaeli, Extrusion Dies for Plastics and Rubber 3E: Design and Engineering Computations, 3rd Edn., Hanser Publications (2003).

5. Peter Unger (Ed), Injection Molds: 130 Proven Designs, , 4th Edn., Hanser Publications (2006).

6. Mould Engineering, Herbert Rees, 2nd Edn., Hanser Publishers (1995).

7. E.G. Fisher, Extrusion of Plastics, 3rd Edn., Halsted Press (1976).

8. George Menges, Walter Michaeli, Paul Mohren, How to Make Injection Moulds, 3rd Edn., Hanser Publishers (2001).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	3	2

CO2	3	3	3	2	3	2
CO3	3	3	2	3	3	1
CO4	2	3	2	2	2	1
CO5	1	1	2	1	2	1

Revision: 0 %

24–440–0225 Polymers for Advanced Electrical and Electronics Applications

Course Outcome

On successful completion of the course, the students will be able to:

CO 1:	Understand the basic concepts of conducting polymers, laws of conductivity, doping process and conduction mechanism. (Understand)
CO 2:	Synthesize various classes of conducting polymers and fabricate devices based on conducting polymers (Analyse)
CO 3:	Get an insight into the processing and properties of conducting polymers.(Analyse)
CO 4:	Understand the synthesis, properties and applications of ionically conducting polymers.(Understand)
CO 5:	Analyze various applications of conducting polymers based on their properties. (Analyse)

Unit 1: Basics on inorganic and organic semiconductors–Introduction to inorganic and organic semiconductors. Classification of materials based on electrical conductivity. Basic laws on electrical conductivity: Ohm's Law, Watt's Law, Kirchhoff's Current Law (KCL), Kirchhoff's Voltage Law (KVL), Faraday's Law, Lenz's Law, Coulomb's law, Gauss's Law, Valance band theory- basic concept of band model. Molecular orbit theory-basic concept. Concept of doping and doping techniques: p-type and n-type doping and doping mechanism. Inorganic and organic dopants. Type of doping technique. Charge carriers polarons, bipolarons and solitons. Effect of doping on the properties of organic and organic semiconductors. Effect of temperature on conductivity of inorganic and organic semi-conductors. p-n junctions and characteristics of p-n junctions: depletion layer, bias current, breakdown voltage, Oxidative and reductive dopants

Unit 2: Historical development and synthesis of important conducting polymers– Introduction to electronically conducting polymers. Historical development of organic conductors. Discovery of polyacetylene. Conducting polymers and Nobel Prize. Basic structural characteristics of organic conductors. Methods of preparation of conducting polymers: Chain growth polymerization, Step growth polymerization. Polymerization techniques: Chemical polymerization, electrochemical polymerization. Template synthesis, precursor synthesis, soluble polymers (colloids and dispersions). Metathesis polymerization (Ring opening metathesis polymer (ROMP). Redox type polymers (electro active polymers). Synthesis of organic conductors: poly acetylene, poly-para phenylene, polyphenylene vinylene Synthesis of Polyhetero cyclic and polyaromatic conducting polymers: polyaniline, polypyrrole, polythiophene, polypyridine, polyvinyl carbazole. Conduction mechanism in organic conductors. Poloron, bipolron and solitons. Interchain and intra chain conduction.

Unit 3: Properties and Processing of conducting polymers– important properties of conducting polymers: electrical conductivity, photo conductivity, thermal conductivity, charge storage

capacity, photoluminescence and electro luminescence. Dielectric properties of conducting polymers in high and very high frequency fields (a.c) ultra-high frequency field (microwave field) Dielectric constant, dielectric loss and absorption properties of conducting polymers in the a.c and microwave fields. Processing of conducting polymers. Methods to enhance the processability of conducting polymers. Advantages and disadvantages of conducting polymers

Unit 4. Ionically conducting polymers and their electrical applications– Ionically conducting polymers. Proton exchange membranes. Synthesis of Nafion membrane and PEEK proton exchange membranes. Sulphonation and protonation of polymeric membranes. Ionomers and poly electrolyte. Single ion conductors. Application of ionically conducting polymers for energy storage applications: rechargeable batteries, super capacitors and fuel cells.

Unit V: Analytical Techniques for Characterization and testing of conducting polymers: Impedance spectroscopy, Thermo gravimetric analysis, Scanning Electron microscopy (SEM), Transmission electron microscopy (TEM), Electrical and ionic conductivity measurement. Temperature dependant ionic transportation in polymers. Applications of conducting polymers: Rechargeable batteries, supercapacitors, optical applications, display systems, o-LED, antistatic coating, Telecommunication system, Electromagnetic screening material, aerospace applications.

Reference

1. Tony Blythe, David Bloor, Electrical Properties of Polymers, 2nd Edn., Cambridge University Press. (2005).
2. H.S. Naiwa, Organic conductive Molecules and Polymers, Vol. 2, John Wiley and sons;(1977).
3. Prasanth Raghavan, Jabeen Fatima, Polymer Electrolytes for Energy Storage Devices,Vol. 1, 1st Edn., CRC Press (2020).
4. Prasanth Raghavan, Jabeen Fatima, Ceramic and Speciality Electrolytes for Energy storage devices, Vol. 2, 1st Edn., CRC Press (2020).
5. Neethu T. M. Balakrishnan, Raghavan Prasanth, Electrospinning for Advanced Energy Storage Applications, Springer-Nature (2020).
6. J. L. Bredas, R. Silbey, Conjugated Polymers, kluwer, Dordrecht (1991).
7. Pradip Kar, Doping in Conjugated Polymers Scivener Publishing , (2013).
8. M.E.O.Lyons, Electroactive Polymers, Plenum Press; (1994).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	3	2	2	2
CO 2	3	3	3	2	3	2
CO 3	2	3	2	2	3	1
CO 4	2	3	2	1	2	1
CO 5	1	1	2	1	2	1

Revision: 30%

24-440-0226 Materials in Space Applications

Course Outcome

On successful completion of the course, the students will be able to:

CO 1	Describe synthesis, processing and applications of high temperature polymers. (Understand)
CO 2	Explain composites for satellites and launch vehicles. (Understand)
CO 3	Describe carbon based materials, ceramic materials and metallic materials used for space applications. (Apply)
CO 4	Explain materials used in cryogenic applications. (Understand)
CO 5	Employ polymers as propallent binders. (Apply)

Unit 1. Polymers for aerospace research – Adhesives, coatings and ablatives. Synthesis, processing and applications of high temperature polymers : Aromatic liquid crystalline polyesters, phenolics, polyimide, bismaleimide, polyether etherketones.

Unit 2. Composites for satellites and launch vehicles – Composites. Type of composites : fibre composites, particulate composites and foam composites. Polymer matrix : desired properties of a matrix, thermosets and thermoplastics. Carbon based materials: carbon fiber carbon-carbon composites- production, properties and applications, carbon aero-gels, carbon foams,. Advanced fabric materials- Carbon phenolics, Silicon phenolics.

Unit 3. Polymers for thermal protection systems-Synthesis and processing of thermal protection systems in space research, high temperature resistant resins such as epoxy, phenolic . High temperature resistant polymers with metals in their back bone - Boron, Silicon and Phosphorous containing polymers for space applications. Thermofoaming Polymers-PU foaming.

Unit 4. Materials for space environment- Space radiation environment, Radiation effects, Radiation shielding materials, atomic oxygen resistant materials, space suit materials and materials for life support systems. Ultra high molecular weight polyethylene (UHMWPE): fundamentals, processing of UHMWPE- ram extrusion, Screw extrusion, Radiation shielding properties of polymers

Unit 5. Propellants – Classification of propellants: solid, liquid, hybrid and air breathing. Solid propellants : homogenous-single base and double base propellants, heterogeneous propellants, Composite propellants: preparation of oxidiser, fuel, mixing of ingradients, curing and testing of solid composite propellants. Propellant binders: high energy binders- synthesis, characteristics, pplications. Materials for cryogenic applications- cryo insulation materials, polymers and adhesive for cryo temperature applications.

References

1 S.C Lin, E.M. Pearce, High Performance Thermosets, Chemistry, Properties and Applications, Hanser Publictions (1994).

2 C.A. Dostal, Engineered Materials Handbook Adhesives and sealants, Vol.3, ASM International (1990).

3 S.K. Mazundar, Composites manufacturing; materials, product and process engineering, CRC press (2002).

4 K. Friedrich, S. Fakirov, Z. Zhang, Polymer composite-from nano-to macro-scale, Springer (2005).

5 G. Savage, Carbon-Carbon Composites, 1st Edn., Chapman and Hall (1993).

6 H.M. Flower, High Performance Materials in Aerospace, 1st Edn., Chapman & Hall (1995).

7 B.Horst, B. Ilschner, K.C. Russel, Advanced Aerospace Materials, Springer-Verlag (1992).

8 T.W. Clyne, P.J. Withers, E.A. Davis, I.M. Ward, Introduction to Metal Matrix Composites, Cambridge Solid State Science Series, 1st Edn., Cambridge University Press (1993).

9 R.R. Luise, Applications of High Temperature Polymers, 1st Edn. CRC press (1996).

10 C. Boyars, Klager K., Propellants manufacture, Hazards and Testing, Advances in Chemistry Series, Vol.88, American Chemical society (1969).

Mapping of course outcomes with program outcomes: Level - Low (1), Medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	2
CO 2	2	2	2	2	2	2
CO 3	3	2	3	2	3	1
CO 4	2	2	2	1	2	1
CO 5	2	2	2	1	2	1

Revision – 25%

SEMESTER III

24-440-0321 Adhesives and Surface Coatings

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Understand the basics and theories of adhesion. (Understand)

CO 2: Identify suitable adhesive formulation for various applications. (Analyse)

CO 3: Understand the mechanism of adhesion and design different adhesive joints . (Understand)

CO 4: Understand pigment properties and prepare paint dispersions (Understand)

CO 5: Evaluate the various paint properties (Analyse)

Unit 1. Introduction to Adhesives – Adhesive bonding, characteristics and functions of adhesives. Adhesive and cohesive failure. Structural and non-structural adhesives. Classification of adhesives. Theories of adhesion: Adsorption, mechanical, diffusion and weak boundary layer theories. Wettability. Surface energy. Contact angle. Work of adhesion and cohesion.

Unit 2. Classification and Composition of Adhesives – Classification based on origin, function, chemical composition, and method of reaction: single-part, multi-part, hot-melt, pressure sensitive etc. Epoxy, urethane, acrylic, phenolic, cynoacrylate, silicone, water based adhesives etc. Adhesive compositions and applications – Adhesive compounding additives: binders, hardeners, solvents, fillers, plasticizers etc.

Unit 3. Performance and application of adhesives – Types of stresses acting on adhesive joints: Tension/compression, shear, cleavage and peel stresses. Factors affecting stress distribution. Factors affecting adhesive performance. Adhesive composition. Design of adhesive joints. Testing of adhesives and adhesive joints. Adhesives for special environments- high/low temperature, thermal cycling, vacuum, UV, ozone and corrosive atmosphere. Adhesives for specific substrates.

Unit 4. Paint Basics – Significance of paint, Components of paint- Pigments, Binders, Solvents, various additives. Properties of pigments, Preparation of pigment dispersion, Factors affecting dispersion, Surface preparation and Paint application techniques. Paint preparation and formulation. Mechanism of film formation.

Unit 5. Paint Properties – Paint properties and their evaluation- wet properties: fineness of grind, viscosity, Weight Per Litre, Non-volatile matter (NVM), Medium separation, settling, drying properties, ease of application, flow and levelling, spreading rate, flashpoint; dry properties: hiding, gloss, scratch hardness, flexibility and adhesion, impact resistance, cross cut adhesion, chemical resistance, abrasion and scrub resistance, antimicrobial, corrosion and weathering resistance. General paint defect, Causes and remedies.

References

1 E. M. Petrie, Handbook of Adhesives and Sealants, 2nd Edn., McGraw Hill Handbook (2007).

2 A. Pizzi, K.L. Mittal, Handbook of Adhesive Technology, 2nd Edn., Marcel and Dekker Inc. (2003).

3 I. Skeist (Ed.), Handbook of Adhesives,3rd Edn., Chapman and Hall (1990).

4 S. Paul, Surface Coatings, 3rd Edn., Wiley (1996).

5 W.M. Morgen, Outline of Paint Technology, 3rd Edn., CBS Publishers (2000).

6 D. Stoye, Paint Coatings and Solvents, 2nd Ed.,Wiley VCH- (1998)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	2
CO 2	3	2	2	2	3	2
CO 3	2	2	2	2	2	2
CO 4	2	3	2	1	2	1
CO 5	2	2	2	2	3	2

24-440-0322 Advanced Biomaterials for Medical Applications

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Gain fundamental knowledge on the approaches followed in the regenerative tissue e

CO 2: Obtain a comprehensive knowledge on polymeric medical devices. (Understand)

CO 3: Gain principles of advanced drug delivery.(Understand)

CO 4: Design Polymer - Bioceramics Composites for biomedical applications. (Create)

CO 5: Design of Nanomedicine for targeted drug/gene delivery for cancer therapy. (Create)

Unit 1. Biomaterials – Factors affecting the success of biomaterials in biological milieu. Biomaterial interactions: with blood, cells and tissues. Inflammatory responses associated with implantation of biomaterial. In vitro and in vivo testing protocols. Biocompatibility assays and animal models. International standards followed for biomaterials and medical devices: FDA, ISO, ASTM.

Unit 2. Tissue Engineering – Principles of tissue engineering, polymer porous scaffolds for tissue engineering applications. Fabrication of tissue engineering scaffolds techniques: self assembly, phase separation, electrospinning, 3D bioprinting and 4D printing. Hydrogels. Biomaterials for biological factor delivery: gene, growth factor and stem cell delivery. Design of a typical drug delivery system.

Unit 3. Biomimetic approaches for advanced biomaterials design – Biomineralization and biomimetics, surface modification techniques for improving biocompatibility/imparting biomimetic response. Biomimetic approaches for bone tissue regeneration. Surface functionalization of polymers for biomedical applications. Regenerative medicine.

Unit 4. Implants and medical devices – Design of medical devices. Important medical devices: heart valves, vascular grafts and extracorporeal device. Hard tissue implants: orthopaedic implants, fracture plates, spinal fixation, urinary catheters, wound dressing, cosmetic and maxillofacial implants. Soft tissue implants-contact lenses. Controlled drug delivery systems.

Unit 5. Nanomedicine – Concept, significance and attractions, targeted drug/gene delivery, factors affecting the functioning of nanomedicine. Physiological and cellular barriers of nanomedicine: significance of shape, size and functional groups associated with surface engineering of nanoparticles. Smart targeted drug delivery systems. Passive and active targeting. Magnetic nanomedicine.

References

1. Joon Park, R. S. Lakes, Biomaterials: An Introduction , 3rd Edn., Springer Science (2007).

2. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science: An Introduction to Materials Science, 3rd Edn., Elsevier Academic Press (2004)

3. Richard J. Miron, Yufeng Zhang, Next-Generation Biomaterials for Bone & Periodontal Regeneration., Quintessence Publishing (2019).

4 Joon Park, R. S. Lakes, Biomaterials: An Introduction , 3rd Edn., Springer Science (2007).
5 Claudio Migliaresi, Antonella Motta, Scaffolds for Tissue Engineering: Biological Design, Materials and Fabrication, 1st Edn., CRC press (2014).
6 D. A. Puleo, Rena Bizios, Biological Interactions on Materials Surfaces - Understanding and Controlling Protein, Cell, and Tissue Responses, Springer (2009).
7 P Ducheyne, K. Healy, D. W. Hutmacher, D. W. Grainger, C. James Kirkpatrick,Comprehensive Biomaterials II, 2nd Edn., Elsevier (2017).
8 Binghe Wang, Longqin Hu, Teruna J. Siahaan, Drug Delivery: Principles and Applications, 2nd Edn., John Wiley & Sons, Inc. (2016).
9 Nihal Engin Vrana, Cell and Material Interface: Advances in Tissue Engineering, Biosensor, Implant, and Imaging Technologies (Devices, Circuits, and Systems)., 1st Edn., CRC Press (2015).
10 O'Hare, Sheila, Atterwill, Christopher K, Methods in Molecular Biology, Volume 43, In Vitro Toxicity Testing Protocols, Springer Science and Business Media (1995).
11 Ohn Haycock, Arti Ahluwalia, J. Malcolm Wilkinson, Cellular In Vitro Testing: Methods and Protocols., 1st Edn., Jenny Stanford Publishing (2014).
12 Marek Los, Andrzej Hudecki, Emilia Wiechec, Stem Cells and Biomaterials for Regenerative Medicine, 1st Edn., Academic Press (2018).
13 J.C.L. Schuh , K.A.Funk Compilation of International Standards and Regulatory Guidance Documents for Evaluation of Biomaterials, Medical Devices, and 3-D Printed and Regenerative Medicine Products., Toxicol Pathol (2019).
14 Bikramjit Basu, Biomaterials Science and Tissue Engineering: Principles and Methods, Ist Edn., Cambridge University Press (2017).

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	2	2	2
CO 2	2	2	2	2	2	2
CO 3	2	2	2	2	2	2
CO 4	3	3	2	2	3	2
CO 5	3	3	2	2	3	2

20-440-0323 MODELLING AND SIMULATION

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Learn discrete event simulation, reliability problem [Understand]

CO 2: Learn parameterization of continuous and discrete distributions, empirical distributions, summary statistics, estimation of parameters, fit non stationary Poisson process. [Analyse]

CO 3: Know techniques of random number generation, its properties, generation of inverse transform technique and acceptance- rejection technique and queing models.[Understand]

CO 4: Learn verification, calibration and validation and validating of input- output and analysis of simulation data.[Analysis]

CO 5: Learn simulation of manufacturing and material handling systems and features of simulation languages.[Analysis]

Unit 1. Simulation: Definition, Areas of Application, System: Discrete and Continuous Systems, Model of System, Steps in a Simulation Study. General Principles of Discrete Event–Simulation, Event Scheduling/Time Advance Algorithms, World Views, Simulation Examples: Single and two channel queues, Newspaper Selling Problem, Reliability Problem, Lead-Time Demand -Continuous System and Hybrid System Simulation Models and Applications, Monte Carlo Simulation.

Unit 2. Input Modelling: Useful Probability Distributions, Parameterization of Continuous Distributions, Continuous Distributions, Discrete Distributions, Empirical Distributions, Techniques for Assessing Sample Independence, Hypothesizing Families of Distributions: Summary Statistics andhistograms, Quantile Summaries and Box Plots, Estimation of Parameters, Goodness-of-Fit Tests, Fitting Non-Stationary Poisson Process, Selecting Input Models Without Data, Multivariate and Time Series Input Models.

Unit 3. Random Number Generation, Properties of Random Numbers, Techniques of Generation of Pseudo–Random Numbers, Test for Random Numbers, Random Variate Generation: Inverse Transform Technique, Convolution Method, Acceptance–Rejection Technique. Queuing Models, Long Run Measures of Performance, Steady State Models M/G/1, M/M/1/N/∞, M/M/C/∞/∞, M/M/C/K/K.

Unit 4. Verification, Calibration and Validation, Face Validity, Validation of Model Assumption, Validating Input-Output. Analysis of Simulation Data: Output Analysis for Terminating Simulations, Output Analysis for Steady State Simulations.

Unit 5. Simulation of Manufacturing and Material Handling Systems: Modeling of Manufacturing System, Material Handling Systems, Goals and Performance Measurement, Modeling of Down Times and Failures, Trace Driven Models; Features of Simulation Languages: Promodel– Extend - Auto Mod – Taylor II – Witness, Simul8– AIM – Arena -Basic Introduction to Agent Based Simulation and Applications.

References

1 Jerry Banks et.al. : Discrete – Event System Simulation, Fifth Edition, Prentice Hall, 2009.

2 Law A. M: Simulation Modeling and Analysis, Fifth edition, McGraw Hill New York, 2015.

3 Robinson S: Simulation, The Practice of Model Development and Use, Red Globe Press; Second edition, 2014.

4 Gordon G: System Simulation, Second Edition, Prentice Hall, 1978

***M*apping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	2	2	1	2	2
CO 2	2	2	2	2	2	2
CO 3	1	1	2	1	2	2
CO 4	2	2	2	2	2	2
CO 5	2	2	2	2	2	2

20–440–0341 Dissertation - I

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Perform literature survey (Analyse)

CO 2: Analyse the recent technology developments in the field of polymer engineering.

CO 3: Perform experiments related to a research problem. (Apply)

CO 4: Design experiments related to the development of polymer products. (Create)

CO 5: Assess the experimental data generated during the experimental work.(Analyse)

Project Plan:

Do through literature survey to acquire in-depth knowledge on the research topic assigned by the company/ institution. Finalization of the objectives and methodology relating to the assigned topic, preparing a detailed work plan for conducting the project work, including team work. Design the experiments and do the research work for attaining the initial objectives of the research problem. Preparing a report in the standard format for being evaluated by the assessment board.

Evaluation

Maximum Marks : 100
(i) One internal assessment. Evaluation by the faculty supervisor/ internal faculty members (Report and presentation)

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	3	3	3	2
CO 2	2	3	3	3	3	2
CO 3	2	3	3	3	3	2
CO 4	2	3	3	3	3	2
CO 5	2	3	3	3	3	2

SEMESTER IV

20-440-0441 Dissertation II

Course Outcome

On successful completion of the course, the students will be able to:

CO 1: Complete literature survey and prepare report as introduction for dissertation. (Analyse)

CO 2: Design and perform experiments related to the development of polymer products (Create)

CO 3: Analyse and solve problems related to polymer industries, Analyse results. (Analyse)

CO 4: Develope components, products, processes or technologies in the polymer engineering field. (Create)

CO 5: Interpret results and make reports based on the project work, Apply knowledge gained in solving real life engineering problems. (Analyse)

Project Plan:

Do through literature survey to aquire indepth knowledge on the research topic assigned by the company/ institution. Finalization of the objectives and methodology relating to the assigned topic, preparing a detailed work plan for conducting the project work, including team work. Detailed Analysis/ Modelling/ Simulation/ Design/ Problem Solving/ Experiment as needed. Final development of product/process, testing, results, conclusions and future directions. Preparing a paper for Conference presentation/Publication in Journals, if possible. Preparing a report in the standard format for being evaluated by the assessment board. Final project presentation and viva voce by the assessment board including external expert.

Evaluation

Maximum Marks : 200

Report: Project presentation and viva voce: Evaluation by the assessment board

Mapping of course outcomes with program outcomes: Level - Low (1), medium (2) and high (3)

CO 1	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 2	2	3	3	3	3	2
CO 3	2	3	3	3	3	2
CO 4	2	3	3	3	3	2
CO 5	2	3	3	3	3	2