दिल्ली विश्वविद्यालय

UNIVERSITY OF DELHI

Bachelor of Science in Polymer Science
or
Bachelor of Science (Hons.) Polymer Science with Dissertation/ Academic Projects/ Entrepreneurship
or
Bachelor of Science (Hons.) Polymer Science with Discipline-1 (Major) & Discipline-2 (Minor)

Under UGCF-2022 based on NEP-2020
(Effective from Academic Year 2022-23)

Syllabus as approved by

Academic Council

Date: **No:**

Executive Council

Date: **No:**

Syllabus for Semester I to VI is complete and finalized

Syllabus for Semester VII and VIII is yet to be decided

The syllabus for undergraduate programme in Polymer Science has been drafted in accordance with the recommendations of the Undergraduate Curriculum Framework-2022. The preamble, definitions and abbreviations, features and important aspects of UGCF have been incorporated in this document as mentioned in UGCF 2022. In step with the evolving trends and developments in higher education globally, UGCF-2022 distinctly integrates the objectives and underlying philosophy of National Education Policy (NEP) 2020 in its attributes. The salient features such as holistic development, academic flexibility, life-long learning, multidisciplinary education, multilingualism, intra- and inter-university mobility, apprenticeship, research, innovation, entrepreneurship, social outreach, and the like, aim to enrich the learning experience, creativity, innovation, and skill development of the youth of our nation.

-Drafting Committee

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Undergraduate Curriculum Framework – 2022

1. Preamble

The Preamble of the Undergraduate Curriculum Framework-2022 underlines the historical perspective, philosophical basis, and contemporary realities of higher education as enshrined in the National Education Policy (NEP) 2020 and endeavours to synchronize these cornerstones while charting the road ahead for the state of higher education.

The University of Delhi, a premier Institution for teaching, learning, and research in higher education, acclaimed nationally and internationally, has nurtured the quest for reaching the peak in every sphere of education, in its true sense, in the process of its contribution to nation-building. Being a Central University, mandated to act as the torchbearer in expanding the horizons of human resource development through the expansion of higher education, it has always paid adequate premium towards constructive and meaningful innovation as a regular feature in its undergraduate curriculum development over the years. A reflection of such sustained and continued endeavour is amply exemplified in the successive revision of undergraduate curricular framework over the decades and especially in the last two decades, keeping pace with the emerging trends in higher education in the new millennium globally and its critical importance in enriching the youth of our nation, well equipped with the prevailing priorities of skill development through innovative and practical oriented teaching-learning more than anything else. To actualize the noble objective, as succinctly brought out in the National Education Policy 2020, the university has endeavoured to explore the possibility of further restructuring and refinement of its undergraduate curriculum framework in line with the objective and underlying philosophy of the NEP 2020 to capture the imagination of the youth of our nation which depicts the contemporary realities of our demographic advantage globally. The resultant outcome of this comprehensive exercise undertaken by the university is the Undergraduate Curriculum Framework-2022 (UGCF-2022) which not only underlines the heart and soul of the NEP 2020 in letter and spirit but also goes on to create a teaching-learning framework at the undergraduate level to attract the young minds towards research, innovation, apprenticeship, social outreach, entrepreneurship and similar such areas of human knowledge and endeavour while imbibing the truly charged academic environment of the university and its constituent colleges.

After completion of B.Sc. (Hons.) Polymer Science, students are eligible for masters in polymer science/ materials science/packaging technology offered by national universities (like Sardar Patel University (Gujarat), CIPET (Ahmedabad, Bhuvneshwar), CCS university (Meerut), IIP (Delhi, Mumbai), GGSIP University (Delhi), and MS in materials science/chemical engineering/polymer science by international universities (eg., Bordeaux University (France), Tomas Bata University (Czech Republic), University of Potsdam (Germany), MIT (USA) and other reputed universities. Students can also be placed in polymer based industries/organizations like DRDO, GAIL, IOCL, Premier Polyfilms, Relaxo Footwear, Nestle, ITC, Pidilite, Bayer, Michelin, Solvey, UFlex Pvt. Ltd., ALP overseas Ltd., Asian Paints, etc. or join as an entrepreneur after completing B.Sc. (Hons.) Polymer Science.

2. UGCF-2022: Definitions and Abbreviations

(a) Academic credit – An academic credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work per week.

(b) Courses of study – Courses of the study indicate pursuance of study in a particular discipline. Every discipline shall offer four categories of courses of study, viz. Discipline Specific Core courses (DSCs), Discipline Specific Electives (DSEs), Skill Enhancement Courses (SECs) and Generic Electives (GEs). Besides these four courses, a student will select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the College/ University.

(i) Discipline Specific Core (DSC): Discipline Specific Core is a course of study, which should be pursued by a student as a mandatory requirement of his/her programme of study. In Bachelor of Science (Polymer Science), DSCs are the core credit courses of Polymer Science; which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020. A student will study three Core Courses each, in Semesters I to VI and one core course each in semesters VII and VIII.

(ii) Discipline Specific Elective (DSE): The Discipline Specific Electives (DSEs) are a pool of credit courses of Polymer Science from which a student will choose to study based on his/her interest. A student of Bachelor of Science in Polymer Science gets an option of choosing one DSE course in each of the semesters III to VI from a pool of DSEs courses as specified for Odd and Even Semesters (Table-3). The student has an option of choosing a maximum of six DSE courses of Polymer Science in semesters VII and VIII, not a combination of both.

(iii) Generic Elective (GE): Generic Electives is a pool of courses offered by various disciplines of study, which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond his/her discipline specific course(s) of study, such DSEs shall be treated as GEs for that student. In semesters I, II, V and VI, a student has to compulsorily study one GE course from a pool of courses offered by the institution. However, in semesters III and IV a student has an option of choosing between a DSE course in Polymer Science and a GE course of any discipline offered by the Institution. Similarly, in semester VII and VIII a student can exercise an option of choosing a maximum of two Generic elective courses out of a combination of three DSE and GE courses.

(iv) Ability Enhancement course (AEC), Skill Enhancement Course (SEC) & Value Addition Course (VAC): These three courses are a pool of courses offered by all the Departments in groups of odd and even semesters from which a student can choose. A student who desires to make Academic Project/Entrepreneurship as Minor has to pick the appropriate combination of courses of GE, SEC, VAC, & Internship/Apprenticeship/Project/ Community (IAPC) which shall be offered in the form of various modules as specified in the scheme of studies.

• **AEC courses** are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are Language and Literature and Environmental Science and Sustainable Development which are mandatory for all disciplines. Every student has to study "Environmental Science and Sustainable Development" courses I and II of two credits each in the first year (I/II semester) and the second year (III/IV semester), respectively. The AEC pool consists of credit courses in languages listed in the Eighth Schedule of the Constitution of India, as updated from time to time.

• **SEC** are skill-based courses and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction. A student will study one Skill Enhancement Course of 2 credits each in all the semesters from I to VI. It is to be noted that in the semesters III, IV, V and VI; students can choose

either one SEC paper or can join any Internship/ Apprenticeship/ Project (following two credit system).

• **VAC** courses are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural & constitutional values; promote critical thinking, Indian Knowledge Systems, scientific temperament, communication skills, creative writing, presentation skills, sports & physical education and teamwork which will help in all round development of students.

3. Features of UGCF-2022

The Undergraduate Curriculum Framework- 2022 (UGCF) is meant to bring about systemic change in the higher education system in the University and align itself with the NEP 2020. The objectives of the NEP 2020 have been reflected in the following features of UGCF:

a) Holistic Development
Holistic development of the students shall be nurtured through imparting life skills in initial years. These life skill courses shall include courses on 'Environment and Sustainable Development Studies', 'Communication Skills', 'Ethics and Culture', 'Science and Society', 'Computational Skills', 'IT & Data Analytics', and similar such skills which shall make the students better equipped to deal with the life's challenges.

b) Academic Flexibility
Flexibility to the students to determine their learning trajectories and pursuance of programmes of study has been well ingrained in the UGCF. The Framework allows students to opt for one, two, or more discipline(s) of study as a core discipline(s) depending on his/her choice. He/she has been provided the option of focusing on studying allied courses of his/her selected discipline(s) (DSEs) or diversifying in other areas of study of other disciplines. Students have also been provided with the flexibility to study SECs or opt for Internships or Apprenticeship or Projects or Research or Community Outreach at an appropriate stage. In the fourth year, students are provided flexibility to opt for writing a dissertation (on major, minor, or combination of the two) or opt for Academic Projects or Entrepreneurship depending upon their choice and their future outlook, post completion of their formal education.

c) Multiple Exits/ Re-entry/ Academic Bank of Credit (ABC)/ Academic Outreach
Given the extent of plurality of the Indian society and the diverse background to which students belong, multiple exits and provision of re-entry have been provided at various stages of the undergraduate programme to accommodate their requirement and facilitate them to complete their studies depending upon their priorities of life. The earning and accumulation of credits in the Academic Bank of Credit (ABC), and the flexibility to redeem the requisite credit for award of appropriate Certificate / Diploma/ Degree, as the per the norms laid down by the UGC and the University, shall be made available to the students to provide the opportunity for lifelong learning as well as for availing academic outreach beyond the superstructure of the programme of study in another University / Institution at the national /international level depending upon individual choice of the student(s).

d) Multidisciplinary Education

UGCF has incorporated multidisciplinary education by embedding within the framework. In Bachelor of Science Polymer Science, a student can study DSC, DSE, and SEC courses of Polymer Science. More importantly a student can choose to study Generic Elective courses in all the disciplines offered by the college/University. The framework does not maintain/support hierarchy among fields of study/disciplines and silos between different areas of learning. As long as a student fulfills the prerequisites of a course of study, he/she shall be able to study it. Modules or systems of study shall be meaningfully laid down so as to guide the students in choosing the track/academic paths for the desired outcome.

e) Multilingualism

One of the significant hallmarks of the framework is a provision of pursuing multilingualism while studying any other discipline as core subject(s), which has no bearing with any language and linguistics. I and II semesters of the programme provides an opportunity to the students to study languages which are enshrined under the eighth schedule of the Constitution of India, thereby allowing the students for their holistic development, including the ability to acquire proficiency in a language beyond their mother tongue.

f) Research and Innovation

The framework provides a mandatory programme on research methodologies as one of the discipline specific electives (DSE) courses at the VI & VII semester for students who opt for writing dissertation on major/minor or interdisciplinary subjects at VII and VIII semesters. Dissertation/ Academic Project/Entrepreneurship in four-year undergraduate course shall commence from VII semester and conclude in VIII semester. Detailed outcomes of each track chosen out of these three options shall be notified at the end of VII and VIII semesters shall be done accordingly.

Further, provision for internship/apprenticeship/project/community outreach right from the III semester up to VI semester provides ample opportunity to the students to explore areas of knowledge/activity beyond the four walls of the classroom and reach out to the world outside without any dilution of the academic feature of the course of study, he/she is pursuing. This also acts as a precursor for the students to take up academic projects or entrepreneurship at a later stage in VII & VIII semester. Such an initiative will help in skill development and laying a strong foundation for research and thus contribute towards overall national development through the development of skilled manpower and innovation.

g) Intra- and Inter-University Mobility

Intra and inter University mobility of students is another element of critical importance which has been ingrained in the framework. A student, by virtue of such mobility, will be able to make lateral movement within the University as well as from the University to any other Institution and vice-versa. Such an attribute allows a student maximum flexibility in terms of pursuance of education with special reference to higher education and enables him/ her to achieve the goal of life, the way he/she perceived it.

Based on the aforementioned features of UGCF-2022, the University expects maximum involvement of the student fraternity in utilizing the benefits of such a flexible yet rigorous curriculum framework at the undergraduate level and reaping the benefits of it through enrichment of their skills in their area of interest which will eventually help them in gaining employment, entrepreneurship, start-ups and various other ways of a dignified life and living as a global citizen with comparable skills and

innovative ideas befitting to the contemporary global demands. The university expects the youthful nation to reap the maximum benefits out of the UGCF-2022 in developing skilled manpower to harness the youthful energy at one hand and expand the permeation of the skilled workforce globally, taking the demographic advantage on the other hand.

4. Introduction to Undergraduate Degree course in Polymer Science

As per the recommendations of UGCF 2022, the undergraduate degree course in **Polymer Science** is a six/ eight semester course spread over three/ four academic years. The teaching – learning process is student-centric and it involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. Besides the DSCs of Polymer Science, a student can opt courses from the syllabus comprising of DSEs, GEs, SECs, AECs and VACs. Thereby, bringing out the multidisciplinary approach and adherence to innovative ways within the curriculum framework. Moreover, it allows a student maximum flexibility in pursuing his/ her studies at the undergraduate level to the extent of having the liberty to eventually design the degree with multiple exit options depending upon the needs and aspirations of the student in terms of his/ her goals of life, without compromising on the teaching learning, both in qualitative and quantitative terms. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.

5. Programme Duration and Exit Options

The minimum credit to be earned by a student per semester is 18 credits and the maximum is 26 credits. ***However, students are advised to earn 22 credits per semester***. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits have to be secured for the purpose of award of ***Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Polymer Science are listed in Table 1***.

Table 1: Qualification Type and Credit Requirements

S. No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award
1	*Undergraduate Certificate in Polymer Science*	After successful completion of Semester II	44
2	*Undergraduate Diploma in Polymer Science*	After successful completion of Semester IV	88
3	*Bachelor of Science in Polymer Science*	After successful completion of Semester VI	132

4	*Bachelor of Science (Hons.) in Polymer Science with Dissertation/ Academic Projects/ Entrepreneurship*	After successful completion of Semester VIII	176
5	*Bachelor of Science (Hons.) in Polymer Science with Dissertation/ Academic Projects/ Entrepreneurship Discipline-1(Major) & Discipline-2 (Minor)*	After successful completion of Semester VIII with minimum credits for major and minimum 28 GE credits in Discipline-2 (Minor)	176

6. PROGRAMME LEARNING OUTCOME IN COURSE

The B.Sc. (Hons) programme in polymer science is designed to nurture the in depth knowledge in students with the core concepts and principles. Undergraduate students pursuing this programme undergo laboratory training to develop quantitative and qualitative skills. This provides vast scope for critical thinking, teamwork and exposes students to techniques useful for applied areas of scientific study.

- **Knowledge:** Students acquire theoretical knowledge and understanding of the fundamental concepts, principles and processes in main branches of polymer science namely, basics of polymers science, processing and applications, and biopolymer science. Width results from the choice of electives that students are offered.
- **Laboratory Skills:** During the course students develop laboratory skills as a much valued learning outcome of this programme. Quantitative techniques gained through hands-on training opens the choice of joining the industrial laboratory work force.
- **Communication:** In today's world communication is a highly desirable attribute to possess. Opportunities to enhance students' ability to write methodical, logical and precise reports are inherent to the structure of the programme. Techniques that effectively communicate scientific chemical content to large audiences are acquired through oral and poster presentations and regular laboratory report writing.
- **Research skills:** Students of this discipline will also get exposure to develop their research skills through SEC, project and Dissertation

7. PROGRAMME STRUCTURE:

The detailed framework of undergraduate degree programme in Polymer Science is provided **in Table-2.**

The programme offers Discipline Specific Core (DSC) Courses, Discipline Specific Elective (DSE) Courses, Skill Enhancement Course (SEC), Value Added Course(VAC) and Generic Elective courses . The Core Courses are compulsory in nature. There are three types of Elective Courses – Discipline Specific Elective (DSE), Generic Elective (GE) and Skill Enhancement Courses (SEC). In addition, there are two mandatory Ability Enhancement Courses (AEC) namely English/MIL Communication

and EVS. The Core, DSE and GE papers are of 4 credits each; while the SEC and AEC are of 2 credits each.

To graduate in B.Sc. (Hons.) Polymer Science, the students will be studying twenty Discipline Specific Core papers, minimum four to maximum ten Discipline Specific Elective papers, minimum four to maximum ten Generic Elective papers, minimum two to maximum six Skill Enhancement Courses, two Ability Enhancement Courses and six Value Added Course.

The students will study courses in the following manner

- Semesters I and II, III, IV, V and VI : 3 Discipline Specific Core papers
- Semesters VII and VIII : 1 Discipline Specific Core paper
- Semester I and II : 1 GE, 1 AEC, 1 SEC and 1 VAC Papers in each
- Semester III and IV : 1 GE/1 DSE paper +1 VAC+ 1 AEC + either 1 SEC/one project/internship in each semester.
- Semester V and VI : 1DSE+ 1 GE + either 1 SEC/ 1 project/internship in each semester.
- Semester VII and VIII : 3DSE OR 2DSE+1GE OR 1DSE+2GE in each semester along with Dissertation.

The distribution of the papers is given in Table 2

The Department of Polymer Science offers six GE Courses to students of other disciplines (Table 3).

The list of the DSE papers offered by the Department of Polymer Science for its students (Table 3).

Students will study one Skill Enhancement paper in each Semesters I to VI (Table 3).

Table 2: B.Sc. (Hons) POLYMER SCIENCE PROGRAMME STRUCTURE AND COURSE DISTRIBUTION (CREDITS ARE MENTIONED IN PARENTHESIS)

Semester	Discipline specific Core	Elective DSE	GE	SEC/ Project	AEC	Dissertation	VAC	CREDIT
I	Introduction to Polymer Science (IPS) (3T+1P)	—	GE1 (4)	SEC 1 (2)	English/EVS (2)		VAC 1 (2)	22
	Raw Materials for Polymers (RMP) (3T+1P)							
	Unit Operations (UO) (3T+1P)							
II	Chemistry and Engineering of Polymer Reactions (CEPR) (3T+1P)	—	GE 2 (4)	SEC 2 (2)	EVS/ English (2)		VAC 2 (2)	22
	Polymer Rheology (PR) (3T+1P)							
	Polymer Technology (PT) (3T+1P)							
III	Rubber Additives (RA) (3T+1P)	DSE 1 (4) or GE 3 (4)		Sec-3/ Internship/Project (2)	(2)		VAC 3 (2)	22
	Plastic Additives (PA) (3T+1P)							
	Polymer Degradation (3T+1P)							

IV	Polymer Testing and Specifications (PTS) (3T+1P) Polymer Processing Technology (PPT) (3T+1P) Polymer Recycling and Waste Management (RWM) (3T+1P)	DSE 2 (4) or GE (4)		Sec-4/ Internship/Project (2)	(2)		VAC 4 (2)	22
V	Fibre Science (FS) (3T+1P) Polymer Characterization (PC) (3T+1P) Polymers in Packaging (PP) (3T+1P)	DSE-3 (4)	GE5 (4)	Sec-5/ Project/ Internship/ Technical Report/ Project (2)				22
VI	Polymer Blends and Composites (PBC) (3T+1P) Polymeric Nanomaterials and Nanocomposites (PNN) (3T+1P) Rubber Technology (RT) (3T+1P)	DSE-4* (4)	GE6 (4)	SEC-6/ or Internship/Project (2)				22

VII	Paints, Coatings and Adhesives (PCA) (3T+1P)	Choose 3 DSE/2DSE+1GE/ DSE+2GE (12)				Dissertation (6)	22
VIII	Speciality Polymers (SP) (3T+1P)	Choose 3 DSE/2DSE+1GE/ DSE+2GE (12)				Dissertation (6)	22

*** DSE-15 is a compulsory paper of Research Methodology for those who want to pursue VI and VII Semesters. In case a student doesn't take DSE-15 paper as research methodology, he/she has to take research methodology as DSE in VII semester to complete a major degree in polymer science.**

Table 3: COURSES OFFERED UNDER B.Sc. (H) POLYMER SCIENCE PROGRAMME

7.1 Semester-wise Distribution of Discipline Specific Core (DSC) Courses			
CORE COURSES –20 (4 credits each) – Each course has 3 Hrs/week for Theory & 2 Hrs/week for Practical			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
I	DSC-1	Introduction to Polymer Science (IPS)	T=3, P=1
	DSC-2	Raw Materials for Polymers (RMP)	T=3, P=1
	DSC-3	Unit Operations (UO)	T=3, P=1
II	DSC-4	Chemistry and Engineering of Polymer Reactions (CEPR)	T=3, P=1
	DSC-5	Polymer Rheology (PR)	T=3, P=1
	DSC-6	Polymer Technology (PT)	T=3, P=1

III	DSC-7	Rubber Additives (RA)	T=3, P=1
	DSC-8	Plastic Additives (PA)	T=3, P=1
	DSC-9	Polymer Degradation (PD)	T=3, P=1
IV	DSC-10	Polymer Testing and Specifications (PTS)	T=3, P=1
	DSC-11	Polymer Processing Technology (PPT)	T=3, P=1
	DSC-12	Recycling and Waste Management (RWM)	T=3, P=1
V	DSC-13	Fibre Science (FS)	T=3, P=1
	DSC-14	Polymer Characterization (PC)	T=3, P=1
	DSC-15	Polymers in Packaging (PP)	T=3, P=1
VI	DSC-16	Polymer Blends and Composites (PBC)	T=3, P=1
	DSC-17	Polymeric Nanomaterials and Nanocomposites (PNN)	T=3, P=1
	DSC-18	Rubber Technology (RT)	T=3, P=1
VII	DSC-19	Paints, Coatings and Adhesives (PCA)	T=3, P=1
VIII	DSC-20	Speciality Polymers (SP)	T=3, P=1
			Credits: 20×4 = 80

7.2 Details of Discipline Specific Elective (DSE) Courses

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) – (4-10) (4 credits each)
Each course has 2 Hrs/week for Theory, 4 Hrs/week for Practical

COURSE CODE	NAME OF THE COURSE	CREDITS T=Theory Credits P=Practical Credits
DSE: Paper 1	Advanced Analytical Techniques	T=2, P=2
DSE: Paper 2	Fibre Manufacturing Technology	T=2, P=2
DSE: Paper 3	Tyre Technology	T=2, P=2

DSE: Paper 4	Polymer Product Design	T=2, P=2
DSE: Paper 5	Polymers in Biomedical Applications	T=2, P=2.
DSE: Paper 6	Conducting Polymers	T=2, P=2
DSE: Paper 7	Bio-based and Biodegradable Polymers	T=2, P=2
DSE: Paper 8	Engineering Drawing & Mold Design	T=2, P=2
DSE: Paper 9	Polymer Physics	T=2, P=2
DSE: Paper 10	Material Science	T=2, P=2
DSE: Paper 11	Smart Materials	T=2, P=2
DSE: Paper 12	Automobile Applications of Polymers	T=2, P=2
DSE: Paper 13	Polymers in Energy Application	T=2, P=2
DSE: Paper 14	3D Printing of Polymers	T=2, P=2
DSE: Paper 15	Research Methodology	T=2, P=2

***DSE:Paper 1 to DSE: Paper 7 will be offered in odd semesters & DSE:Paper 8 to DSE: Paper 14 will be offered in even semesters.**

****DSE:Paper 15 is compulsory for all the students who want to pursue VII and VIII semester. It will be offered in both VI and VII semesters.**

7.3 Details of Skill Enhancement Courses (SECs)

SKILL ENHANCEMENT ELECTIVE COURSES (SEC) – (2-6) [2 credits each], 4Hrs Practical/Week

SEMESTER	COURSE CODE	NAME OF THE COURSE	CREDITS T=Theory Credits P=Practical Credits
I-VI	SEC: Paper 1	Natural Polymers	P=2
	SEC: Paper 2	Estimation of Polymers and Polymeric Compounds	P=2
	SEC: Paper 3	Wire and Cable Technology	P=2
	SEC: Paper 4	Polymer in Sports and Footwear Technology	P=2
	SEC: Paper 5	Polymer Membrane	P=2
	SEC: Paper 6	Fire Retardant Polymers	P=2
	SEC: Paper 7	Polymers in Defense Technology	P=2
	SEC: Paper 8	Polymer Foam Technology	P=2
	SEC: Paper 9	Fabrication of Polymer products	P=2
			Credits: 2 each paper

7.4 Details of Generic Elective (GE) Courses

GENERIC ELECTIVES COURSES (GE)– (min 4-max 10)(4 credits each) –offered for other Departments

Each course has 2 Hrs/week for Theory, 4 Hrs/week for Practical

COURSE CODE	NAME OF THE COURSE	CREDITS T=Theory Credits P=Practical Credits
GE: Paper 1	Basics of Polymer Science	T=2, P=2
GE: Paper 2	Advanced Analytical Techniques	T=2, P=2
GE: Paper 3	Polymer and Environment	T=2, P=2
GE: Paper 4	Nanocomposite and It's Application Biomedical applications of Polymers	T=2, P=2
GE: Paper 5	Polymers for Packaging	T=2, P=2
GE: Paper 6	Polymers in Daily Life Polymers for Electrical and Electronic Applications	T=2, P=2

7.5 Details of Ability Enhancement Courses (AECs)

ABILITY ENHANCEMENT COURSES (AEC) – 4 [2 credits each Paper]

SEMESTER	COURSE CODE	NAME OF THE COURSE	CREDITS T=Theory Credits P=Practical Credits
I-IV	AEC1		T = 2
	AEC2		T = 2
	AEC3		T = 2
	AEC4		T = 2

7.6 Details of Value Addition Courses (VACs)

VALUE ADDED COURSES (VAC)– (4) (2 credits each) –offered for B. Sc. (Hons) Polymer Science and other Departments

Each course has 2 Hrs/week for Theory.

COURSE CODE	NAME OF THE COURSE	CREDITS T=Theory Credits P=Practical Credits
VAC: Paper 1	Polymer Science: Intellectual Property Rights	T = 2
VAC: Paper 2	Polymer Science: Entrepreneurship and Marketing strategies	T = 2

VAC: Paper 3	Polymer Science: Industrial Safety and Equipments' Maintenance	T = 2
In addition to the following three courses, VAC courses offered by University of Delhi may also be adopted		
DISSERTATION – 6 credits –offered for B. Sc. (Hons) Polymer Science **This course has 12 Hrs/week for Research.**		
DSR	Dissertation	6 credits
		TOTAL CREDITS = 176

Students will also opt for a dissertation course in Semester VII-VIII. It will be a six credit course. It will involve experimental work under the supervision of a faculty member and will involve eight hours of work per week). The project will be evaluated by internal

and external examiners and the report should be sent to examiners in advance (prior to the day of examination).

Internship/Project: Students may also opt for internship/project under the guidance of faculty members in place of SEC papers in semester III, IV, V and VI. The report of the project has to be submitted and will be evaluated internally. Each project will have two credits.

8. TEACHING – LEARNING PROCESS

B.Sc. (Hons) Polymer Science programme is a four-year degree programme designed to train the students with a thorough theoretical background and practical training in all aspects of polymer science. This is an interdisciplinary course and includes fundamental as well as in-depth knowledge of the course. Along with the above core courses there are discipline specific elective courses, generic elective courses and ability enhancement courses to address the need of the hour.

These courses are delivered through classroom, laboratory work, projects, case studies and industry visits in a challenging, engaging and inclusive manner that accommodates a variety of learning styles and tools (PowerPoint presentations, audio visual resources, e-resources, seminars, workshops).

The Laboratory training complements the theory learned in the classroom and includes synthesis of polymers, processing, testing and applications with modern instruments, computational data analysis, modeling and laboratory safety procedures.

In addition to traditional teaching procedures, presentations, demonstrations, group discussions, research lab/industrial visits, models etc.

9. Assessment Methods

The primary objective of assessment will be to assess the learning outcomes of the course in tune with the broad outcomes of strengthening core theoretical knowledge base, practical laboratory skills, and research. Assessment will be based on continuous evaluation (class test, presentation, quiz, assignment etc.) and end of semester examination of University of Delhi.

(i) Internal Assessment or Continuous Evaluation: During a semester, students' learning outcomes as described in the syllabus will be assessed through class tests, assignments, group assignments, laboratory record files, project reports, presentations etc. Each theory paper will have 25% marks for internal assessment. The component of internal assessment for each practical paper will be 50 % marks. The critical analysis of internal assessment/ continuous evaluation outcomes will provide opportunities to improve the teaching-learning process by focusing on the areas that need conceptual strengthening, laboratory exposure or design of new experiments, and research.

(ii) End of Semester University Examinations: The end-semester university examinations will be conducted for both theory and practical courses. Besides internal assessment, each theory paper will have 75% marks and each practical paper will be of 50% marks for the end of semester examination of the university.

10. Scheme of Examination

The total marks for a four-credit course is 100 and for a two credit course is 50. The distribution of 100 marks for each of DSC, DSE and GE courses having four credits is shown in Table 4. Further, the distribution of 50 marks for each of SEC course in (0T+2P) and VAC course in (2T+0P) format is given in Table 4.

Table 4: Distribution of total marks for each DSC/DSE/SEC/GE/VAC courses in different credit formats

Marking scheme Theory

S. No	Maximum Marks (Theory)	End Semester Theory Examination**	Internal Assessment/Continuous evaluation Marks Distribution		
			Class Test	Assignment/presentation/Quiz/group discussion	Attendance
1	100	75	10	10	5
2	75	56	8	8	3
3	50	38	5	5	2

Marking Scheme Practical/ Internship /Dissertation

S. No.	Maximum Marks	Practical Examination**	Internal Assessment/Continuous evaluation Marks Distribution

		Experiment/ presentation	Viva-voce	Record file	Performance* Assessment
1	25	10	03	08	04
2	50	20	05	10	15
3	100	40	10	20	30
4	150	100	50	-	-

* Performance Assessment: Performance throughout the semester
**Duration of end-semester theory and practical examinations of different credit courses will be as per University regulations/ordinances.

Minimum Acceptable Level of Academic Standards
The minimum acceptable level of achievement that a student must demonstrate to be eligible for the award of academic credit or a qualification is the minimum acceptable level of academic standards. The Letter Grades and Grade Points which shall be used to reflect the outcome of the assessment process of the student's performance is indicated in Table 5.

TABLE 5: Letter Grades and Grade Points

Letter Grade	Grade point
O (outstanding)	10
A+ (Excellent)	9
A (Very good)	8
B+ (Good)	7

B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
AB (Absent)	0

11. Syllabus for Undergraduate Programme in Polymer Science

11.1 Discipline Specific Core Courses (DSC)

SEMESTER-I

11.1.1: DSC-1 INTRODUCTION TO POLYMER SCIENCE

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To familiarize with the structure of polymers.
2. To acquaint students with knowledge of molecular weight determination and polymer solubility.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand physical state of polymers
2. Develop fundamental knowledge of thermal transitions of temperature
3. Understand structure-property relationship of polymers
4. Apply mathematical formulae to depict polymer solution properties

THEORY: (75 MARKS)

UNIT 1: INTRODUCTION TO POLYMERS **8 L**

Introduction and history of polymeric materials, classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, cumulative interaction, entanglement, random chain model and RMS end-to-end distance, Various structures of copolymers such as linear branched and cross-linked copolymers and their types.

UNIT 2: POLYMER CRYSTALS **7 L**

Crystal morphologies, extended chain crystals, chain folding, lamellae, spherulites, crystallization, crystallinity, crystallizability & orientation, Crystalline melting point, Crystallization kinetics, effect of orientation and crystallinity on polymer properties, determination of crystallinity.

UNIT 3: PROPERTIES OF POLYMERS **8 L**

Physical properties, introduction of mechanical properties (stress–strain curves, tensile, flexural, impact, fatigue, hardness, creep and abrasion), electrical properties (dielectric strength, volume resistivity and power factor,)

UNIT 4: POLYMER MOLECULAR WEIGHT **7 L**

Nature and structure of polymers: structure-property relationships, molecular weight of polymers (M_n, M_w etc.), polydispersity, molecular weight distribution and determination of molecular weight by solution viscosity, end group analysis,

UNIT 5: SOLUTION PROPERTIES OF POLYMERS **8 L**

Polymer solutions, solubility parameter, athermal solvents, theta solvents, solution viscosity, thermodynamics of polymer solutions, Flory-Huggins theory

UNIT 6: GLASS TRANSITION BEHAVIOUR OF POLYMERS **7 L**

Glass transition temperature (T_g) and measurement of T_g, factors affecting the glass transition temperature, WLF equation

PRACTICALS: (25 MARKS)

1. Chemical identification of polymers- • Unsaturation • Testing of functional groups (associated with polymers).
2. Measurement of glass transition temperature (T_g).
3. To determine the melting point of crystalline polymers.
4. To check the solubility of the given polymeric sample in different solvents.
5. Determination of molecular weight by solution viscosity.
6. Determination of number average molecular weight by end group analysis.
7. Determination of softening point by ring and ball method.
8. To find out the acid number and hydroxyl number of a given polymer.
9. To measure volume resistivity of polymer samples.

REFERENCES:

1. Odian, G., (2004) Principles of Polymerization, Wiley-interscience.
2. Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition.
3. Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
4. Shah V., (1998) Handbook of Plastics Testing Technology, Wiley Interscience.
5. Seymour R.B., Carraher C.E., (2003) Polymer Chemistry, Marcel Dekker.
6. Teraoka, I. (2002). Polymer solutions: an introduction to physical properties.
7. Hiemenz, P. C., & Lodge, T. P. (2007). Polymer chemistry. CRC press.

ADDITIONAL RESOURCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
3. Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, Tata McGraw Hill.
4. Shah V., (2006) Handbook of Plastics Testing and Failure Analysis,John Wiley & Sons, Inc., 3rd Edition.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

End to end distance, Lamellae, Glass transition temperature, Molecular weight distribution, Viscosity average molecular weight

11.1.2: DSC-2 RAW MATERIALS FOR POLYMERS

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about the resources of polymers
2. To learn about basic concepts of polymer latex
3. To gain knowledge of properties of monomers and their synthesis

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply the knowledge of latex manufacturing and compounding
2. Apply the knowledge of techniques used in monomer production

THEORY: (75 MARKS)

UNIT 1: INTRODUCTION TO CRUDE OIL AND IT'S REFINING **5 L**

Petroleum oil, natural gas, coal: capabilities and limitations. general consideration of petrochemicals, an overview of petroleum refining, desalting, distillation, cracking and its types

UNIT 2: SYNTHESIS OF MONOMERS FROM PETROCHEMICALS **15 L**

Formaldehyde, ethylene, vinyl acetate, vinyl chloride, ethylene oxide and ethylene glycol, acrylonitrile, toluene diisocyanate, methyl methacrylate, isoprene, phenol, styrene, terephthalic acid, adipic acid, caprolactam, hexamethylenediamine

UNIT 3: LATEX **5 L**

Natural rubber latex: collection process, composition, concentration and stabilization of latex

UNIT 4: LATEX ADDITIVES AND IT'S COMPOUNDING **10 L**

Vulcanizing agents, fillers, coagulating agent, wetting, dispersing and emulsifying agents, stabilizers, thickening agents and other additives, Method of preparation of ZnO-sulphur-ZMBT-dispersion with typical formulations working and parts of ball mill, few compounding formulations for product manufacturing, compounding equipments

UNIT 5: LATEX PRODUCT MANUFACTURING TECHNIQUES **10 L**

Latex compound formulation, process of manufacturing, finishing and applications of Spreading, casting and dipping (Dipping-principal and procedure of dipping process-different types of dipping –after treatment of latex deposits -Manufacture of dipped goods with formulation and flow chart-defects and remedies . latex casting –principle and procedure of casting-production of cast articles –mould preparation, latex thread and latex foam

PRACTICALS: (25 MARKS)

1. Analysis of formalin/phenol/epichlorohydrin/Plasticizer
2. Determination of hydroxyl value/carboxyl value/ester value/epoxy value
3. Determination of colour and viscosity by gardner's tube method
4. Fractional distillation of crude oil.
5. To calculate dry rubber content (DRC) of latex.
6. To determine the coagulation strength of latex.
7. Preparation of balloon by dipping process.
8. Latex compounding for preparation of gloves & balloons.
9. Synthesis of adipic acid from cyclohexanol using Conc. HNO_3.
10. To prepare monomers from C_4 hydrocarbons.
11. Determination of percentage purity of phenol.

REFERENCES:

1. Kumar D., Chandra R., (2001) Latex Technology, Dhanpat Rai & Co.
2. Rao B.K.B., (2007) Textbook on Petrochemicals, Khanna Publishers.
3. Blackley, D.C., "High Polymer Latices", Vol 1 and 2, Chapman and Hall, 1997
4. Mausser,R.F., "The Vanderbilt Latex Hand book" 3rd edn.R.T. Vanderbilt Company, 1987.

ADDITIONAL RESOURCES:

1. Rao B.K.B., (2007) Modern Petroleum Refining Processes, Oxford and IBH
2. Maiti S., (2002) Introduction to Petrochemicals, Oxford & IBH Publ. Co.
3. Speight J.G., (2006) Chemistry and Technology of Petroleum, CRC Press.
4. Martin J. M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publishers.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Latex, Thickening agent, Vinyl acetate, Cracking

11.1.3: DSC-3 UNIT OPERATIONS

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To understand concepts of unit operations and their importance in polymer industries
2. To learn about the concepts of separation equipments used in the process industry

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Select suitable criteria for solving material and energy balance problems
2. Illustrate energy and material balance equations for open and closed systems

THEORY: (75 MARKS)

UNIT 1: INTRODUCTION TO UNIT OPERATIONS 5 L

Unit operations: concept and requirement, material and energy balances (with and without chemical reactions), energy transport in non-isothermal systems

UNIT 2: MECHANICAL OPERATIONS 10 L

Size reduction and its equipment (ball mill, jack crusher, end and edge roller mill), filtration: theory of filtration, filter aids, filter media, industrial filters including filter press, rotary filter, edge filter, etc., factors affecting filtration

UNIT 3: HEAT TRANSFER 15 L

Conduction (Fourier law, Reynolds number), convection, radiation, heat exchangers (tube shell, shell plate)

UNIT 4: MASS TRANSFER MECHANISM 15 L

Mass transfer: diffusion and its mechanism, factors affecting diffusion, gas absorption (Henry's Law, Langmuir Absorption Isotherm, BET equation), various types of distillation, drying

PRACTICALS: (25 MARKS)

1. Handling of jaw crusher, ball mill for crushing and grinding.
2. Distillation of various liquid mixtures.
3. To evaluate diffusion percentage of a plasticizer in a PVC.
4. Filtration of solids from slurry.
5. Calculation of pressure drop and pipe size.
6. Heat Transfer through different materials like glass and plastics.
7. Analysis of different adsorption isotherms.

REFERENCES:

1. Mccabe W., Smith J., Harriott P., (2005) Unit Operations in Chemical Engg., McGraw-Hill Education.
2. Chattopadhaya P., (2003) Unit Operations in Chemical Engg., Vol. 1 & Vol. 2, Khanna Publishers.
3. Coulsan J.M., Richardson J.F., (2010) Chemical Engg., Vol. 1, Elsevier.

ADDITIONAL RESOURCES:

1. Kumar D. S., (2009) Heat and Mass Transfer, S K Kataria & Sons.
2. Rao G. K., (2002) Solved Example in Chemical Engg., Khanna Publishers.
3. Treybal R., (2012) Mass Transfer Operations, Tata McGraw Hill.

TEACHING LEARNING PROCESS:
Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
Mass Transfer, Energy Transfer, Distillation, Reynolds Number

SEMESTER-II

11.1.4: DSC-4 CHEMISTRY AND ENGINEERING OF POLYMER REACTIONS

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about the different polymerizations
2. To study kinetics of chain growth and step growth polymerization
3. To understand general concepts, principles, kinetics and methodology of polymerization

COURSE LEARNING OUTCOMES:
After studying this paper, students will be able to

1. Know about overview of aspects of polymer engineering
2. Understand essential fundamentals and chemistry of the polymerization processes.
3. Learn about various terms such as reaction initiation, propagation and termination

THEORY: (100 MARKS)
UNIT 1: INTRODUCTION **7 L**

Introduction to polymerization process, control of polymer synthesis; thermodynamic and kinetic control, diffusion control, polymer end chain control & control strategies, Introduction to reactor design, Interpretation of batch reactor data; design equations for ideal reactors, namely batch, CSTR, plug flow, design equation for single reaction systems using batch and semi batch, CSTR, PFR, Multiple reactor system; reactor in series and parallel, preference of type of reactor used

UNIT 2: RADICAL CHAIN POLYMERIZATION **10 L**

Introduction, thermodynamic and kinetic aspect of radical chain polymerization, rate of polymerization, kinetic chain length, Mayo's equation, cage efficiency, selection criteria of initiators, ceiling temperature, Tromsdorff effect, inhibition and retardation Ziegler-Natta catalyst and stereoregular polymerizations, Radical chain copolymerization (reactivity ratio, copolymer equations)

UNIT 3: REDOX & OTHER INITIATIONS **5 L**

Initiation in aqueous media, initiation in non-aqueous media, rate of redox polymerization, photochemical initiation, rate of photo-polymerization, initiation by ionizing radiation, electrolytic polymerization, plasma polymerization.

UNIT 4: IONIC CHAIN & CONTROLLED POLYMERIZATIONS **10L**

Classification of ionic species, effect of solvents, initiation, propagation and termination in ionic polymerization, cationic polymerization, anionic polymerization, introduction of Atom Transfer Radical Polymerization (ATRP), Reversible Addition-Fragmentation Chain Transfer Polymerization (RAFT) and Nitroxide mediated polymerization (NMP)

UNIT 5: STEP GROWTH POLYMERIZATION **8L**

Reaction engineering of step growth polymerization: basic properties & examples of commercially important polymers, reactivity of functional groups kinetics of step polymerization, self-catalyzed & external catalysis of polymerization, molecular weight distribution in linear & nonlinear polymerization, effect of non-equivalence of functional groups, equilibrium considerations,

UNIT 6: POLYMERIZATION TECHNIQUES **5L**

Bulk, solution, precipitation, suspension & emulsion polymerization.

PRACTICALS: (25 MARKS)

1. To prepare polystyrene/poly(methyl methacrylate) by bulk polymerization and determine the rate of polymerization.
2. To study the effect of reaction temperature on free radical polymerization of styrene/MMA.
3. To study the effect on initiator concentration of free radical polymerization of styrene/MMA.
4. Redox initiated polymerization of MMA & investigate the effect of viscosity on polymerization kinetics
5. Redox polymerization of acrylamide
6. To investigate Trommsdorff effect in bulk polymerization of MMA
7. Solution polymerization of methyl methacrylate/styrene.
8. Suspension polymerization of styrene/MMA.
9. Emulsion polymerization of styrene/ methyl methacrylate.
10. Preparation of Poly (vinyl butyral).

REFERENCES:

1. Odian, G., (2004) Principles of Polymerization, Wiley-interscience.
2. Billmeyer F.A., (2011) Textbook of Polymer Science, John-Wiley & Sons.
3. Seymour R.B., Carraher C.E., (2003) Polymer Chemistry, Marcel Dekker.
4. Flory P.J., (2007) Principles of Polymer Chemistry, Asian Books Private Limited.
5. Levenspiel, O. (1998). Chemical reaction engineering. John Wiley & Sons.

ADDITIONAL RESOURCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Lenz, R. W. (1967). Organic chemistry of synthetic high polymers.
3. Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Industrial Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Plug Flow, Chain growth polymerization, Mayo's equation, Suspension polymerization, Ring opening polymerizations, ATRP

11.1.5: DSC-5 POLYMER RHEOLOGY

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To enhance fundamental knowledge of flow behaviour of polymer melts
2. To understand the concept of mixing of polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply the knowledge of measurement of viscosity in handling of rheological instruments
2. Interpret rheology of polymer melts by mechanical models

THEORY: (100 MARKS)

UNIT 1: RHEOLOGICAL PRINCIPLES 10 L

Viscosity and polymer processing, rheological properties of fluids, shear stress in polymers, Newtonian & non-Newtonian flow, polymer melt viscosities (ideal molten chains, microscopic studies of melts), flow in channels, simple shear flow, melt-flow index, Weissenberg effect, die swell, melt fracture, creep & creep compliance, stress relaxation, isochronous stress-strain curves

UNIT 2: MELT FLOW ANALYSIS 15 L

Types of fluid & rheological models, rheological measurements by capillary, parallel plate and cone & plate viscometers, simple elongational flow and its significance, dynamic flow behavior, time dependent fluid behavior

UNIT 3: RHEOLOGICAL MODELS 10 L

The elastic and viscoelastic state of polymers – viscoelasticity, viscoelastic models: Maxwell model, Voigt-Kelvin model, Boltzmann superposition principle, dynamic mechanical testing

UNIT 4: MIXING OF POLYMERS 10 L

Types of mixing, concept and importance of master batches, mixing of additives with the polymers, melt compounding

PRACTICALS: (25 MARKS)

1. Determination of melt flow index of a polymer such as PP, PS, LDPE etc.
2. Determination of intrinsic viscosity by Ubbelohde viscometer.
3. Determination of rheological properties of polymer melts by rheometers.
4. Measurement of resin/paint viscosity by Ford cup 4.
5. Measurement of dynamic viscosity by Brookfield Viscometer.
6. Compounding of polymers and investigation of their rheological behavior.
7. Industry/R&D organization visit.

REFERENCES:

1. Mccabe W., Smith J., Harriott P., (2005) Unit Operations in Chemical Engg., McGraw-Hill Education.
2. Chattopadhaya P., (2003) Unit Operations in Chemical Engg., Vol. 1 & Vol. 2, Khanna Publishers.
3. Bennett, C. O., & Myers, J. E. (1982). Momentum, heat, and mass transfer (Vol. 370, p. 569).

New York: McGraw-Hill.
4. Cengel, Y.A. and Ghajar, A.J. (2015) Heat and Mass Transfer Fundamentals & Applications. 5th Edition, Grawhil Education, Stillwater.
5. Coulsan J.M., Richardson J.F., (2010) Chemical Engg., Vol. 1, Elsevier.
6. Gupta B.R., (2004) Applied Rheology in Polymer Processing, Asian Books.
7. Rosen S.L., (2012) Fundamental Principles of Polymeric Materials, Wiley-Interscience.
8. Ghosh P., (2010) Polymer Science and Technology of Plastic and Rubber, Tata McGraw Hill.
9. Aklonis J., Macknight W.J., (2005) Introduction to Polymer Viscoelasticity, John Wiley & Sons
10. Middleman, S. (1968). Flow of high polymers; continuum and molecular rheology.
11. De Gennes, P. G., & Gennes, P. G. (1979). Scaling concepts in polymer physics. Cornell university press.

ADDITIONAL RESOURCES:

1. Kumar D. S., (2009) Heat and Mass Transfer, S K Kataria & Sons.
2. Rao G. K., (2002) Solved Example in Chemical Engg., Khanna Publishers.
3. Treybal R., (2012) Mass Transfer Operations, Tata McGraw Hill.
4. Bird R.B., Armstrong R.C., Hassager O., (1977) Dynamics of Polymeric Liquids (volume 1), John Wiley & Sons, New York.
5. Shaw M.T., (2012) Introduction to Polymer Rheology, John Wiley & Sons.
6. Dealy, J. M., & Wissbrun, K. F. (2012). Melt rheology and its role in plastics processing: theory and applications. Springer Science & Business Media.
7. Hiemenz, P. C., & Lodge, T. P. (2007). Polymer chemistry. CRC press.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Mass transfer, Energy transfer, Distillation, Boltzmann superposition, Weissenberg effect, Power law model, Drag flow, Maxwell model

11.1.6: DSC-6 POLYMER TECHNOLOGY

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about the production, properties and applications of thermoset and thermoplastic polymers
2. To learn about the chemistry and manufacturing of flexible and rigid polyurethane foams
3. To understand the modification of unsaturated polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Learn preparation of thermoplastic polymers
2. Learn preparation of thermosetting polymers
3. Apply the knowledge of polymer synthesis to obtain polymers with desired properties

THEORY: (75 MARKS)

UNIT 1: THERMOPLASTIC POLYMERS — 27 L

Manufacturing process, properties and applications of the following polymers:

- Polyethylene (LDPE,LLDPE,VLDPE, HDPE)
- Polypropylene and related copolymers
- Polystyrene ABS, HIPS and related copolymers
- Poly (vinyl chloride) and related copolymers
- Poly (vinyl acetate) and related polymers
- Acrylic polymers (PMMA,PEA, PAA, PAN, Polyacrylamide)
- Aliphatic polyamides (Nylon 6, Nylon 66, Nylon 6,10)
- Polyester (PET, PBT)

UNIT 2: THERMOSETTING POLYMERS — 18 L

Manufacturing process, curing, properties, and applications of the following polymers:

- Unsaturated polyester resins
- Phenol formaldehyde resins (resols and novolacs)
- Urea and melamine formaldehyde resins
- Epoxides
- Polyurethanes (Flexible & Rigid foams)

PRACTICALS (25 MARKS)

1. Preparation of PMMA bone cement.
2. Preparation and testing of epoxy resins
3. Preparation of Nylon 6,10 by interfacial polymerization
4. Preparation of phenolic resin for adhesive applications.
5. Preparation of unsaturated polyester resin and determination of molecular weight by acid value/hydroxyl value.
6. Synthesis of copolymer of styrene & maleic anhydride, and styrene & MMA and determination of reactivity ratios.
7. To prepare melamine formaldehyde product viz. crockery etc.
8. Synthesis of Polyurethane Foams
9. Preparation of sodium polyacrylate salt and poly(acrylic acid) from polyacrylamide.

REFERENCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Mittal Vikas, (2011) High Performance Polymers and Engineering Plastics, Wiley.
3. Seymour R.B., Carraher C.E., (2003) Polymer Chemistry, Marcel Dekker.
4. Billmeyer F.A., (2011) Textbook of Polymer Science, John-Wiley & Sons.
5. Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition

ADDITIONAL RESOURCES:

1. Flory P.J., (2007) Principles of Polymer Chemistry, Asian Books Private Limited.
2. Mark J.E. Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier Academic Press.
3. Sperling, L. H. (2005). Introduction to physical polymer science. John Wiley & Sons.
4. Crompton R.T., (1989) Molecular Motions in High Polymers, Pergamon Press N.Y.
5. Crompton T.R., (1989) Analysis of Polymers, Pergamon Press N.Y.
6. Treloar, L. R. G. (1983). Mechanical Properties of Solid Polymers, IM Ward, John Wiley & Sons Ltd, Chichester.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Industrial Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Polyethylene, Poly(vinyl chloride), Urea Formaldehyde resins, Polyester resins, Polyurethane

SEMESTER-III

11.1.7: DSC-7 RUBBER ADDITIVES

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

Course Objectives:

1. To enable the students to know about need for additives in compounding of rubber
2. To understand the different types of ingredients in compounding.
3. To know about property modification by vulcanization
4. To enrich knowledge on testing of compounded rubber

Course Outcomes:

After completing the course, the students

1. Will understand concept of rubber compounding.
1. Will modify the properties of rubber by incorporation of additives.
2. Will develop rubber compound for required end use application.
3. Will modify the strength by varying vulcanizing agents.
4. Will do testing of rubber and asses quality of rubber compound.

UNIT1: Fillers and Processing Aids

Fillers: Carbon black, Non carbon black, Colors and Pigments,Plasticizers, Process aids, Softeners and Extenders.

UNIT 2: ADDITIVES FOR RUBBERS 10 L

Vulcanizing agents (sulphur, peroxide and metal oxide, phenolic curatives, benzoquinone derivatives, bismaleimides), accelerators (benzothiazoles, benzothiazolesulfenamide, dithiocarbamates, amines), lubricants, retarders (pre-vulcanized inhibitor), activators, s

Unit III Antidegradation and Miscelleous

Uv stabilizers, Heat stablizers, Antioxidants, Antiozonants- Mechanism of degradation – Mechanism of ozone attack. Special purpose additives: Chemical blowing agents – Flame retardants – Antistatic agent – Abrasives -Integral bonding additives – stiffening agents. antioxidants, thermal), softners, tackifying agents, blowing agents, surface property modifiers etc.

UNIT IV INDIVIDUAL RUBBER FORMULATIONS

Formulating for natural and synthetic rubbers and typical recipes for a few rubber products, Implications of FDA Regulations - Toxicity and environmental issues.

UNIT V FORMULATION FOR PERFORMANCE REQUIREMENTS

Compounding to meet different Hardness requirements – Iow compression set – For damping application – Compounding to meet bonding requirements with metals and textiles– Compounding to meet processing – Economics of compounding – Cost estimation.

Pricticals (25 Marks)

1. Mastication of NR on two roll mill
2. Mixing of rubber compounds
3. Compression moulding of rubber compounds
4. Preparation of dry rubber products – play ball
5. Preparation of dry rubber products – Hawaii sheet
6. Preparation of dry rubber products – M.C Sheet
7. Preparation of dispersions for compounding of latex
8. Preparation of latex products: i. Hand Gloves ii. Balloon iii. Rubber band iv. Thread

9.Compression moulding of fabric/rubber composite
10. Preparation of rubber blends

REFERENCES:

1. John S Dick, Rubber Technology- Compounding and Testing for Performance Hanser Publishers, 2001.
2. C. Hepburn, Rubber Technology and Manufacturing, Butterworth-Heinemann, 2009
3. Brendon Rodgers, Rubber Compounding- Chemistry and Applications, Taylor and Francies, 2016.
4. Roger Brown, Physical Testing of Rubber, Chapman and Hall, 3rd Edition, 1996.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Industrial Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Filler, Plasticizer, Antiozonants, Blowing Agent, Heat Stabilizer, Formulation

11.1.8: DSC-8 PLASTIC ADDITIVES

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To introduce the basics of polymer additives and their significance
2. To study different additives and their representative formulations

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the role of various compounding additives used for plastics and rubbers
2. Describe various steps & variables for mixing and blending of additives

3. Utilize understanding of compounding additives and methods for modification of polymer properties

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO ADDITIVES AND COMPOUNDING **10 L**

Importance of additives and their selection criteria for commercial polymers and technical requirements of additives, limitation of polymer additives, physical behavior of polymer additives (solubility etc.), limitation of polymer compounding, two roll mill, high speed mixer, internal batch mixer, single screw & twin screw extruders

UNIT 2: ADDITIVES FOR PLASTICS **26 L**

Plasticizers, theories of plasticization, types of plasticizer (phthalate, polymeric, hydrocarbon oil, vegetable oil, phosphates trimellitic etc.), methods of incorporation, fillers, introduction, classification, selection criteria (particle size, shape & geometry, packing fraction, hardness and abrasiveness, optical properties), impact of fillers on properties (mechanical properties, thermal properties, moisture content and electrical properties), Foaming agents, blowing agents, stabilizers (UV, heat, antioxidants and light), metal deactivators, Colorants (Dyes and pigments, coloring properties, classification of pigments, inorganic and organic pigments, method of incorporation (dispersion, pre mixing, agglomerate breakdown, compaction and wetting)

UNIT 3: ADDITIVES FOR SPECIAL NEEDS **10 L**

Flame retardants (halogen based, metal oxides, hydrated salts etc.), impact modifiers, lubricants & flow promoters, dry bonding agent and antistatic agents, conductive additives, biodegradation additives

UNIT 4: CASE STUDY **4 L**

Compounding techniques with illustration of few formulations like:

I. Rigid PVC pipes
II. Clear bags and flexible films
III. Acrylic sheet and display board
IV. Rubber sole
V. Air water hose
VI. Conveyor belt

PRICTICALS: (25 MARKS)

1. Determination of bulk density of fillers.
2. Determination of pore size and net size of fillers.
3. Determination of thermal stability of polymer stabilized by heat stabilizer.
4. Measurement of flash point of a plasticizer.
5. Identification of additives using chromatography.
6. Determination of the plasticizer and filler content in plastic materials.
7. Evaluate the bleeding and blooming properties of an additive.
8. Evaluate the effect of fillers/plasticizers on the properties of a plastic/rubber.
9. To prepare a PVC masterbatch.
10. Identification of a pigment by spot test.

11. Estimation of Iodine value of Castor oil
12. Determination of DBP value and sieve analysis of Carbon black.

REFERENCES:

1. Lutz J.T., (2001), Polymer Modifiers and Additives, Marcel Dekker.
2. Zweifel H., Amos S.E., (2001) Plastics Additives Handbook, Hanser.
3. Gachter R., Muller H., (1987) Plastics Additive Handbook, Hanser Publishers.

ADDITIONAL RESOURCES:

1. Mascia L., (1974) The Role of Additives in Plastics, Edward Arnold Publishers Ltd., U.K.
2. Murphy J., (2001) Additives for Plastics Handbook, Second Edition, Elsevier Advanced Technology, Oxford.
3. Gerard J. F., (2001) Fillers and Filled Polymers, Wiley-VCH verlag GmbH

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

High speed mixer, Accelerators, Plasticizers, Stabilizers, Antistatic agents, Tackifying agents, Flame retardants

11.1.9: DSC-9 POLYMER DEGRADATION

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVE:

1. To familiarize with the utility and importance of polymer degradation
2. To learn about the conditions and the reactions of degradation of polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Explain the factors responsible for degradation

2. Understand the handling of various polymers without affecting the properties
3. Evaluate degradation of polymers by various methods

THEORY: (100 MARKS)

UNIT 1: CONCEPT OF DEGRADATION 15 L

Introduction to degradation, classification of degradation based on

a) Pattern of degradation:
- i. Random degradation
- ii. Side chain degradation
- iii. Chain end degradation

b) Cause of degradation (mechanism, factors affecting thermal degradation, example)
- i. Thermal degradation
- ii. Oxidative degradation
- iii. Degradation by radiation
- iv. Mechanical degradation
- v. Chemical degradation
- vi. Biological degradation

UNIT 2: DEGRADATION OF A FEW THERMOPLASTICS 25 L

Different types of degradation patterns with mechanism of the polymers:
- i. Polyolefins (PE and PP)
- ii. PVC
- iii. Polyamides
- iv. PMMA
- v. Cellulose
- vi. Polyacrylonitrile (PAN)
- vii. Polystyrene (PS)
- viii. PET

UNIT 3: DEGRADATION OF ELASTOMERS 10 L

i. PU **ii.** Natural rubber **iii.** SBR

UNIT 4: QUANTITATIVE AND QUALITATIVE EVALUATION OF DEGRADATION 10 L

Degradation studies using DSC, TGA

PRACTICALS (25 MARKS)

1. To study biodegradation of polymers.
2. To study mechanical degradation of polymers and its effect on properties.
3. To study thermal degradation of polymers under various conditions.
4. To study thermal analysis of a given polymer by DSC/ TGA.
5. To study photo-degradation of PVC.
6. To evaluate chemical degradation of PET.
7. To determine environmental stress cracking resistance of polymers.
8. To evaluate chemical degradation of Nylon 66.
9. To study epoxidation of Natural Rubber Latex.

10. To study the effect of degradation on properties like: Mechanical strength, hardness, solubility, viscosity etc.

REFERENCES:

1. Pesce W.J., (2007) Encyclopedia of Polymer Science and Technology, Wiley.
2. Turi E.A., (1997) Thermal Characterization of Polymeric Materials, Academic Press.
3. Glaser, J. A. (2019). Biological degradation of polymers in the environment (Vol. 1, p. 13). London, UK: IntechOpen.
4. Gilbert, M. (2017). Cellulose plastics. In Brydson's Plastics Materials (pp. 617-630). Butterworth-Heinemann.
5. Krasowska, K., Heimowska, A., & Rutkowska, M. (2015). Environmental degradability of polyurethanes. Thermoplastic Elastomers—Synthesis and Applications; IntechOpen: London, UK, 75-94.

ADDITIONAL RESOURCES:

1. Hamid S.H., Amin M.B., (1992) Handbook of Polymer Degradation, Marcel Dekker.
2. Ehrenstein G.W., Riedel G., Trawiel P., (2004) Thermal analysis of plastics, Hanser.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Thermal degradation, Elastomeric degradations, Oxidative degradation, EPDM

SEMESTER-IV

11.1.10: DSC-10 POLYMER TESTING AND SPECIFICATIONS

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about the fundamentals of polymer testing
2. To understand testing standards of polymeric materials on various testing instruments
3. To acquaint the students with the modern instrumental techniques and their applications in characterization of polymeric materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Perform tests of polymeric materials on testing instruments
2. Establish the structure property correlation (mechanical, thermal, optical, electrical) of polymers
3. Interpret IR–Spectra, UV-Vis and XRD spectra for characterization of molecular structure of polymeric materials

4. Elucidate stability of various polymers and their characterization on the basis of their thermogram and glass transition temperature

THEORY: (100 MARKS)

UNIT 1: TESTING STANDARDS, THERMAL AND MECHANICAL ANALYSIS OF POLYMERS **20 L**

Principles of standardization, preparation of sample, different standards: BIS and ASTM standards (thermal and mechanical analysis), testing methods, evaluation of errors in polymer testing, correction of errors

a. Short term strengths: tensile, flexural, impact, tear resistance, abrasion, etc.
b. Long term strengths: creep and fatigue properties, compression set
c. Thermal and mechanical properties: thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, heat distortion temperature, vicat softening point, low temperature flexibility etc.

UNIT 2: ELECTRICAL AND FIRE RESISTANT PROPERTIES **15 L**

Dielectric strength, surface and volume resistivity, electro active properties, Burning behavior, flammability tests (UL-94, oxygen index, critical temperature index, smoke density)

UNIT 3: GAS BARRIER AND ENVIRONMENTAL ASSESSMENT **10 L**

Permeability to gases and moisture: Standard methods of measuring the permeability of gases, **Environment resistance:** Cause of deterioration of polymer by aging & weathering, assessment of deterioration, natural and artificial weathering, chemical resistance

UNIT 4: INTRODUCTION & SPECTROSCOPIC TECHNIQUES **5 L**

Basic principle of spectroscopy, molecular and atomic spectra, Infra-red spectroscopy, UV-Vis spectroscopy, introduction to the basic principles of NMR & XRD.

UNIT 5: THERMAL ANALYSIS **10 L**

Thermal gravimetric analysis (TGA): Principle, estimation of thermal stability from TGA curves, qualitative methods, semi quantitative and quantitative methods, thermal behaviour of polymers (eg., styrenated polyester, poly(tetrafluoroethylene) etc.) by TGA

Differential thermal analysis (DTA) and differential scanning calorimeter (DSC): Principle, physical transitions, melting thermo grams, heat of fusion and degree of crystallinity or isotacticity, identification (random copolymer structure, block copolymer structure, polymer mixture), melting point depression by diluents, crystallization, melt crystallization, cold crystallization, glass transition

PRACTICALS (25 MARKS)

1. To determine the melt flow index of LLDPE, PP etc.
2. To evaluate limiting oxygen index (LOI)/ UL-94 of plastic samples: PVC, PE, PP etc.
3. To determine the heat distortion temperature (HDT) & vicat softening point (VSP) of polymers.
4. To measure the abrasion resistance of polymer sheets.
5. To measure the dielectric strength of polymer films/sheets.
6. To determine the coefficient of friction of polymeric samples.
7. To determine the Izod impact strength of polymeric samples.
8. To determine the environment stress cracking resistance of PE/PP films.
9. To verify Lambert-Beer's law by UV-Vis. spectrophotometer.
10. To calculate weight percentage of inorganic and organic ingredients in polymeric compounds.

11. Demonstration and Interpretation of TGA thermogram of polymers
12. Demonstration and Interpretation of DSC thermogram of polymers and Evaluate percentage crystallinity of polymeric samples by DSC.
13. Demonstration and Interpretation of FTIR spectra of polymers
14. To study UV-Vis spectra of polymers by UV-Vis spectrophotometer..

REFERENCES:

1. Shah V., (2007) Handbook of Plastic Testing & Technology, Wiley-Inter science.
2. Hylton D., (2004) Understanding Plastic Testing, Hanser publication
3. Grellmann W., Seidler S., (2013) Polymer Testing, Hanser publication.
4. Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
5. Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
6. Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.
7. Seidel, A. (Ed.). (2008). Characterization analysis of polymers. Wiley-Interscience.
8. Pethrick, R. A., & Viney, C. (2003). Techniques for polymer organization and morphology characterisation. Wiley.

ADDITIONAL RESOURCES:

1. Berins M. L., (1991) SPI Plastic Engineering Hand book, Springer.
2. Ward I.M., Sweeney J., (2004) An Introduction to the Mechanical Properties of Solid Polymers, Wiley.
3. Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
4. Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
5. Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.
6. Mirau, P. A. (2005). A practical guide to understanding the NMR of polymers. Wiley-Interscience.
7. Turi, E. A. (1997). Thermal characterisation of polymeric materials. Polymer Testing, 5(16), 523-524.
8. Grellmann, W., & Seidler, S. (2013). Polymer testing. In Polymer Testing (pp. I-XXXIV). Hanser.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Tensile strength, UL-94, Thermal analysis, FTIR, UV-Visible spectroscopy

11.1.11: DSC-11 POLYMER PROCESSING TECHNOLOGY

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about the various processing techniques and their components
2. To learn the fundamentals of extrusion and different extrusion processes of thermoplastics.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand significance of the single screw and multiple screw extruder systems
2. Understand the fundamentals of injection and compression molding process and interpret processing variables for upgradation of quality of products

THEORY: (100 MARKS)

UNIT 1: EXTRUSION — 10 L

Extrusion process, film and sheet extrusion, the extrusion die, extruder and die characteristics, classification of extrusion dies, multi-layer extrusion, die swell and die defects

UNIT 2: INJECTION & BLOW MOLDING — 20 L

Principles, material used, injection molding cycle, injection molding machine, some aspects of product quality, reaction injection molding (RIM), blow molding, extrusion blow molding, injection blow molding, stretch blow molding, blow moulding of PET

UNIT 3: THERMOFORMING — 10 L

Principles, material used, types and applications: thermoforming process

UNIT 4: COMPRESSION & TRANSFER MOLDING — 10 L

Introduction, material used, types and applications: compression moulding process, transfer moulding process

UNIT 5: MISCELLANEOUS PROCESSING METHODS — 10 L

Principles, material used, types and applications: casting and rotational moulding processes

PRACTICALS (25 MARKS)

1. Compounding of PVC and rubbers in a two-roll mill with fillers and reinforcing agents (by varying filler loading and nature).
2. To prepare a polymeric sheet/ specimen by compression molding.
3. To prepare polymeric specimens by transfer molding.
4. Preparation of polymeric specimens/product by injection molding.
5. To process a polymer using extruder and to determine the production rate & residence time

6. To prepare polymer film/ membrane by solution casting method.
7. To prepare thermo formed polymeric products.
8. To determine moisture content of polymers and additives.
9. Industrial/lab visit.

REFERENCES:

1. Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
2. Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.
3. Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
4. Griff A. L., (2021) Plastics Extrusion Technology, Creative Media Partners, LLC
5. Gogos, C. G., & Tadmor, Z. (2013). Principles of polymer processing. John Wiley & Sons.
6. Berins, M. (Ed.). (1991). Plastics engineering handbook of the society of the plastics industry. Springer Science & Business Media.

ADDITIONAL RESOURCES:

1. Chan I. Chung, Hanser Verlag (2000) Extrusion of Polymers: Theory and Practice,
2. R. J. Crawford, Rotational Molding of Plastics –, Research Studies Press Ltd.
3. Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
4. J.L. Throne (1987) Thermoforming Hanser Publishers.
5. Rosato (1987) Blow Molding Handbook , Hanser Publishers.
6. Harper, C. A., & Petrie, E. M. Plastic materials and processes: a concise encyclopedia. 2003.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Injection molding, Compression molding, Thermoforming, Rotational moulding, Transfer moulding, Extrusion, Casting

11.1.12: DSC-12 RECYCLING AND WASTE MANAGEMENT

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about the life cycle analysis
2. To learn about the solid waste management policies
3. To learn about various sources of polymer waste generation and their management
4. To learn about various waste disposal and treatment methods

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand policies and legislations related to polymeric waste management and their impact on environment
2. Apply the 4 R's approach (reduce, reuse, recycle, recover) for polymeric waste management

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO WASTE MANAGEMENT — 10 L

Introduction to basics of life cycle analysis, plastic wastes and litter, social and environmental challenges of plastic waste recycling in India, sorting techniques and classification (density - float sink and froth floatation methods, selective dissolution, optical, spectroscopic, sorting by melting temperature, triboelectric separator etc.)

UNIT 2: CLASSIFICATION OF WASTE MANAGEMENT — 10 L

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle, recover), recycling classification - primary, secondary, tertiary, quaternary recycling with examples (mechanical, chemical and thermal processes)

UNIT 3: DISPOSAL AND WASTE TREATMENT TECHNIQUES — 15 L

Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification, on-site disposal methods, compacting and baling

UNIT 4: PLASTIC RECYCLING — 15 L

Recycling of polyolefins, PVC, PET, polystyrene, polyamides (nylon-6 and nylon-6, 6) etc.

UNIT 5: WASTE MANAGEMENT OF THERMOSET — 10 L

Recycling of thermosets, reclaiming of rubber, tire retreading, uses of recycled rubber

PRACTICALS (25 MARKS)

1. Primary recycling of various waste collected from the environment.
2. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
3. To study composting of natural/biopolymers.
4. Separation of polymer mixture by sink flotation technique.
5. Separation of polymer mixture by selective dissolution technique.
6. To recover BHET from PET by chemical recycling process

7. To recover adipic acid from nylon 66 by chemical recycling technique
8. To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
9. To study the effect of vulcanized rubber at varying ratio (in powder form) on thermal properties of rubber vulcanizate
10. To study the effect of vulcanized rubber at varying ratio (in powder form) on physical properties of vulcanized rubber

REFERENCES:

1. Niti Aayog (2021), Undp Handbook on Sustainable Urban Plastic Waste Management
2. N. C. Saha, M. Garg, S. Dey Sadhu, A. K. Ghosh(2022) Food Packaging-Materials, Techniques and Environmental Issues" by published by Springer.
3. Chandra R., Adab A., (2004) Rubber and Plastic Waste: Recycling, Reuse and Future Demand, CBS Publisher.
4. NIIR Board of Consultant and Engineers, (2007) Medical, Municipal and Plastic Waste Management Handbook, National Institute of Industrial Research.
5. La Mantia, F. (2002). Handbook of plastics recycling. iSmithers Rapra Publishing.
6. Braun, D. (2002). Recycling of PVC. Progress in polymer science, 27(10), 2171-2195.
7. Scheirs J., (1998) Polymer Recycling, John Wiley & Sons.
8. Blow S., (2000) Handbook of Rubber Technology, Hanser Gardner.
9. Bandrup J.E., (1996) Recycling and Recovery of Plastics, Hanser Gardner.
10. Goodship V., (2007) Introduction to plastics recycling, Rapra.

ADDITIONAL RESOURCES:

1. Maharana, T., Negi, Y. S., & Mohanty, B. (2007). Recycling of polystyrene. Polymer-Plastics Technology and Engineering, 46(7), 729-736.
2. Caillol, S. (2014). Lifecycle assessment and green chemistry: a look at innovative tools for sustainable development. Environmental Impact of Polymers, 65-89.
3. Klöpffer, W. (Ed.). (2014). Background and future prospects in life cycle assessment. Springer Science & Business Media.
4. Dimitris, S., & Achilias, L. (2014). Recent advances in the chemical recycling of polymers (PP, PS, LDPE, HDPE, PVC, PC, Nylon, PMMA). Mater. Recycl. Trends Perspect, 3, 64.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Triboelectric separator, 4 R's approach, Incinerators, Tire retreading, Plastic waste,

SEMESTER-V

11.1.13: DSC-13 FIBRE SCIENCE

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To study the basic concepts of natural and synthetic fibres

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Explain classification, structure and properties of natural and synthetic fibres

UNIT 1: INTRODUCTION TO FIBRES **10 L**

Introduction, classification, structure and general properties of a fibre such as moisture absorption, tex, denier, tenacity, elongation at break, elastic recovery etc.

UNIT 2: NATURAL FIBRES **10 L**

Brief introduction to structure, properties and application of naturally occurring fibres: vegetable fibres, animal fibres and mineral fibres

UNIT 3: SYNTHETIC FIBRES **10 L**

Structure, properties and applications of synthetic fibres: viscose rayon, cellulose acetate, nylon 6, nylon – 66, polyester, acrylic, carbon fibre and aramid fibres

PRACTICALS (25 MARKS)

1. To determine physical properties of fibres: tex, tenacity, denier, moisture content, density etc.
2. To investigate the diametric swelling of fibres.
3. To identify fibres through elemental analysis.
4. To analyze the effect of heat & flame on fibres.
5. To analyze microscopic properties of fibre.
6. R & D Lab visit (demonstration of spinning & testing).

REFERENCES:

1. Cook J.G., (2009), Hand Book of Textile Fibres, Woodhead Publishing.
2.

ADDITIONAL RESOURCES:

1.
2. Morton W.E., Hearle J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Tenacity, Viscose rayon,

11.1.14: DSC-14 POLYMER CHARACTERIZATION

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

COURSE OBJECTIVES:

1. To acquaint the students with the modern instrumental techniques and their applications in characterization of polymeric materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Interpret NMR, Raman, Mass and IR–Spectra for characterization of molecular structure of polymeric materials

2. Elucidate stability of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

THEORY: (75 MARKS)

UNIT 1: INTRODUCTION 10 L

Basic principle of spectroscopy, molecular and atomic spectra, Lambert-Beer's law, Frank-condon principle, electromagnetic radiation and it's properties, interaction of radiation with matter, statistical method of analysis

UNIT 2: SPECTROSCOPIC TECHNIQUES 10 L

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.): Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance, raman, nuclear magnetic resonance spectrometer

UNIT 3: CHROMATOGRAPHY TECHNIQUES IN POLYMER 10 L

Thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography and size exclusion chromatography

UNIT 4: MICROSCOPIC AND X-RAY TECHNIQUES 10 L

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) in polymers characterization

UNIT 5: THERMAL & THERMO-MECHANICAL CHARACTERIZATION 10 L

Thermal gravimetric analysis (TGA): Estimation of thermal stability from TGA curves, qualitative methods, semi quantitative and quantitative methods, Thermal behaviour of styrenated polyester, poly(tetraflouroethylene) by TGA, Differential thermal analysis (DTA): physical transitions, melting thermo grams. Heat of fusion and degree of crystallinity or isotacticity, Random copolymer structure, block copolymer structure, polymer mixture, melting point depression by diluents, crystallization, melt crystallization, cold crystallization, glass transition, differential scanning calorimeter (DSC), dynamic mechanical analyser (DMA) and thermal mechanical analyser (TMA): principle and applications in polymer characterization

UNIT 6: MOLECULAR MASS AND MASS SPECTROSCOPY 10 L

Gas chromatography-mass spectrometer (GC-MS), MALDI-TOF, ESI-MS and methods for determination of molecular mass (principles and applications in polymer characterization)

PRACTICALS: (25 MARKS)

1. To verify Lambert-Beer's law by UV-Vis. spectrophotometer.
2. Calculate weight percentage of inorganic and organic ingredient in polymeric compound.

3. Analyze thermal behavior of polymers.

4. Quantitative determine of impurities by UV-Vis. spectrophotometer.

5. Evaluate percentage crystallinity of polymeric sample by XRD, DSC (Interpretation).

6. Identification of additives in a processed polymer by chromatography.

7. Interpretation of FTIR, NMR and Raman spectra of polymers.

REFERENCES:

1. Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.

2. Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.

3. Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.

4. Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.

ADDITIONAL RESOURCES:

1. Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.

2. Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.

3. Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

GC-Mass, Thermal Analyzer, FT-IR, Size Exclusion Chromatography, TEM

11.1.15: DSC-15 POLYMERS IN PACKAGING

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about the primary requirement and importance of packaging
2. To acquire knowledge of various types of polymers as packaging materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apprehend the basic concept of packaging and its utilization for desired applications
2. Assess the quality of packaging material and packaged product

THEORY: (75 MARKS)

UNIT 1: PACKAGING SYSTEMS **10 L**

Types of packaging systems: box, bottle, tetrapack, pouch, shrink, vacuum packaging, controlled atmospheric packaging (CAP), modified atmospheric packaging (MAP), aseptic packaging

UNIT 2: POLYMERS IN PACKAGING 10 L

Properties and applications: LLDPE, LDPE, HDPE, HMHDPE, PP, BOPP PVC, nylon, polyester, polycarbonate, PS, EPS.

UNIT 3: TESTING OF POLYMER PACKAGING MATERIAL 10 L

Bursting strength, tensile strength, tear strength, puncture test, impact test (drop, falling dart), permeability test (water vapour, oxygen), sealing strength.

PRACTICALS: (25 MARKS)

1. Preparation of packaging films (PP/ HDPE/ LDPE/ LLDPE/PVA)
2. To prepare polyester film and find its WVTR.
3. Identification of packaging materials with the help of FT-IR, DSC, TGA etc.
4. Preparation of laminate films by various methods (heat, solvent, adhesives)
5. Determination of physico-mechanical properties (density, bursting strength, tensile strength, tear strength, puncture strength, impact strength etc) of packaging materials.
6. Determination of water vapor transmission rate of packaging material.
7. To determine the seal strength of packaging materials.
8. To determine compatibility of packaging film with the packaged material.
9. Industrial visit of packaging industry/plant

REFERENCES:

1. Robertson G.L., (2012) Food Packaging – Principles and Practice, CRC Press Taylor and Francis Group.
2. Paine F.A., Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional
3. Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher
4. N. C. Saha, M. Garg, S. Dey Sadhu, A. K. Ghosh(2022) Food Packaging-Materials, Techniques and Environmental Issues" by published by Springer.
5. Garg, M., Meena, P.L., Sadhu, S.D., Alam, T. (2019). Food Packaging: A Practical Guide : Viba Press Pvt. Ltd.

ADDITIONAL RESOURCES:

1. Coles R., McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.

2. Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging and containers in the food industry, VSP.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Aseptic packaging, Polyester, BOPP, Puncture Test, Impact strength

SEMESTER-VI

11.1.16: DSC-16 POLYMER BLENDS AND COMPOSITES

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

COURSE OBJECTIVES:

1. To gain knowledge of polymer composites and its basic construction
2. To learn about preparation, properties and characterization of polymer blends.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand various techniques for preparation of polymer blends
2. Understand the types and forms of reinforcement materials used in composites
3. Apply different production techniques for fabrication of polymer composites

THEORY: (100 MARKS)

UNIT 1: BASIC CONCEPT OF BLENDS **15 L**

Definition of blends, types of blends (plastic-plastic, rubber-rubber and plastic-rubber blends), differences between: copolymer and IPNs, blends, alloys and composites; concept of miscibility, concept of free energy of mixing, phase equilibria, Flory-Huggins theory, spinodal, binodal and critical phase, Gibb's phase rule

UNIT 2: PREPARATION AND PROPERTIES OF BLENDS **10 L**

Methods of blending, compatibilizers, methods of compatibilization, factors affecting miscibility of

polymer blends, effect of composition on properties (rheology, morphology, mechanical and thermal)

UNIT 3: CHARACTERIZATION TECHNIQUES OF BLENDS **10 L**

Applications of the following techniques: IR, microscopy (TEM, SEM and optical), TGA, DSC, DMA, viscosity, refractive index

UNIT 4: POLYMER COMPOSITES **10 L**

Definition; classification of composites; dispersed phase: (reinforcing fillers, non-reinforcing fillers), and (particulate matter, fibrous structure and platelet structures), continuous phase: thermoset matrix, thermoplastic matrix and high-performance resins, mechanism of reinforcement, various factors affecting reinforcements

UNIT 5: DESIGN AND FABRICATION OF COMPOSITES **15 L**

Fabrication techniques: Prepreg technology, injection and compression molding, vacuum bag molding, hand-lay-up process, spray-up technique, filament winding process, fibre placement process, Pultrusion, reaction transfer molding, laminating techniques, expansion processes, fabrication processes: adhesion, cohesion and mechanical processes & FRPs.

Design of a few polymer composite: basic design practice – material considerations, product considerations and design considerations, rule of mixture

PRACTICALS (25 MARKS)

1. To prepare polymer blends by melt, solution and latex blending.
2. To check the compatibility of blends by using microscope/DSC
3. Determination of Lower and Upper Critical Solution Temperature of a polymer.
4. To study the miscibility of the polymer blend using ultrasonic method.
5. To study the miscibility of the polymer blend using viscosity method.
6. To study the miscibility of the polymer blend using refractive index method.
7. Determination of miscibility of polymer blends by density measurement method.
8. Preparation of FRP laminates by hand lay-up technique.
9. Evaluate the effect of filler loading on mechanical properties of a composite.
10. Fabrication of composites by various techniques.
11. Characterization (thermal and mechanical) of blends and composites.
12. Determine the refractive indices of polymer blends by using abbe's refractometer.

REFERENCES:

1. Paul D.R., Bucknall C.B., (2000) Polymer Blends Vol. 1 & Vol. 2, Wiley-Interscience.
2. Robeson L.M., (2007) Polymer Blends, Hanser Gardner.
3. Singh R.P., Das C.K., Mustafi S.K., (2002) Polymer Blends and Alloys, Asian Books Private Limited.

ADDITIONAL RESOURCES:

1. Utracki L.A., (2003) Polymer Blends Handbook Vol. 1 & Vol. 2, Kluwer Academic

Pub.

2. Bhowmick A.K., De S.K., (1990) Thermoplastic Elastomers from Rubber-Plastic Blends, Ellis Horwood Publishers Ltd.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Flory-Huggins theory, Compatibilizers, TEM, Hand lay-up process, Reinforcing fillers

11.1.17: DSC-17 POLYMERIC NANOMATERIALS

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

ials

erials on polymer nanocomposites

3. To understand modification techniques of nanomaterials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Synthesize polymeric nanomaterials
2. Demonstrate the knowledge of properties and structural aspects of polymeric nanomaterials
3. Explore various areas of polymeric nanomaterial applications

THEORY: (75 MARKS)

UNIT 1: NANO-REINFORCING AGENTS **8 L**

Preparation, structure and properties of nano-reinforcing agents: 1 D, 2 D and 3 D nanomaterials eg. nanoparticles, nanotubes, nano-clays, POSS, carbon nanostructures (CNTS, graphene)

UNIT 2: PROPERTIES AND CHARACTERIZATION OF NANOMATERIALS **15 L**

Morphology analysis of crystallites in nanocomposites: X-ray scattering & diffraction technique, Analysis of Nanostructure developed in semi-crystalline polymers during deformation,

Nanostructure of two component amorphous block copolymers, effect of chain architecture.

Factors governing properties of nanocomposites such as loading, dispersion and percolation, influence of size, shape and diameter of nanoparticles nanotubes, functionalization of nanomaterials

UNIT 3: POLYMER NANOCOMPOSITES **7 L**

Basic concepts, preparation, characterization and applications of polymer nanocomposites, technical challenges and understanding of interfacial dynamics using LJ potential and many body problems approach

PRACTICALS: (25 MARKS)

1. To analyze particle size of nanomaterials (nanoparticles).
2. To prepare polymer nanocomposites by solution casting
3. To prepare polymer nanocomposite by melt compounding.
4. To determine the polymer nanocomposite by in-situ polymerization
5. Determination of mechanical properties of nanocomposites.
6. To prepare graphene oxide and its nanocomposite.
7. Chemical modification of nanoclay and its characterization.
8. Characterization (morphology and thermal) of nanocomposites by optical microscope, SEM, TEM, DSC, DMA, TG-DTA etc.
9. Determination of electrical properties of nanocomposites.
10. To prepare nano metal oxides and nano silica by chemical modification.

REFERENCES:

1. Koo J.H., (2010) Polymer Nanocomposites, Tata McGraw-Hill.
2. Bhattacharya S.N., (2008) Polymeric Nanocomposites-Theory and Practice, Hanser Gardner.

3. Michler G.H., Balta F.J., (2005) Mechanical Properties of Polymer based on Nanostructure and Morphology, CRC Press.

ADDITIONAL RESOURCES:

1. Tjong S.C., (2006) Nanocrystalline Materials, Elsevier Science.

2. Owens F.J., Papoose C., (2003) Introduction to Nanotechnology, John-Wiley & Sons.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

POSS, LJ Potential, Interaction parameter, Percolation, Carbon nanotube, X-ray scattering

11.1.18: DSC-18 RUBBER TECHNOLOGY

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

2. To learn about the concept of vulcanization and properties of rubbers

COURSE LEARNING OUTCOMES:
After studying this paper, students will be able to

2. Apply the knowledge of preparation of rubbers and fibres
3. Learn the knowledge of different types curing techniques

THEORY: (100 MARKS)

UNIT 4: RUBBERS: INTRODUCTION **15 L**

Properties of rubber: Structure, glass transition temperature, mechanical properties (tensile, % elongation, compression set, fatigue resistance, resilience, hysteresis, hardness etc.)
Preparation, properties and applications: Natural rubber and synthetic rubbers (styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber
Thermoplastic elastomers: Structure, properties, preparation, types and applications

UNIT 5: VULCANIZATION OF RUBBER **15 L**

Theory and mechanism of sulphur and non-sulphur vulcanization (with and without accelerators), rheocurve of compounded rubber, pre and post vulcanization processes, properties of vulcanized rubber

PRACTICALS (25 MARKS)

7. To determine tensile strength, modulus, elongation at break of Rubber sheet.
8. To determine tear strength, abrasion resistance, heat build-up, resilience, hardness, flex resistance for rubber compounds.
9. To determine curing time and physical properties of rubber compounds.
10.
11. To determine mooney viscosity of rubber using Mooney viscometer.

REFERENCES:

3. Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publisher.
4. Mark J. E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier Academic Press.
5. Blow S., (2000), HandBook of Rubber Technology, Hanser Gardner.

ADDITIONAL RESOURCES:

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3. Morton W.E., Hearle J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

EPDM, Rheo-curve, Asbestos, Nitrile rubber

SEMESTER-VII

11.1.19: DSC-19 PAINTS, COATINGS AND ADHESIVES

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To learn about of basics of paints, coatings and adhesive technology and their applications
2. To gain knowledge of formulations of various types of paints, coatings and adhesives

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Make formulations of various types of paints, coatings and adhesives for desired applications
2. Evaluate quality assessment of paints, coatings and adhesives
3. Understand the challenges and scope of paints, coatings and adhesives industry

THEORY: (75 MARKS)

UNIT 1: INTRODUCTION TO PAINTS, COATINGS AND ADHESIVES 10 L

General information about paint, paint composition, types of paints, function and properties of paints, types of adhesives (structural, elastomeric and pseudo plastic), definition and importance of coating, composition of coating, challenges and future scope of paints, coatings and adhesives industry

UNIT 2: RAW MATERIALS OF PAINTS, COATINGS AND ADHESIVES 10 L

Pigments (natural and synthetic), binders (natural and synthetic: thermoset and thermoplastic eg., polyester, epoxy, alkyd, phenolic, vinyl etc.) solvents, thinners, dryers, drying oils

UNIT 3: SURFACE TREATMENT 10L

Surface preparation (plastic, metal, wood and cemented), heat treatment, corona discharge treatment, flame treatment, mechanical treatment types and preparations of adhesive, adsorption and surface reaction, surface topography, wetting and setting, interfacial bonding

UNIT 4: PREPARATION OF PAINTS, COATINGS AND ADHESIVES 8L

Formulations, selection and water solubility, manufacturing and uses of paints, coatings (manufacture, criteria and type), adhesive (manufacturing of structural and elastomeric), manufacturing equipments: high-speed mixers, mill (vertical, horizontal, continuous, sand mill and ball mill)

UNIT 5: COATING OPERATIONS 7L

Coating operations: brush, roller, both side roller, spray (manual/airless/air guns), dip coating (advantages & limitations), flow coating

PRACTICALS: (25 MARKS)

1. To prepare paints (water and solvent based).
2. To determine adhesive strength by peel test method.
3. To prepare adhesive of different formulations.
4. To measure the wettability of adhesives.

5. To measure the resin/paint viscosity by Ford cup 4 and Brookfield viscometer.
6. To test film hardness of a coated adhesive film.
7. To measure the scratch resistance of painted films.
8. To calculate weight percent of paint in a painted film.
9. To analyze humidity of painted films.
10. Analysis of paints film by pencil hardness test

REFERENCES:

1. Morgan W.M., (2000) Outline of Paint Technology, CBS Publisher.
2. Stoye D., (2008) Paints, Coatings and Solvents, Wiley-VCH.
3. Talbert R., (2008) Paints technology Handbook, CRC Press.

ADDITIONAL RESOURCES:

1. Pocius A.V., Carl H., (2002) Adhesion and Adhesives Technology, Hanser-Verlag.
2. Ryntz R.A., Yaneff P.V., (2003) Coatings of polymers and plastics, Marcel Dekker.
3. Mittal K.L., (2003) Adhesion aspects of polymeric coatings, VSP.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Structural adhesives, Wettability, Dip coating, Sand mill, Surface treatments

SEMESTER-VIII

11.1.20: DSC-20 SPECIALITY POLYMERS

Total Credits: 4 (Theory-3 Hrs/week, Practical – 2 Hrs/Week)

(Total Lectures: Theory-45 Hrs, Practical – 30 Hrs)

Total Marks: 100 (Theory – 75 Marks, Practical – 25 Marks)

COURSE OBJECTIVES:

1. To study basic concepts of speciality polymers including temperature & fire-resistant high-performance polymers, biopolymers and conducting polymers
2. To learn about applications of speciality polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the chemistry, preparation, properties and applications of high temperature resistant polymers
2. To analyze the properties of specialty polymers for specific application such as aerospace, telecommunication, biomedical, defense etc.

THEORY: (75 MARKS)

UNIT 1: PREPARATION, PROPERTIES AND APPLICATIONS OF SPECIALITY POLYMERS — 20 L

I. Polycarbonate (PC)
II. Poly(ether ether ketone) (PEEK) and poly(ether-ketone) (PEK)
III. Sulphur based polymers (Polysulfone and poly(phenylene sulfide)
IV. Aromatic polyamides, polyamideimide (PAI) and polyimide resins
V. Polyacetals
VI. Polyphenylene oxide (PPO)
VII. Silicones and polyphosphazenes
VIII. Floropolymers
IX. High performance thermosetting resins such as epoxides, polybenzoxazine etc.

UNIT 2: CONDUCTING POLYMERS — 5 L

Synthesis, properties and applications of polyaniline, polypyrrole, polythiophene and poly (p-phenylenevinylene)

UNIT 3: RECENT ADVANCES IN SPECIALITY POLYMERS — 5 L

High performance polymer blends and nanocomposites, dendrimers

UNIT 4: LIQUID CRYSTAL POLYMERS — 10 L

Introduction, polymers, chemistry of liquid crystal polymerization, synthesis, properties, characteristics of liquid crystal polymers

PRACTICALS: (25 MARKS)

1. Preparation and polyaniline/polypyrrole.
2. Preparation and testing of thiokol rubber
3. To determine conductivity of polymeric samples.
4. Investigation of performance properties of speciality polymers such as thermal stability and fire

resistance.

5. To determine the strength of nomex/kevlar fibre.
6. To prepare PLA and test its enzymatic degradation

REFERENCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Dyson R. W., (1990) Engg. Plastics, Blackie, Chapman and Hall.
3. Mohammad, F., (2007) Specialty Polymers: Materials and Applications, I.K. International Publishing House Pvt. Ltd.
4. Fink, J. K. (2014). High performance polymers. William Andrew.

ADDITIONAL RESOURCES:

1. Domb. A.J., (1997) Handbook of Biodegradable Polymer, Gordon and Breach Science Publishers.
2. Seymour R.B., Kirshenbaum G.S., (1986) High Performance Polymers: their origin and development, Springer.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Polysulfones, Polyaniline, PEEK, Smart hydrogels, Polycarbonate

11.2 Discipline Specific Elective (DSE) Courses

11.2.1: ADVANCED ANALYTICAL TECHNIQUES

Discipline Specific Elective - DSE: Paper 1

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. To acquaint the students with the modern instrumental techniques and their applications in characterization of polymeric materials
2. Students will be able to determine a chemical property and identify a chemical substance in a polymer.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Interpret NMR, raman, mass and IR–spectra for characterization of molecular structure of polymeric materials
2. Elucidate the morphology of various polymers
3. Acquire the knowledge about separation of components from polymer mixture

THEORY: (50 MARKS)

UNIT 1: SPECTROSCOPIC TECHNIQUES 10 L

Principles and applications of structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.) using FT-IR, electron spin resonance, raman, nuclear magnetic resonance (^{1}H NMR, ^{13}C NMR).

Mass Spectroscopy: introduction, basic principles, instrumentation, fragmentation patterns, nitrogen rule, McLafferty rearrangement, interpretation of mass spectra and applications, MALDI-TOF, ESI-MS and methods for determination of molecular mass (principles and applications in polymer characterization).

UNIT 2: CHROMATOGRAPHY TECHNIQUES 10 L

Introduction to chromatographic methods: TLC, column and gas chromatography, principles, instrumentation, GC column, detectors and stationary phases and applications, hyphenated techniques (GC-MS). Liquid chromatography LC/HPLC, gel permeation chromatography (GPC)

UNIT 3: MICROSCOPIC AND MISCELLANEOUS TECHNIQUES 10 L

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) for polymers characterization.

Particle size analyzer, zeta potential, etc.

PRACTICALS: (50 MARKS)

1. To identify the functional groups in various polymers using FTIR.

2. To analyze the NMR spectra of a given polymer.
3. To analyze the raman spectra of given polymers.
4. Evaluate percentage crystallinity of polymeric samples by XRD.
5. To separate additives in a given polymeric sample by chromatography.
6. To separate a polymeric mixture by TLC.
7. To analyze film morphology by compound/electron/Atomic Force microscope.
8. To determine the size of polymer/additives particles by particle size analyzer.
9. To study the polymers tacticity using NMR.
10. Visit to an analytical laboratory.

REFERENCES

1. Willard H.H., Merritt L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
2. Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
3. Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
4. Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.

ADDITIONAL RESOURCES:

1. Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
2. Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
3. Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

NMR, FT-IR, Raman, TEM, AFM, Chromatography, GC-MS

11.2.2: FIBRE MANUFACTURING TECHNOLOGY

Discipline Specific Elective - DSE: Paper 2

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. To learn about the basic concepts of spinning including melt and solution spinning.
2. To understand various parameters affecting spinning, drawing and heat setting of fibre structure and properties

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Manufacture fibre with desired properties.
2. Understand the various spinning variables.

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION TO FIBRES **5 L**

Manmade fibres: definition of man-made fibres, brief history of manmade fibres, relative merits and demerits of manmade and natural fibres

UNIT 2: MELT SPINNING **10 L**

Melt spinning process: Crystallization in spin line, stress induced crystallization, melt spinning of PP, polyester and nylon-6 and nylon -66, effect of process parameters on structure and properties of melt spun filament.

UNIT 3: SOLUTION DRY & WET SPINNING **15 L**

Dry spinning of cellulose acetate, acetylation of cellulose, dope preparation and spinning of cellulose diacetate and triacetate, dry spinning of acrylic, significance and types of co-monomers used during polymerization of acrylonitrile (PAN)

Wet spinning of acrylic fibre and viscose rayon, formation of structure in viscose, influence of various additives and temperature of the regeneration bath on the process and properties of viscose rayon

PRACTICALS: (50 MARKS)

1. To prepare polypropylene fibre by melt spinning.
2. Melt spinning of Nylon 6/66.
3. To prepare polyester fibre by melt spinning
4. Solution spinning of acrylic fibre.
5. Dry spinning of PAN fibre.
6. To characterize a woven fabric with respect to its dimensional properties: thread density , yarn number, yarn crimp, weave, cover factor, areal density, skewness, thickness
7. Identification of dyestuff on different substrates
8. To determine the crease recovery of fabric and observe the effect of loading time and recovery time on crease recovery.
9. Drawing and heat setting of fibres.
10. Chemical modification of fibres.

REFERENCES:

1. Gupta V.B., Kothari V.K., (1997) Manufactured Fibre Technology, 1st Ed Chapman and Hall.

2. NPTEL course material on Manufactured fibre Technology.

3. Macintyre J.E., (2005) Synthetic Fibres: Nylon, Polyester, Acrylic, Polyolefin, Elsevier Science.

ADDITIONAL RESOURCES:

1. Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.
2. Kothari V.K., (2000), Textile Fibres: Developments and Innovations, IAFL Publications.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Melt spinning, Dope, Drawing, Heat setting, Fibre quenching

11.2.3: TYRE TECHNOLOGY

Discipline Specific Elective - DSE: Paper 3

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. Familiarizing various types of tyres and their components
2. Developing the knowledge of manufacturing techniques of various tyres

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply knowledge of basic concept of manufacturing technology of tyre
2. Understand designing and compounding of various tyre components
3. Evaluate testing and quality assessment of tyre

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION AND TYRE MANUFACTURING 10 L

Classification: based on construction (pneumatic, radial, bias, cross ply, tube, tubeless, solid), Mixing (Mixing instruments: two roll mill, kneader, internal mixers), processing (extrusion, calendaring, bead winding), building drum, curing (molding machines etc.), mold

UNIT 2: TYRE DESIGN 10 L

Compound design (selection of chemical ingredients); process design (process parameters correlating with properties); product design (constructions), latest advances in materials and technologies

UNIT 3: TYRE TESTING 10 L

Endurance, groove crack test, plunger test, traction: dry, wet and snow, air permeation, noise test, rolling resistance, drivability, road test, wet braking test, fuel economy test, tread to ply pull out, bead seating test

PRACTICALS: (50 MARKS)

1. To identify the type of rubber by reverse engineering.
2. To prepare fabric- rubber coated ply.
3. To test mechanical and physical properties of vulcanized rubber.
4. To perform air aging properties of rubber and rubber to fabric ply.
5. To determine bonding strength of rubber to fabric.
6. To calculate abrasion losses of tyre tread.
7. To calculate rebound resilience of a rubber.
8. Tyre indexing and cut section analysis.
9. To evaluate the compression set of a rubber.
10. To determine rolling resistance test
11. Industrial Visit of Tyre Industry/ R&D

REFERENCES:

1. Clark S.K., (1971) Mechanics of Pneumatic Tires, National Bureau of Standards, Monograph, US Govt. printing office.
2. French T., (1989) Tyre Technology, Adam Hilger, New York.

ADDITIONAL RESOURCES:

1. Ford T.L., Charles F.S., (1988) Heavy Duty Truck TIRE Engineering SAE's 34th L. Ray Buckingdale Lecture, SP729.
2. Gent A.N., Walter J.D., (2006) The Pneumatic TIRE, U.S. Department of Transportation, National Highway Traffic Safety Administration.
3. Mark J.E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier.
4. Koutny F., Zling, (2007) Geometry and Mechanics of Pneumatic TIRE, CZE.

TEACHING LEARNING PROCESS:
Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
Radial tyre, Tread, Plunger test, Rolling resistance, Tubeless tyre.

11.2.4: POLYMER PRODUCT DESIGN

Discipline Specific Elective - DSE: Paper 4

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. To learn physical properties of polymers required for product design
2. To design plastic parts such as static and dynamic loaded parts for electrical, optical and mechanical applications (gears, bearings, pipes, seals, couplings and vibration dampers)

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Demonstrate the response of polymers for various loads.
2. Apply the knowledge to develop plastic products.
3. Develop the design for polymer products in engineering applications.

THEORY: (50 MARKS)

UNIT-1: INTRODUCTION 8 L

Introduction to structure and physical properties of polymers, stress – strain behaviour of polymers, effect of fillers on properties of polymers, stress analysis of polymers, structural design of beams, plates and other structural members.

UNIT 2: CHARACTERISTICS OF PRODUCT DESIGN 7 L

Dynamic load response of polymers, effects of cyclic loading, other forms of stress applied to polymer parts, design for stiffness, processing limitations on polymers product design. Material and process interaction and the effects on the performance of plastic parts and the resulting design limitations, performance in service and environmental exposure.

UNIT 3: PRODUCT DESIGN TECHNIQUES 15 L

Design procedure for plastic parts- basic principles-shrinkage-flash lines-undercuts-suggested wall thickness-draft-tolerance-moulded holes-threads radius- moulded hinges-integral hinge- snap fits – product design thumb rules – case studies and product design. design of plastic structural parts for static loads, design of dynamically loaded plastic parts, design of plastic parts for electrical applications, design of plastic parts for optical applications.

PRACTICALS: (50 MARKS)

1. To prepare a poly styrene sheet with in-situ polymerization.
2. To prepare open and closed cell foam.
3. To prepare laminates such as epoxy, polyester and epoxy-polyester.
4. To prepare a PMMA sheet using bulk polymerizations.
5. To join polymer products by molding.
6. Preparation of polymer products by different processing techniques.
7. To study the post curing of rubber
8. To prepare a composite mouse pad
9. To prepare rubber - metal composite products

10. To determine mechanical properties of designed products

REFERENCES:

1. Levy S. & Dubois J.H., (1977) Plastic Product Design Engineering Hand Book, Van Nostrand Reinhold Co., New York.
2. Miller E., Plastics Products Design Hand Book, Marcel Dekker,

ADDITIONAL RESOURCES:

1. Malloy R. A., (1994) Plastic Part Design for Injection Moulding, Hanser Pub., Munich Vienna NY.
2. Belofsky H., (1995) Plastics Product Design and Process Engineering, SPE, Hanser Publication, Munich Vienna NY.
3. Freekly P.K. & Payne A. R., Theory and Practice of Engineering with Rubber.
4. Hepburn B. and Raynolds R.J.W. , Elastomers, Criteria for Engineering Design.
5. Beck R.D., Plastic Product Design, Van Nostrand Reinhold Co.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Lamination, Design of plastic parts, Welding, Pad Printing, Microinjection molding

11.2.5: POLYMERS IN BIOMEDICAL APPLICATIONS

Discipline Specific Elective - DSE: Paper 5

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. To acquire knowledge of biocompatibility and biodegradation
2. To learn about applications and testing of bio-compatible polymer in tissue engineering

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the basic concepts and requirement of biomedical applications and biocompatibility
2. Apply the knowledge of various polymers in biomedical application

THEORY: (50 MARKS)

UNIT 1: BASICS OF BIOMATERIALS 8 L

Concept of biocompatibility and biodegradability, responsiveness, estimations of degradation and biocompatibility. Importance of biomaterials: hydrogel, fibres, bio-ceramics, bio-elastomers and membrane

UNIT 2: POLYMERS AS BIOMATERIALS 7 L

Sources, properties and applications: polyamides, polyesters, carbohydrates, natural gums, polyurethanes, polylactic acid, alginates, silicone.

UNIT 3: BIOMATERIALS FOR ORGAN TRANSPLANTS & DRUG DELIVERY 15 L

Properties and uses of polymers for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc., basic concept of tissue engineering, uses of cellulose, chitosan and alginate

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels

PRACTICALS: (50 MARKS)

1. Evaluate the biocompatibility of polymeric samples.
2. Determination of the degradation behavior of polymers such as thermal, hydrolytic etc.
3. Preparation of membranes and measurement of their absorption behavior.
4. Preparation and characterization of dental cement.
5. Prepare a hydrogel and characterization.
6. Prepare jaw by powdered silicone rubber
7. To find out biocompatibility of polymer products by enigmatic test
8. Determination of mechanical strength of polymers.
9. To find out hydro degradation of artificial bone.
10. To prepare porous membranes.

REFERENCES:

1. Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
2. Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.

ADDITIONAL RESOURCES:

1. Ratner B.D., Hoffman A.S., (1996) An Introduction to Materials in Medicine, Academic Press.
2. Saltzman W.M., (2001) Drug delivery: Engineering principles for drug therapy, Oxford University Press.
3. Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Hydrogel, Tribological, Tissue engineering, Drug delivery, Organ transplants.

11.2.6: CONDUCTING POLYMERS

Discipline Specific Elective - DSE: Paper 6

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

COURSE OBJECTIVE:

1. To impart knowledge of structure and electrical properties of conducting polymers.
2. To learn about applications of conducting polymers.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand synthesis and requirement of doping in polymers.
2. Analyze properties of conducting polymers

THEORY: (50 MARKS)

UNIT 1: BASIC ASPECTS OF CONDUCTING POLYMERS 10 L

Historical background, band structure, band alignment, conduction mechanism, theory of electrical conduction in conducting polymers

UNIT 2: SYNTHESIS OF CONDUCTING POLYMERS 10 L

Chemical and electrochemical polymerizations: polyaniline, polypyrrole, polythiophene etc.; doping and its effects on properties of conducting polymers

UNIT 3: PROPERTIES & APPLICATIONS OF CONDUCTING POLYMERS 10 L

Electrical properties, resistance, impedance, capacitance, magnetic properties and optical properties Electronic devices, sensors, rechargeable batteries, solar cells, light emitting devices, biomedical devices, bio-system, organ transplant, artificial mussels and EMI shielding etc.

PRACTICALS: (50 MARKS)

1. Synthesis of polyaniline, polypyrrole and polythiophene by chemical polymerizations.
2. Synthesis of conducting polymers by electro chemical polymerizations.
3. To improve electrical conductivity of PANI by doping
4. Evaluation of mechanical properties of conducting polymer films/sheets.
5. Determination of the thermal properties of conducting polymers.
6. To prepare a molded sheet of conducting polymers.
7. To Manufacture molded conducting device
8. To study the effect of doping of Polypyrrole
9. To measure the electrical conductivity and resistivity of conducting polymer films/sheets.
10. To design light emitting devices for conducting applications.

REFERENCES:

1. Chandrasekhar P., (1999) Conducting Polymers, fundamentals and applications: A practical approach, Springer.
2. Nalwa H.S., (1997) Handbook of Organic Conductive Molecules and Polymers: Conductive polymers: synthesis and electrical properties, Vol. 2, Wiley.
3. Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (2007) Handbook of Conducting Polymers, CRC Press.
4. Batrinescu, G., Constantin, L. A., Cuciureanu, A., & Constantin, M. A. (2016). Conductive polymer-based membranes. Conducting Polymers.
5. Fernandez O.T., (2015) Conducting Polymers, Royal Society of Chemistry.
6. Almeida L.C., (2013) Conducting Polymers: Synthesis, Properties & Applications, Nova Publishers.

ADDITIONAL RESOURCES:

1. Dyson, R. W., (1982) Speciality polymers Chapman and Hall publications.
2. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
3. Sołoducho, J., & Cabaj, J. (2016). Conducting polymers in sensor design. Conducting Polymers. Rijeka: Intech, 27-48.
4. Otero, T. F. (2016). Conducting Polymers: Bioinspired Intelligent Materials and Devices. Royal Society of Chemistry.
5. Gupta, R. K. (Ed.). (2022). Conducting Polymers: Chemistries, Properties and Biomedical Applications. CRC Press.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Capacitance, Polythiophene, Band alignment, Nanoblends, EMI shielding, Polyaniline.

11.2.7: BIO-BASED AND BIODEGRADABLE POLYMERS

Discipline Specific Elective - DSE: Paper 7

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

COURSE OBJECTIVES:

1. To gain knowledge of biopolymers and their isolations
2. To acquire knowledge on structure and properties of biopolymers
3. To understand the basic applications of various biopolymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Gain knowledge of biopolymers applications
2. Characterize and analyze biopolymers

THEORY: (50 MARKS)

UNIT 1: BASICS TO BIOPOLYMERS & NATURAL MACROMOLECULES 10 L

Significance, classifications, properties and applications of biopolymers and natural polymers such as Starch, cellulose, chitosan, gelatine, protein, fatty acids, lipids, aliphatic polyesters (PLA, PHB), cellulose

UNIT 2: PROCESSING 10 L

Isolation, processing of biopolymers: composite formation, blending and solvent casting

UNIT 3: APPLICATIONS 10 L

Applications of biopolymers in packaging, biomedical testing and devices, agriculture: soil conditioning and micro-nutrient delivery

PRACTICALS: (50 MARKS)

1. To determine the molecular weight of biopolymers.
2. Isolation of starch from wheat/rice/potato
3. Isolation of gelatin from natural resources
4. To prepare Poly lactic acid
5. To prepare a chitosan based composite for biomedical applications.
6. To prepare blends of natural polymers and find out miscibility
7. Develop a biodegradable film by solution casting of biopolymers.

8. Estimate the biodegradability by soil burial test.
9. Evaluate swelling index, porosity, hardness of a film.
10. Estimate the water vapor transmission rate of a biopolymeric film.

REFERENCES:

1. Byrom D., (1991) Biomaterials: Novel Materials from Biological Sources, First Edition, Macmillan Publishers Ltd.
2. Bastioli C., (1987) HandBook of Biodegradable polymers, Rapra Technology.
3. Niaounakis M., (2015) Biopolymers: Processing and Products, First Edition, Elsevier Inc.

ADDITIONAL RESOURCES:

1. Johnson R.M., Mwaikambo L.Y., Tucker N., (2003) Biopolymers, Rapra Technology.
2. Pilla S., (2011) Hand Book of Bioplastics & Biocomposites for Engineering Applications, Wiley.
3. Alexander S., (2003) Biopolymers, Vol. 1, Wiley.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Biodegradability, Starch, Chitosan, Soil conditioning, Gelatin.

11.2.8: ENGINEERING DRAWING & MOLD DESIGN

Discipline Specific Elective - DSE: Paper 8

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

COURSE OBJECTIVES:

1. To understand the various planes of work pieces
2. To learn about the various processing techniques and their components
3. To acquaint with the concepts of mold & die design and their key features

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. To learn about the graphics design
2. Understand significance of the single screw and multiple screw extruder systems
3. Understand the fundamentals of injection and compression molding process and interpret processing variables for upgradation of quality of products
4. Apply design features in structure of injection molds with materials
5. Apply design features in structure of extrusion dies

THEORY: (50 MARKS)

UNIT I INTRODUCTION & PROJECTIONS OF PLANES, POLYHEDRA SOLIDS AND SOLIDS OF REVOLUTION 15 L

Introduction of Drawing instruments, sheet layouts lines, lettering and Dimensioning scales, various types of projections, First and Third angle systems of orthographic projections. Projection of Points in different quadrants:parallel to one reference plane, inclined to one plane but perpendicular to the other, inclined to both reference planes. Projections of Polyhedra Solids and Solids of Revolution – in simple positions with axis perpendicular to a plane, with axis parallel to both planes, with axis parallel to one plane and inclined to the other, Projections of sections of Prisms, Pyramids, Cylinders and Cones.

UNIT 2: MOLD DESIGNING AND MAKING 8 L

Materials selection for mold and die, mold making processes: casting, electro deposition, cold hobbing, pressure casting, spark machining. Tool room machines and their application : CNC machines-CNC EDM-CNC, Milling- CNC Lathe-assembly of moulds – rapid prototyping. bench fitting, defects and remedy. Feed system: runner, gates and cooling unit.

UNIT 3: EJECTION SYSTEM & UNDER CUTS 7 L

Ejector grid, ejector plate assembly, ejection techniques, ejection from fixed half and sprue pullers, Form pin, split cores, side cores, stripping internal undercuts, molds for threaded components. Daylight molds–general, undercut molds, double & triple daylight mold

PRACTICALS: (50 MARKS)

1. Lines, lettering & Dimension (Sketch Book): Scale-representative Fraction, Plan scale, Diagonal Scale, Vernier scales (In sheet), comparative Scale, & scale of chords (Sketch Book)
2. Geometric conception, caners used in drawing practice. Conic Section: Construction of Ellipse, Parabola & Hyperbola by different methods (In sheet)
3. Construction of cycloid, Epicycloids, Hypocycloid and Involutes (In sheet) Archimedean and Logarithmic spiral, (Sketch book)
4. Type Projection, Orthographic Projection: First Angle and third Angle Projection (Sketch Book)
5. Projection of Straight lines, different position of straight lines, methods for determining True length, true inclinations and Traces of straight lines (Four problems in sheet and three problems in Sketch Book)
6. Projection of Planes: Different positions of Plane lamina like.: - Regular polygon, circle three of planes (Four problems in Drawing sheet and three problems in Sketch Book).
7. Demonstration software used in mold and die design (Auto CAD, solid works, etc.)
8. To design and validate well labelled mold from clay/POP/resin etc.
9. Demonstration of Lathe, milling, CNC and wire cutting machine
10. Tool room/industrial visit

REFERENCES:

1. Engineering Drawing, Basant Agarwal & CM Agrawal, Tata McGraw Hill.
2. Engineering Drawing Geometrical Drawing, P.S. Gill, S.K. Katara & Sons.
3. Engineering Drawing, Dhanarajay A Jolhe, Tata McGraw Hill.
4. Pye R.G.W., (2000) Injection mould design, Affiliated East West Press Pvt. Ltd.
5. Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
6. Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.

ADDITIONAL RESOURCES:

1. Engineering Drawing, N.D. Bhatt, Charotar Publishing House Pvt. Ltd.
2. Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
3. Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
4. Rees H., (1995) Mould Engineering, Hanser Publisher.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Plain projection, Scale of chords, Injection molding, Die designing, Triple daylight mold, Die defects

11.2.9: POLYMER PHYSICS

Discipline Specific Elective - DSE: Paper 9

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. To learn about the conformations of polymer chains.
2. To understand the morphology of crystalline and amorphous polymers.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Learn the basic concepts of polymer physics.
2. To study various physical properties of polymers.
3. To understand various characterization techniques.

THEORY: (50 MARKS)

UNIT 1: MOLECULAR SIZES AND SHAPES AND ORDERED STRUCTURES 10 L

Distributions of molecular weight and their determination, Number-average and weight-average molecular weight, shapes of polymer molecules, Bonding and the shapes of molecules, Conformations and chain statistics, single and freely jointed chain, More realistic chains – excluded-volume effect, Chain flexibility and the persistence length.

UNIT 2: REGULAR CHAINS AND CRYSTALLINITY 10L

Regular and irregular chains, Polymers with 'automatic' regularity, Vinyl polymers and tacticity, Polydienes, Helical molecules, Determination of crystal structures by X-ray diffraction, Crystal structures of some common polymers (PE, PP, PET, Nylons, PVC)

UNIT 3: MORPHOLOGY AND MOTION 10 L

Introduction, degree of crystallinity, Experimental determination of crystallinity. Crystallites: fringed-micelle model, Chain-folded crystallites, Extended-chain crystallites, Non-crystalline regions and polymer macro-conformations:, Lamellar stacks, Spherulites and other polycrystalline structures, Optical microscopy of spherulites, Light scattering by spherulites.

PRACTICALS: (50 MARKS)

1. Interpretation of X-ray spectra and determine the d-spacing in a given polymer sample
2. To find out the swelling of rubber in various solvents and thus find out its degree of crosslinking, etc.
3. To develop and study the growth of polymer spherulites in different crystallization conditions.
4. DSC Interpretation and analysis for crystallization and isothermal crystallization.
5. To study X-ray scattering to determine crystallinity and orientation in polymers.
6. Morphological study of polymers by optical microscopy and interpretation of optical micrograph.
7. Interpretation of molecular weight distribution curve/chromatogram
8. To study tyndall effect in polymer solution.
9. To study the effect of crystallinity on mechanical properties of polymers.
10. Lab Visits

REFERENCES:

1. Sperling L.H., (1993) Introduction to Physical Polymer Sciences, J. Wiley N.Y.
2. Crompton R.T., (1989) Molecular Motions in High Polymers, Pergamon Press N.Y.
3. Hiemenz, P. C., & Lodge, T. P. (2007). Polymer chemistry. CRC press.

ADDITIONAL RESOURCES:

1. Crompton T.R., (1989) Analysis of Polymers, Pergamon Press N.Y.
2. Ward I.M., (1979)Mechanical Properties Of High Polymers, John Wiley.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

SAXS, Light scattering, X-ray diffraction, Spherulites, Axialites , Chain flexibility

11.2.10: MATERIAL SCIENCE

Discipline Specific Elective - DSE: Paper 10

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

COURSE OBJECTIVES:

1. To introduce the fundamentals of material science especially dielectric materials, semiconducting materials and nanomaterials
2. To impart knowledge of different types of materials, their properties and applications

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Discuss the structure, function, properties of various materials
2. Apply the knowledge of smart materials for desired applications

THEORY: (50 MARKS)

UNIT 1: BASICS OF MATERIALS STRUCTURE 10 L

Amorphous and crystalline structure, unit cells and space lattices, X-ray diffraction of crystal structures, miller indices of planes and directions, packing geometry in metallic, covalent and ionic solids, single and polycrystalline materials, imperfections in crystalline solids magnetism, intrinsic and extrinsic semiconductors, dielectric properties, absorption and transmission of electromagnetic radiation.

UNIT 2: ADVANCED MATERIALS 10 L

Ferroelectric, piezoelectric, optoelectronic, semiconducting behaviour, lasers and optical fibres, photoconductivity and superconductivity, nanomaterials (synthesis, properties and applications), biomaterials, shape memory alloys, Ceramics: structure, properties, processing and applications of traditional and advanced ceramics.

UNIT 3: METALS AND ALLOYS 10 L

Solid solutions, solubility limit, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels, cold, hot working of metals, recovery, recrystallization and grain growth. Microstructure, properties and applications of ferrous, non-ferrous alloys and polymer alloy

PRACTICALS: (50 MARKS)

1. To check the hardness of composite materials by rockwell hardness tester.
2. To determine % composition of metals, fillers etc.
3. Thermogravimetric analysis of different Polymers (Using TGA)
4. Determination of degradation profile and filler content of a polymer (using TGA).
5. Study of mechanical stress v/s strain behavior of a polymer (tensile and flexural)
6. Determination of impact strength of a polymer by izod method.
7. Determination of impact strength of a polymer by charpy method.
8. To determine magnetic properties of materials.
9. To determine mechanical properties (strength, modulus) of materials.
10. Preparation of advanced polymer composite material for different applications(packaging and biomedical).
11. To prepare safety glass and evaluate its properties.

REFERENCES:

1. Shackelford J.F., (2010) Materials Science And Engineering Handbook, Third Edition CRC Press.
2. Mittemeijer E.J., (2011) Fundamentals of Materials Science: The Microstructure–Property Relationship Using Metals as Model Systems, Springer.
3. Sedha R.S., Khurmi R.S., (2004) Materials Science, S. Chand.

ADDITIONAL RESOURCES:

1. Kakani S.L., Kakani A., (2006) Material Science, New Age International.
2. Yao J., Zhou Z., Zhou H., (2019) Highway Engineering Composite Material and its Application, Springer.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Lattice structure, Phase diagram, Piezoelectric, Solubility limit, Ceramics

11.2.11: SMART MATERIALS

Discipline Specific Elective - DSE: Paper 11

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. Overview of smart materials, Piezoelectric Ceramics, Piezo-polymers, Magnetostrictive Materials, Electroactive Polymers, Shape Memory polymers.
2. Electro and magneto rheological fluids, modeling of smart materials, introduction to composite smart materials,

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. This course provides a detailed overview of smart materials, piezoelectric materials structures and its characteristics.
2. The study of smart structures and modeling helps in vibration control using smart materials in various applications.

THEORY: (50 MARKS)

UNIT-1: INTRODUCTION 10 L

Smart materials and structures: components and classification of smart structures, common smart materials and associated stimulus-response, application areas of smart systems, piezoelectric materials-piezoelectric effect, parameter definitions, piezoceramics, piezopolymers, piezoelectric materials as sensors, actuators and bimorphs

UNIT 2: SMART POLYMERS 10L

Thermally responsive polymers, electroactive polymers microgels (synthesis, properties and applications), protein-based smart polymers, ph-responsive and photo-responsive polymers, self-assembly, molecular imprinting using smart polymers, approaches to molecular imprinting, drug delivery using smart polymers

UNIT 3: SMART HYDROGELS 10L

Synthesis, fast responsive hydrogels, molecular recognition, smart hydrogels as actuators, controlled drug release, artificial muscles, hydrogels in microfluidics. smart systems for space applications: elastic memory composites, smart corrosion protection coatings, self-healing materials, sensors, actuators, transducers, deployment devices, molecular machines

PRACTICALS: (50 MARKS)

1. To determine the elastic properties of polymers.
2. To determine swelling % age of hydrogel
3. To determine the sensing power of a sensor.
4. To prepare corrosion resistance coatings

5. To test the corrosion inhibition of materials
6. To prepare electroactive microgel
7. To prepare polymer for artificial muscles and study its behaviour with pH change.
8. To determine the flexural strength of epoxy/ polyester composite.
9. To synthesise and test water absorption behaviour of hydrogel
10. To prepare a polymer based photosensor

REFERENCES:

1. Leo D.J., (2007) Engineering Analysis of Smart Material Systems, Wiley.
2. Addington M., Schodek D.L., (2005) Smart Materials and New Technologies in Architecture, Elsevier.
3. Otsuka K., Wayman (Eds.) C.M., (1998) Shape Memory Materials, Cambridge University Press.
4. Gandhi, M.V., Thompson B. S., (1992) Smart Materials and Structures, Chapman & Hall.
5. Schwartz, M., (2006) New Materials, Processes, and Methods Technology, CRC Press.

ADDITIONAL RESOURCES:

1. Ball, P., (1997) Made to Measure: Materials for the 21st Century, Princeton University Press.
2. Galaev, I., Mattiasson, B., (Eds.), (2008) Smart Polymers: Applications in Biotechnology and Biomedicine, 2nd ed, CRC Press.
3. Yui, N., Mrsny, R. J., Park, K., (Eds.), (2004) Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems, CRC Press.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Actuators, Piezopolymers, Sensors, Responsive Hydrogels, Artificial Muscles, Photo-responsive Polymers.

11.2.12: AUTOMOBILE APPLICATIONS OF POLYMERS

Discipline Specific Elective - DSE: Paper 12

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. Make themselves familiar with advanced engineering materials and manufacturing processes.
2. Evaluate and arrive at material properties for automotive components and select appropriate materials
3. Recommend suitable manufacturing process to produce a component

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Evaluate and match materials and manufacturing processes
2. Evaluate the cause for failure of the components due to material or manufacturing process and recommend the appropriate remedy to avoid the failure

THEORY: (50 MARKS)

UNIT I: INTRODUCTION TO AUTOMOTIVE COMPONENTS AND MATERIALS 10L

Automotive components categories, different materials used for automotive components, functionality considerations of automotive parts, factors influencing selection of materials for components. influence of material properties on functionality and forming of components, strengthening mechanisms and their need in the automotive industry, polymeric metals for automotive applications, analysis of the relative merits and demerits of polymeric materials for automotive applications. thermoplastic and thermosets usage based on the functionality requirement.

UNIT II: LIGHT WEIGHT MATERIALS FOR ENGINEERING APPLICATIONS 10 L

Background and motivation of introducing lightweight materials in automotive applications. value vs. weight. weight effect on fuel consumption. weight distribution in automotive applications, light weight material implementations. lightweight automotive materials: epoxy composite, polyester composite, advanced high strength fibre composite, carbon fibre composites. efficient material utilization. further directions in automotive materials: environmental and safety viewpoint, design strategies. hybrid design. case analysis and simulation for modeling of light weight materials.

UNIT III: MANUFACTURING PROCESS OF AUTOMOTIVE COMPONENTS 10L

Manufacturing technologies (current and emerging): Adhesive joining, thermal joining. processing of polymeric materials for automotive components: molding, extrusion, thermoforming, foam molding and tooling, processing of ceramics like slip casting technique, etc.

PRACTICALS: (50 MARKS)

1. To prepare EPDM profile for windshield and door seal.
2. To prepare impact resistance bumper material film/sheet and test its impact strength.
3. To prepare O'Rings/gaskets for sealing applications
4. To manufacture automobile carpet/leather and test its mechanical and physical properties.

5. To prepare laminated radiator pipe
6. To Manufacture carbon fibre-epoxy composite for high strength applications
7. To prepare plastic joint and test its strength.
8. To find out scratch resistance of a coated automobile part.
9. To prepare composite for railway breaker
10. To analyze flexural strength of jumping rod.

REFERENCES:

1. Ashby M. F., Shercliff, H., Cubon, D., (2007) Materials Engineering Science, Processing and Design, Butterworth Publications.
2. Brian, C., Patrick, G., and Colin J., (2007) Automotive Engineering: Light Weight, Functional and Novel Materials, Taylor & Francis.
3. Groover M. P. , (2005)Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 2nd edition, John Wiley & Sons.

ADDITIONAL RESOURCES:

1. Callister, W. D., (2005) Materials Science and Engineering an Introduction, 6th edition, John Wiley & Sons.
2. Yamagata, H., (2005) The Science and Technology of Materials in Automotive Engines, Yamaha Motor Co. Ltd., Japan Woodhead Publishing Limited.
3. Davies G., (2003) Materials for Automobile Bodies, Butterworth-Heinemann Publications.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Crash safety laws, Ultrasonic machining, Water jet cutting, CAE analysis and simulation

11.2.13: POLYMERS IN ENERGY APPLICATION

Discipline Specific Elective - DSE: Paper 13

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

Total Marks: 100 (Theory – 50 Marks, Practical – 50 Marks)

COURSE OBJECTIVES:

1. Make themselves familiar with advanced polymers for energy applications
2. Able to learn about the manufacturing of fuel cell and lithium batteries
3. Evaluate and arrive at material properties for energy components and select appropriate materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Able to learn smart applications of polymers
2. To learn working process to lithium batteries

THEORY: (50 MARKS)

UNIT -1: FUEL CELLS AND HYDROGEL 7L

High performance polymer hydrogel based materials for fuel cells: introduction, hydrogel electrolyte, poly(vinyl alcohol) hydrogel

UNIT-2 LITHIUM BATTERIES 8L ,

Introduction, materials for lithium batteries: PVAc based polymer blend electrolytes for lithium batteries, solid polymer electrolytes with inert oxide ceramics, solid polymer electrolytes with fast-ion conductive ceramics, garnet-type composite polymer electrolytes, perovskite-type composite polymer electrolytes, PPO-type composite polymer electrolytes, sulfide-type polymer electrolytes, solid polymer electrolytes with ionic liquid, solid polymer electrolytes with cellulose,

UNIT-3 SOLAR CELL 15L

Introduction to solar cells (Types, functioning, mechanism, materials for solar cell and structure design, molecular layer deposition, concept of solar cells with organic quantum dots, polymer multiple quantum dots, molecular multiple quantum dots.

Solar cell device structure and preparation: spin-coating of active layer, influence of solvent on morphology, residual solvent, polymer-inorganic hybrid solar cells, hybrid conjugated polymer-inorganic semiconductor composites, semiconducting polymer-based bulk heterojunction solar cells

PRACTICALS/ ASSIGNMENTS: (50 MARKS)

1. To prepare methanol fuel cell

2. Manufacturing low, medium and high temperature fuel cell
3. Preparation of proton exchange by membrane fuel cell
4. Synthesis of hydrogen fuel cells
5. To Prepare quantum dots grown by molecular layer deposition for photovoltaics
6. Manufacturing of polymer multiple quantum dots
7. To test efficiency of solar cell
8. Demonstrate the working principle of solar cell
9. To Prepare PVAc Based Polymer Blend Electrolytes
10. To test the energy storage of Lithium Batteries

REFERENCES:

1. Kroschwitz, J. I. (2003). Encyclopedia of polymer science and technology. John Wiley.
2. Mark, H. F. (2013). Encyclopedia of polymer science and technology, concise. John Wiley & Sons.
3. Mohammad, F., (2007) Specialty Polymers: Materials and Applications, I. K. International Pvt Ltd.
4. Chanda M., Roy, S. K., (2008) Industrial Polymers, Specialty Polymers, and Their Applications, CRC Press.

ADDITIONAL RESOURCES:

1. Malaika, S. Al, Wilkie, C. A., Golovoy, A., (2001) Specialty Polymer Additives, Wiley.
2. Dyson, R. W., (1982) Speciality polymers Chapman and Hall publications.
3. Ise, N., Tabushi, I., (1983) An Introduction to Speciality Polymers, CUP Archive.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Fuel cell, Solar cell, Conducting polymers, methanol fuel cell. Lithium batteries

11.2.14: 3D PRINTING OF POLYMERS

Discipline Specific Elective - DSE: Paper 14

Total Credits: 4 (Theory-2 Hrs/week, Practical – 4 Hrs/Week)

(Total Lectures: Theory-30 Hrs, Practical – 60 Hrs)

COURSE OBJECTIVES:

1. Impart students to the fundamentals of various 3D Printing techniques for application to various industrial needs.
2. Students will be able to convert part files into STL format and will understand the method of manufacturing of liquid based, powder based and solid based techniques.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Use software tools for 3D printing
2. Prepare 3D printed modules
3. Construct products using LOM and FDM technologies

THEORY: (50 MARKS)

UNIT I: BASICS OF 3D PRINTING TECHNOLOGIES 10 L

Introduction to 3D printing, advantages. commonly used terms, process chain, 3D modeling, classification of 3D printing process (comparing different 3D printing technologies, including FDM, SLA, SLS, and MJ.), applications to various fields.

UNIT 2: MATERIALS FOR 3D PRINTING 10 L

Comparing the different material types available for 3D Printing product, including PLA, ABS, PETG, TPE, nylon, PC, as well as 8 exotic filaments that are not focussed on physical properties.

UNIT 3: 3D PRINTING TECHNOLOGY 10 L

Laminated Object Manufacturing(LOM): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

Fused Deposition Modeling (FDM): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies, practical demonstration

PRACTICALS: (50 MARKS)

1. Manufacturing of additives by selective laser Sintering (SLS)
2. To prepare fibre by FDM
3. Manufacturing of Polyamide products by powder bed fusion
4. Product manufacturing by extrusion 3D printing process (fusion, deposition, modeling)
5. Direct ink writing of 3D functional materials
6. To manufacture polymer products by Multi jet fusion
7. To prepare photoreactive polymeric materials by material jetting.
8. To prepare the shoe sole by 3D printing.
9. To prepare filament by FFF (fused filament fabrication)

10. Preparation the elastomeric thread by 3 D printing technology

REFERENCES:

1. Chua C.K., Leong K.F. and LIM C.S, (2010) Rapid prototyping: Principles and Applications, World Scientific publications, 3rd Ed.
2. Pham, D.T. and Dimov, S.S. , (2001) Rapid Manufacturing, Springer.
3. Wohlers, T., (2000) Wohlers Report 2000, Wohlers Associates, 2000

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ADDITIONAL RESOURCES:

1. Jacobs, P. F., (1996) " Rapid Prototyping and Manufacturing"–, ASME Press.
2. Gibson, I., Rosen D., Stucker B., 2014) Additive Manufacturing Technologies, Springer, 2nd Ed.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Solid ground curing, Fusion, Deposition, Modeling, Printing technology

11.2.15: RESEARCH METHODOLOGY

Discipline Specific Elective - DSE: Paper 15

Total Credits: 4 (Theory-2 Hrs/week, Practical = 4 Hrs/week)

(Total Lectures: Theory-30 Hrs, Practical - 60 Hrs)

COURSE OBJECTIVE:

1. Understand some basic concepts of research and its methodologies
2. Identify appropriate research topics
3. Select and define appropriate research problem and parameters
4. Prepare a project proposal (to undertake a project)
5. Organize and conduct research (advanced project) in a more appropriate manner
6. Write a research report and thesis
7. Write a research proposal (grants)

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the limitations of particular research methods.
2. Develop skills in qualitative and quantitative data analysis and presentation.
3. Develop advanced critical thinking skills.

UNIT 1: RESEARCH METHODS 15

Identification of the research problem – determining the mode of action - literature survey – mode of approach of actual investigation – abstraction of a research paper – drawing inferences from data - qualitative and quantitative analysis.

Literature survey: Internet and its applications:– e-journals- assessing the status of the problem–results and conclusions – presenting a scientific seminar – publication of research paper - art of writing a thesis. literature survey including patents - chemical nomenclature and literature primary sources- secondary sources including reviews. treatise and monographs, literature searching, review of work relevant to the selected problems.

Thesis/Paper writing: General formation - page and chapter formation. The use of quotation - footnotes - tables and figures - referencing - appendices - revising the paper or thesis - editing and evaluating and the final product - proof reading - the final types copy.

UNIT 2: ONLINE TOOLS AND SCIENTIFIC CONDUCT 8 L

Correct usage of technical language and scientific peer network, ethics with respect to science and research, intellectual honesty and research integrity, scientific misconduct: falsification, fabrication and plagiarism (FFP), redundant publications: duplicate and overlapping publication, salami slicing, selective reporting and misrepresentation of data

UNIT 3: PUBLICATION ETHICS 7 L

Publication ethics: definition, introduction and importance, Best practices / standard setting initiatives and guidelines COPE (Committee on publication ethics), conflicts of interest, publication misconduct:

definition, concept, problems that lead to unethical, behaviour and vice-versa, types, violation of publication ethics, authorship and contributorship, identification of publication misconduct, complaints and appeals, predatory publishers and journals

PRACTICAL:

1. Literature survey (scopus, sciencedirect, elsevier, scifinder etc.)
2. Report writing
3. Reference writing using softwares like Endnote, Mendley etc.
4. Drawing of structures using softwares like chemdraw etc.
5. Poster making
6. Paper writing
7. Graphical representation using excel, origin etc.

REFERENCES:

1. Kothari, C. R., (2012) Research Methodology, methods and techniques, New Age International**.**
2. Rajaraman V., (2008) Computer Oriented Numerical Methods, Prentice Hall of India.
3. Jain M. K., Iyengar S. R. K. and Jain R.K., (2007) Numerical Methods for Scientific and Engineering Computation, New Age International.

ADDITIONAL RESOURCES:

1. Bhattacharya D. K., (2009) Research Methodology, Excel Books India.
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002) An introduction to Research Methodology, RBSA Publishers.
3. Kothari, C.R., (1990) Research Methodology: Methods and Techniques. New Age International. 418p.
4. Sinha, S.C. and Dhiman, A.K., (2002). Research Methodology, Ess Ess Publications. 2 volumes.
5. Trochim, W.M.K., (2005). Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
6. Wadehra, B.L., (2000). Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Abstract, Research paper, Literature survey, Reference, Appendix

11.3 Skill Enhancement Courses (SECs)

11.3.1: BIOPOLYMERS

(UPC: 31143901)

Skill Enhancement Elective Course – SEC: Paper 1

Total Credits: 2 (Practical -4 Hrs/week)

(Total Lectures: Practicals-60 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. To gain knowledge of synthetic biopolymers
2. To acquire knowledge on structure and properties of biopolymers
3. To understand the basic applications of various biopolymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Synthesize synthetic biopolymers
2. Characterize and analyze biopolymers

PRACTICALS: (50 MARKS)

1. Extraction of the biopolymers (Polylactic acid, starch, cellulose, chitosan etc.)
2. Identification of Isomers by polarimeter
3. Determination of molecular weight of the given biopolymers by end group analysis.
4. Determination of molecular weight of the given biopolymers by viscosity method.
5. Develop a bio degradable film by solution casting of biopolymers and evaluate the mechanical strength, swelling index, porosity, hardness, transparency, gloss, impact etc. of the film.
6. Estimate the biodegradability by soil burial test.
7. Estimate the water vapor transmission rate of a film.
8. Preparation and determination of sealing strength of biopolymeric film
9. Enzymatic degradation of biopolymers
10. Determination of chemical Composition of a biopolymer by chemical hydrolysis

REFERENCES:

1. Byrom D., (1991) Biomaterials: Novel Materials from Biological Sources, First Edition, Macmillan Publishers Ltd.
2. Bastioli C., (1987) HandBook of Biodegradable polymers, Rapra Technology.
3. Niaounakis M., (2015) Biopolymers: Processing and Products, First Edition, Elsevier Inc.

ADDITIONAL RESOURCES:

1. Johnson R.M., Mwaikambo L.Y., Tucker N., (2003) Biopolymers, Rapra Technology.
2. Pilla S., (2011) Hand Book of Bioplastics & Biocomposites for Engineering Applications, Wiley.
3. Alexander S., (2003) Biopolymers, Vol. 1, Wiley.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Biodegradability, starch, chitosan, soil conditioning, Film casting

11.3.2: ESTIMATION OF POLYMERS AND POLYMERIC COMPOUNDS (UPC: 31143902)

Skill Enhancement Elective Course – SEC: Paper 2

Total Credits: 2 (Practical -4 Hrs/week)

COURSE OBJECTIVES:

1. To learn about various characterization techniques and methods to identify polymers and their compounds
2. To gain knowledge of isolation of various additives from polymeric compounds

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply knowledge of quantitative and qualitative estimation of compounding ingredients of polymer
2. Understand characterization and testing of polymers and their compounding ingredients

PRACTICALS: (50 MARKS)

1. Identification of the functional group in a polymer by titration
2. Spectroscopic analysis of given polymer sample
3. Thermal analysis of given polymer
4. Determination of total filler content
5. Determine the plasticizer content in processed specimens.
6. Estimate the swelling index of a polymeric hydrogel.
7. Determination of melt viscosity of polymeric compound
8. Estimate the iodine and acid value of polymer products
9. Determine carbon content of polymers
10. Determination ash content of given sample
11. To check the bleeding of polymer additives.

REFERENCES:

1. Shah V., (2007) Handbook of Plastic Testing & Technology, Wiley-Interscience.
2. Forrest M.J., (2001) Rubber Analysis: Polymers, Compounds and Products, Rapra Tech. Ltd.
3. Loadman M.J., (2012) Analysis of Rubber and Rubber-like Polymers, Springer.

ADDITIONAL RESOURCES:

1. Seidel A., (2008) Characterization and Analysis of Polymers, Wiley.
2. Chalmers J.M., Meier R.J., (2008) Molecular Characterization and Analysis of Polymers, Elsevier.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Plasticizers, Swelling index, Iodine value, Hydrogel, Additives

11.3.3: WIRE AND CABLE TECHNOLOGY

(UPC: 31143903)

Skill Enhancement Elective Course – SEC: Paper 3

COURSE OBJECTIVES:

1. To familiarize with the selection criteria of materials for cable
2. To acquire knowledge of insulation thermal and mechanical properties of cable materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the basic concepts of conductors, semiconductors and insulators
2. Develop understanding of the properties and applications of cable materials

PRACTICALS: (50 MARKS)

1. Analysis of the thermal stability of cable material.
2. Determination of the volume and surface resistivity of cable material.
3. Chemical identification of the cable insulating materials
4. Determination of fire resistance and smoke density of cable insulating materials.
5. Evaluate weatherability of cable materials.
6. Determination of mechanical strength (tensile, compressive, elongation and hardness), porosity and density of cable materials.
7. Manufacturing of wire and cables.
8. Determination of limiting oxygen index (LOI) of wire and cable materials.
9. Determination of K-value of PVC.
10. Determination of flash point of plasticizer/oil in wires & cables.
11. Industrial visit.

REFERENCES:

1. Cousins K., (2000) Polymers for wire and cables- changes within an industry, Smithers Rapra Publishing.
2. Black R.M., (1983) The History of Electric wire and Cables, Peter Peregrinus Ltd.
3. Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publishers.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS: Cables, K-value, PVC, Insulators, Weatherability, LOI

11.3.4: POLYMERS IN SPORTS AND FOOTWEAR TECHNOLOGY

(UPC: 31143904)

Skill Enhancement Elective Course – SEC: Paper 4

Total Credits: 2 (Practical -4 Hrs/week)

(Total Lectures: Practicals-60 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. To impart knowledge of the basic concepts of raw material and manufacturing of footwear.
2. To learn design and design criteria of footwear

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply the knowledge of various type of polymers used in footwear manufacturing
2. Understand the soling and its material requirements

PRACTICALS: (50 MARKS)

1. Determination of bonding strength of sole.
2. Preparation of shoe components by compression molding.
3. Preparation of shoe components by transfer molding.
4. Preparation of shoe components by injection molding.
5. Estimate tear strength and abrasion resistance of a sole.
6. To prepare different compounded sheets of EVA.
7. Determine low temperature flexibility of shoe materials.
8. To prepare the sponge sole and calculate its specific gravity.
9. To prepare PU adhesive for sole bonding.
10. To check the compression set of a given sole.
11. To find out colf flexibility of sport goods
12. Industrial visit.

REFERENCES:

1. Martin J.M., Smith W.K., (2007) HandBook of Rubber Technology, CBS Publisher.

2. Harvey A.J., (1982) Footwear Materials and Process Technology, A LASRA publication.
3. Cohn, W.E., (1969) Modern Footwear Materials & Process, Fairchild Publications.

ADDITIONAL RESOURCES:

1. Venkatappaiah, B. (1997). Introduction to Modern Footwear Technology. B. Sita.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Sponge molding, Sole, EVA, Adhesion, PU adhesive

11.3.5: POLYMER MEMBRANES

(UPC:)

Skill Enhancement Elective Course – SEC: Paper 5

Total Credits: 2 (Practical -4 Hrs/week)

(Total Lectures: Practicals-60 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. This course introduces the concept of polymer based membrane along with their properties along with their application in water purification, electrodialysis, reverse osmosis and proton conduction.
2. To provide knowledge of synthesis, device fabrication and application of membranes

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Use the relevant membrane for various chemical processes.
2. Apply membrane technology in process industries.
3. Use appropriate methods to reduce membrane fouling.
4. Apply the concept of economics and feasibility to membrane technology.
5. Interpret concept of advanced membrane technology and nanotechnology.

PRACTICALS: (50 MARKS)

1. To Prepare a membrane by dip coating methods and analyse its morphology
2. Preparation of membrane for Ultrafiltration using Phase Inversion and test its permeability
3. To Fabricate a membrane by interfacial polymerisation and study its condition and performance
4. To Estimate the catalytic behaviour of a standard membrane
5. To Determine the ion exchange capacity of a membrane using titration method
6. To Evaluate the sieving nature of a laboratory prepared polymer membrane
7. To Evaluate the swelling index and percentage porosity of representative membrane
8. To Determine the performance and fouling nature of a standard membrane
9. To Demonstrate the decontamination of polluted water after using ion exchange membrane
10. To Evaluate the proton conducting nature of a standard membrane.

REFERENCES:

1. Winston W. S. Ho, Sirkar K. K., (1992), Membrane handbook, AlChE Journal, 954 pp.
2. Baker R. W., (2012) Membrane Technology and Applications, John Wiley and Sons.
3. Mulder M., (1996) Basic Principles of Membrane Technology.
4. Batrinescu, G., Constantin, L. A., Cuciureanu, A., & Constantin, M. A. (2016). Conductive

polymer-based membranes. Conducting Polymers.

ADDITIONAL RESOURCES:

1. Wang, L. K., Chen, J. P., Hung, Y. T., & Shammas, N. K. (Eds.). (2008). Membrane and desalination technologies (Vol. 13). Springer Science, Business Media, LLC.
2. Porter, M. C. (1989). Handbook of industrial membrane technology.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Membranes, Separation processes, Water treatment, Swelling

11.3.6: FIRE RETARDANT POLYMERS

(UPC:)

Skill Enhancement Elective Course – SEC: Paper 6

Total Credits: 2 (Practical -4 Hrs/week)

(Total Lectures: Practicals-60 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. To familiarize the students with a specific class of advanced polymers defined on the basis of their specific properties.
2. This paper will emphasize on the study of property correlation with various aspects and processing requirements for specialty polymers, engineering and specialty application of these materials in various vital fields like high performance applications, biomedical, aerospace engineering, electronics and other areas.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. To larn fire retardancy test
2. Understand knowledge of burning rating of polymers

PRACTICALS: (50 MARKS)

1. UL-94 Test (horizontal and vertical burning)
2. To determine LOI test of given polymer sample
3. To find out the smoke density of a given polymer.
4. To determine char/ash content of given polymer
5. To perform gravimetric analysis of smoke particulates.
6. Preparation of a fire retardant polymer
7. Analysis of solid combustion products of fire retardant polymers
8. To evaluate the efficiency of various fire retarders with polymers by UL-94 test.
9. To evaluate the quality of wire and cable covering by UL-94 test.
10. Analysis of solid combustion products and their toxicity.

REFERENCES:

1. Fried, J. R. (2014). Polymer science and technology. Pearson Education.
2. Rodriguez, F., Cohen, C., Ober, C. K., & Archer, L. (2014). Principles of polymer systems. CRC Press.
3. Ravve, A. (2013). Principles of polymer chemistry. Springer Science & Business Media.

ADDITIONAL RESOURCES:

1. Elias, H. G. (1999). An introduction to polymer science. In Annales de chimie-Sciences des materiaux (Vol. 4, No. 24, pp. 402-403).

2. Buback, M., Schroeder, H., & Kattner, H. (2016). Detailed kinetic and mechanistic insight into radical polymerization by spectroscopic techniques. Macromolecules, 49(9), 3193-3213.

TEACHING LEARNING PROCESS:
Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
UL-94, LOI, Smoke density test, Fire retardant polymer

11.3.7: POLYMERS IN DEFENSE TECHNOLOGY

(UPC:)

Skill Enhancement Elective Course – SEC: Paper 7

Total Credits: 2 (Practical -4 Hrs/week)

(Total Lectures: Practicals-60 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. Students will be able to understand the significance of nanosize.
2. Students will be able to synthesize various nanomaterials and nanocomposites
3. Students will be aware about new and emerging technology in polymer and coating industry

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the processing techniques
2. Design a microwave absorbing product

PRACTICALS: (50 MARKS)

1. Preparation of polypyrrole nanocomposites containing Fe_2O_3/TiO_2/SnO_2/W_2O_3/CNT as microwave absorber.
2. Preparation and testing of polyethylene glycol containing silica nanoparticles for armor applications.
3. To prepare tungsten sulfide reinforced epoxy/polyacetal nanocomposite and determination of coefficient of friction.
4. To prepare nanoporous polyurethane foam reinforced with silica nanoparticles (shock absorbers/acoustic).
5. To prepare PP clay nanoparticle nanocomposite and determine their fire resistant behaviour.
6. To prepare CNT reinforced polyurethane nanocomposite
7. To prepare polyethyleneimine nanocomposite
8. To prepare polydimethylsiloxane/CNT nanocomposite film for sensor applications (Detection of toxic gases/chemical warfare agents/solvent vapours).
9. To prepare SBR clay nanoparticle nanocomposite (electrostatic charge dissipation study/radiation resistance)
10. To prepare epoxy/carbon fibre nanocomposite with TiO_2 nanoparticles and check its UV Resistance.

REFERENCES:

1. Baird, D. G., Collias, D. I. (2014). Polymer processing: principles and design. John Wiley & Sons.

2. Muccio, E. A. (1999). Decoration and assembly of plastic parts. ASM International.
3. Rosato, D. (2013). Designing with plastics and composites: a handbook. Springer Science & Business Media.

ADDITIONAL RESOURCES:

1. Stevenson, A. (1983). Composite Polymeric Materials. RP Sheldon. Applied Science Publishers, London. 1982. 213 pp. Illustrated.£ 19.00. The Aeronautical Journal, 87(861), 31-31.
2. Chanda, M., & Roy, S. K. (2008). Industrial polymers, specialty polymers, and their applications. CRC press.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

High strength polymers, Nanocomposite, Carbon nanotube, Epoxy

11.3.8: POLYMER FOAM TECHNOLOGY

(UPC:)

Skill Enhancement Elective Course – SEC: Paper 8

Total Credits: 2 (Practical -4 Hrs/week)

(Total Lectures: Practicals-60 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. To understand the perceptions of the physical chemistry and the structure of polyurethanes.
2. To understand the chemical and physico-chemical principles of polyurethane.
3. To learn about the raw materials of foams.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Know about the building blocks of polyurethanes.
2. Learn about types of foams.
3. Understand the effect of chemical composition of polyurethane foam on properties.

PRACTICALS: (50 MARKS)

1. Manufacturing of PU foams.
2. Preparation of elastomeric foams.
3. Preparation of Flexible foam by RIM/RRIM
4. Testing of polymeric foams (density, strength, open space etc.)
5. Preparation of open cell/closed cell foams.
6. Preparation of Black/Green Board Duster.
7. Preparation of foam for handloom and automobile applications.
8. Determination of physical properties of polymeric foams (Impact, compression, Tear etc.)
9. Preparation of a polyester/ polyether based polyurethane.
10. To prepare insulated rubber foam.
11. To determine the thermal conductivity of polymeric foam.

REFERENCES:

1. Mills, N. J. (1993). Handbook of polymeric foams and foam technology: D. Klempner and KC Frisch (eds) Carl Hanser Verlag.
2. Oertel G., (1993), Polyurethane Handbook, Hanser Publishers; 2Rev Ed Edition.

ADDITIONAL RESOURCES:

1. Walker, B. M., & Rader, C. P. (Eds.). (1979). Handbook of thermoplastic elastomers (pp. 115-205). New York: Van Nostrand Reinhold.

2. Elastomers, T. (1987). A Comprehensive Review, edited by NR Legge, G. Holden, and HE Schroeder.
3. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.

TEACHING LEARNING PROCESS:
Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
RIM, Cellular plastics, Polyurethane, Elastomeric foam

11.3.9: FABRICATION OF POLYMER PRODUCTS

(UPC:)

Skill Enhancement Elective Course – SEC: Paper 9

Total Credits: 2 (Practical -4 Hrs/week)

(Total Lectures: Practicals-60 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. To understand laboratory scale polymer processing and compounding operations of various types of thermoplastic and thermoset polymers.
2. To provide knowledge of the subject which will help students to carry out R&D in the areas of polymer blends, Polymer nanocomposites, Fibre reinforced composites, Polymer processing etc.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Design and conduct experiments,
2. Analyze and interpret data, process parameters.

PRACTICALS: (50 MARKS)

1. Preparation of laminates.
2. Preparation of composites with various fillers and various filler loading.
3. Mechanical properties of blends and composites.
4. Compounding of PVC and rubbers in two roll-mills with fillers and reinforcing agents.
5. Preparation of Polymeric sheets by Compression molding
6. Preparation of carrom board striker
7. To produce small components on hand operated compression molding machine
8. To produce components on automatic/semi automatic compression molding machine
9. To produce articles on vacuum forming machine
10. Preparation of FRP sheet by hand lay up technique
11. Preparation of a model

REFERENCES:

1. Morton-Jones, D. (2012). Polymer Products: design, materials and processing. Springer Science & Business Media.
2. Miller, E. (2020). Plastics Products Design Handbook. CRC Press.

ADDITIONAL RESOURCES:

1. Malloy, R. A. (2012). Plastic part design for injection molding: an introduction. Carl Hanser Verlag GmbH Co KG.
2. Pye, R. G. W. (1983). Injection mould design: a design manual for the thermoplastics industry. Godwin Books.

TEACHING LEARNING PROCESS:
Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
PVC flooring,Vacuum compression molding, Injection molding, Vacuum forming

11.4 Generic Elective Courses (GECs)

11.4.1: BASICS OF POLYMER SCIENCE

Generic Elective – GE: Paper 1

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

(Total Lectures: Theory- 30 Hrs, Practicals-60 Hrs)

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

1. To familiarize with the structure of polymers will be introduced to students.
2. To acquaint students with knowledge of molecular weight determination and polymer solubility

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand concept of crystalline and amorphous states of polymers
2. Correlate flexibility with the glass transition temperature
3. Understand structure-property relationship of polymers
4. Apply mathematical formulae to depict polymer solution properties

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION TO POLYMERS **10 L**

Introduction and classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, entanglement, various structures of copolymers such as linear branched and cross-linked copolymers, Polymer solutions, solubility parameter, solution viscosity, polymer solubility, thermodynamics of polymer solutions

UNIT 2: PROPERTIES OF POLYMERS **10 L**

Physical properties, stress–strain behaviour, mechanical properties (tensile, flexural, impact, fatigue, hardness, creep, abrasion), introduction to flow & glass transition temperature (T_g) and its measurement of T_g, factors affecting the glass transition temperature

UNIT 3: MOLECULAR WEIGHT OF POLYMERS **10 L**

Nature and structure of polymers – structure-property relationships, Molecular weight of polymers (Mn, Mw etc.), polydispersity, molecular weight distribution and determination of molecular weight by viscosity, end group analysis, cryoscopy, ebulliometry, light scattering & ultracentrifugation methods

PRACTICALS: (50 MARKS)

1. Chemical identification of polymers: Functional groups (associated with polymers).
2. Determination of molecular weight by solution viscosity/end group analysis.
3. To check the solubility of the given polymeric sample in different solvents.
4. To determine the melting point of crystalline polymers.
5. Determination of heat deflection temperature & vicat softening point of polymers.
6. Acid value of acrylic acid
7. Estimation of hydroxyl value by PVA and Cyclohexanol
8. Determination of epoxy equivalent weight of the epoxy resin.
9. Determination of saponification value of oil.
10. Study of three component systems.

REFERENCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites Tata McGraw-Hill.
3. Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition
4. Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
5. Shah V., (1998) Handbook of Plastics Testing Technology, Wiley interscience publications.

ADDITIONAL RESOURCES:

1. Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
2. Seymour R.B., Carraher C.E., (2000) Polymer Chemistry, Marcel Dekker.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Crystallization, Glass transition temperature, Molecular weight determination, Polymer solubility

COURSE OBJECTIVES:

1. To acquaint the students with the advanced instrumental techniques and their applications in characterization of polymeric materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Learn the electronic microscope for characterization of morphology of polymeric materials
2. Elucidate crystallinity of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION 5 L

Basic principle of spectroscopy, molecular and atomic spectra, Lambert-Beer's law, Frank-condon principle, electromagnetic radiation and it's properties, interaction of radiation with matter, statistical method of analysis

UNIT 2: SPECTROSCOPIC TECHNIQUES 7 L

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.): Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance, raman, nuclear magnetic resonance spectrometer

UNIT 3: CHROMATOGRAPHY TECHNIQUES IN POLYMER 8 L

Thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography.

UNIT 4: MICROSCOPIC AND X-RAY TECHNIQUES 10 L

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) in polymers characterization

PRACTICALS: (50 MARKS)

1. Study of UV stabilization of polymer samples by UV-visible spectrophotometer.
2. Calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
3. Determination of K-value of PVC.
4. Quantitative determination of impurities by UV-Vis. spectrophotometer.
5. Characterization of Filler Content /Ash Content of common polymers by Thermogravimetric Analysis, (TGA).
6. Identification of additives in a processed polymer by chromatography.
7. Interpretation of FTIR, NMR and Raman spectra of polymers.

REFERENCES:

1. Willard H.H., Merritt L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
2. Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
3. Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
4. Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.

ADDITIONAL RESOURCES:

1. Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
2. Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
3. Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Gel Permeation Chromatography, FT-IR, Scanning Electron Microscope, Transmission Electron Microscopy.

COURSE OBJECTIVES:

1. To give understanding of basics of care to be taken while handling polymer products.
2. To know the Safety and hazardous of their manufacturing processes.
3. To impart Knowledge of the subject will help students to see the environmental impact of plastic and resin.
4. To understand the current benefits and concerns surrounding the use of plastics and look to future priorities, challenges and opportunities.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand basics of environmental and safety issues in the chemical industry.
2. Understand safety in handling monomer and resins
3. Impact of final product of polymer on environment after use and its waste management

THEORY: (50 MARKS)

UNIT 1: ENVIRONMENTAL APPROACH OF PLASTIC WASTE 10 L

Health and safety, Plastics in the society, Plastics in the environment, Plastic waste management, Plastic waste in the marine and terrestrial environment, Plastic material degradation, regulations for hazardous chemicals in articles/plastic products, coated articles. Separation techniques of plastic wastes (density, float sink and froth floatation methods, optical, spectroscopic, sorting by melting temperature etc.).

UNIT 2: PLASTIC SEGREGATION 10 L

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle (mechanical and chemical), recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples.

UNIT 3: RECYCLING 10 L

Disposal processes and Various waste treatment methods – controlled tipping, pulverization, compositing, Energy from waste – (incinerators- pyrolysis, factors affecting incineration), new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling. Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides (Nylon-6 and Nylon-6,6). Recycling of Thermosets –reclaiming of rubber –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber.

PRACTICALS: (50 MARKS)

1. Primary recycling of plastic waste collected from the environment.
2. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
3. To study composting of natural/biopolymers.
4. Separation of polymer mixture by sink flotation technique.
5. Separation of polymer mixture by selective dissolution technique.
6. Recovery of BHET from PET by chemical recycling process
7. Recovery of Adipic Acid from Nylon 66 by chemical recycling technique

8. To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
9. Preparation of plasticizer from polyester waste.
10. Preparation of reclaim from tyre waste.

REFERENCES:

1. Chandra, R., & Adab, A. (1994). Rubber & Plastic Waste: Recycling, Reuse and Future Demand. CBD Publishers.
2. Scheirs, J., & Long, T. E. (Eds.). (2005). Modern polyesters: chemistry and technology of polyesters and copolyesters. John Wiley & Sons.

ADDITIONAL RESOURCES:

1. Blow, S. (1998). Handbook of Rubber Technology.
2. Brandrup, J., Bittner, M., Michaeli, W., & Menges, G. (1996). Recycling and Recovery of Plastics, Hanser. Gardner, München.
3. Goodship, V. (2007). Introduction to plastics recycling. iSmithers Rapra Publishing.
4. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

4 R's approach, Incineration, Degradation, Selective dissolution technique, Chemical recycling

11.4.4: BIOMEDICAL APPLICATIONS OF POLYMERS

Generic Elective – GE: Paper 4

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

(Total Lectures: Theory- 30 Hrs, Practicals-60 Hrs)

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

1. To acquire knowledge of biopolymer and biodegradation
2. To gain knowledge of applications and testing of biopolymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the basic concepts and requirement of biomaterials and biocompatibility
2. Apply the knowledge of various biomaterials for a desired bio-application

THEORY: (50 MARKS)

UNIT: 1 BASICS OF BIOMATERIALS 7 L

Concept of biocompatibility and biodegradability, responsiveness, estimations of degradation and biocompatibility, Important biomaterials: hydrogel, fibres, bio-ceramics, bio-elastomers and membranes

UNIT 2: POLYMERS AS BIOMATERIALS 7 L

Polyester and polysaccharides, natural gums, biodegradable polymers, polymers and hydrogels

UNIT: 3 BIOMATERIALS FOR ORGAN TRANSPLANTS AND TISSUE ENGINEERING 8 L

Properties and applications of polymers for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc., basic concepts of tissue engineering, Important polymers for tissue engineering: cellulose, chitosan and alginates

UNIT: 4 DRUG DELIVERY AND WOUND CARE 8 L

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels, polymers for antimicrobial activity, bio-conjugates

PRACTICALS: (50 MARKS)

1. Evaluate the biocompatibility of polymeric samples.
2. Determination of the degradation behavior of polymers such as thermal, hydrolytic degradation etc.
3. Preparation of membranes and measurement of absorption behavior.
4. Preparation and characterization of dental cement.
5. Preparation of a hydrogel and its characterization.
6. Determination of tensile strength of biopolymers.
7. Determine the swelling rate of biopolymers
8. Preparation of nanogel and find its water absorption
9. preparation and characterization of membrane for skin transplant

REFERENCES:

1. Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
2. Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.
3. Ratner, Buddy D., Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons. "Biomaterials science: an introduction to materials in medicine." San Diego, California (2004): 162-4.
4. Park, J. B., & Bronzino, J. D. (2002). Biomaterials: principles and applications. crc press.

ADDITIONAL RESOURCES:

1. Ratner D., Hoffman A.S., (1996) An Introduction to Materials in Medicine, Academic Press.
2. Saltzman W.M., (2001) Drug delivery–Engineering principles for drug therapy, Oxford University Press.
3. Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Chitosan, Tissue engineering, Drug delivery, Organ transplant, Biodegradable polymer

11.4.5: POLYMERS FOR PACKAGING

Generic Elective – GE: Paper 5

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

(Total Lectures: Theory- 30 Hrs, Practicals-60 Hrs)

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

1. To learn about the basic necessities and importance of packaging
2. To acquire knowledge of various types of packaging materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apprehend the basic concepts of packaging and its utilization for desired applications
2. Assess the quality of packaging material and packaged product

THEORY: (50 MARKS)

UNIT 1: PACKAGING SYSTEMS — 7 L

Types of packaging systems: box, bottle, tetra, pouch, shrink, vacuum, gas, controlled atmosphere packaging (CAP), modified atmosphere packaging (MAP), and aseptic packaging

UNIT 2: POLYMERS IN PACKAGING — 8 L

Properties and applications: LLDPE, LDPE, HDPE, HMHDPE, PP, PVC, nylons, polyester, polycarbonate, PS, EPS, PLA, PVA and Starch

UNIT 3: PACKAGING PROCESS TECHNIQUES — 7 L

Preparation of packaging materials by thermoforming, co-extrusion, extrusion-stretch blow molding, injection molding, BOPP films

UNIT 4: TESTING OF POLYMER PACKAGING MATERIAL — 8 L

Bursting strength, tensile strength, tear strength, puncture test, impact test (Drop, falling dart), permeability test (water vapour, oxygen), biodegradability, sealing strength

PRACTICALS: (50 MARKS)

1. To identify packaging materials with the help of FT-IR, DSC, TGA etc.
2. Determination of physico-mechanical properties (density, burst strength, tensile strength, tear strength, puncture test strength, impact strength etc).
3. Determination of water vapor transmission rate of packaging material.
4. To test sealing strength integrity of packaging materials.
5. To check biodegradability of packaging material.
6. Preparation biodegradable packaging film
7. Determination of water vapor transmission rate of packaging material.
8. To test seal strength integrity of packaging materials.
9. To check biodegradability of packaging material.
10. To determine compatibility of film.

REFERENCES:

1. Robertson G.L., (2005) Food Packaging Principles and Practice, CRC press.
2. Paine F.A. and Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional.
3. Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher
4. N. C. Saha, M. Garg, S. Dey Sadhu, A. K. Ghosh(2022) Food Packaging-Materials, Techniques and Environmental Issues" by published by Springer.
5. Garg, M., Meena, P.L., Sadhu, S.D., Alam, T. (2019). Food Packaging: A Practical Guide : Viba Press Pvt. Ltd.

ADDITIONAL RESOURCES:

1. Robertson G.L., (2012) Food Packaging–Principles and Practice, CRC Press.
2. Coles R, McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.
3. Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging materials for preservation of foodstuffs, VSP.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Packaging materials, Dart impact tester, Sealing strength, BOPP

11.4.6: POLYMERS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS

Generic Elective – GE: Paper 6

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

(Total Lectures: Theory- 30 Hrs, Practicals-60 Hrs)

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

1. To learn about basic concepts of polymer electrical and electronic properties
2. To gain knowledge of electrical and electronics applications of polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Synthesize a conducting polymer for a specific application
2. Apply the knowledge of properties of polymers required for electrical and electronics applications

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION TO POLYMERS **7 L**

Petro polymers, conducting polymers, biopolymers, composites, Band diagram, processing of polymers, doping (chemical and ion), advantages and disadvantages of conducting polymers, limitations

UNIT 2: PREPARATION OF CONDUCTING POLYMERS **8 L**

Synthetic methods: chemical, electrochemical, photochemical etc. (polyaniline, polypyrrole, polythiophene, polyacetylene, etc.), methods to enhance the processability of conducting polymers

UNIT 3: PROPERTIES **7 L**

Dielectric strength, dielectric loss, charge storage capacity, electrical conductivity, heat capacity, magnetism, hysteresis loop, shape memory, mechanical properties, EMI shielding

UNIT 4: ELECTRONIC APPLICATIONS **8 L**

Semiconducting organic materials, polymer based electronic devices, organic field effect transistor, organic transistors, plastic solar cell, light emitting diode, supercapacitor, sensors etc.

PRACTICALS: (50 MARKS)

1. Preparation of conducting polyaniline and measurement of their conductivity.
2. Preparation of polypyrrole and measurement of their conductivity.
3. Preparation of polythiophene and measurement of their surface resistivity.
4. Preparation and testing of conducting polymers for sensor applications.
5. Measurement of multilayer insulation of a thin film.
6. Measurement of dielectric strength of a polymer film.
7. Measurement of mechanical properties of insulating cable
8. Preparation polymer sample and analyzed its dielectric strength
9. Preparation of a conducting polymer nanocomposites.
10. Preparation polymeric semiconductor

REFERENCES:

1. Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (1998) Handbook of conducting polymers, Vol. 1 and Vol. 2, Marcel Dekker.
2. Nalwa H.S., (1977) Organic Conductive Molecules and Polymers, John Wiley & Sons.
3. Bredas J.L., Silbey R., (1991) Conjugated Polymers: The Novel Science and Technology of Highly Conducting and Nonlinear Optically Active Materials, Kluwer Academic Publishers.
4. Bikales M., Menges O.B., (1986) Encyclopedia of Polymer science and Engineering, Second Edition, Vol.5, John Wiley & Sons.

ADDITIONAL RESOURCES:

1. Lyons M.E.O., (1994) Electroactive polymers, Plenum Press.
2. Margolis J., (1993) Conducting Polymers and Plastics, Chapman & Hall.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Polyaniline, Polypyrrole, EMI shielding, Light emitting diode, Shape memory polymers

11.5: VALUE ADDED COURSE

11.5.1: POLYMER SCIENCE: INTELLECTUAL PROPERTY RIGHT

(UPC:)

VAC – VAC Paper 1

Total Credits: 2 (Theory-2 Hrs/week)

(Total Lectures: Theory- 30 Hrs)

Total Marks: 50

COURSE OBJECTIVE:

1. To give an idea about IPR, registration and its enforcement.
2. The course is designed to provide comprehensive knowledge to the students regarding Indian position of the Patent Law, Historical development, Procedure for granting a patent, Infringement.
3. The course is designed to provide comprehensive knowledge to the students regarding Indian position of the Copyright Law, Historical background and Development of Copyright Law, Infringement.

COURSE LEARNING OUTCOMES:

1. Ability to manage Intellectual Property portfolio to enhance the value of the firm.
2. To learn about copyright.

UNIT 1: INTRODUCTION **10 L**

Introduction to IPRs, Basic concepts and need for Intellectual Property - Patents, copyrights, geographical indications, IPR in India and abroad – genesis and development – the way from WTO to WIPO –TRIPS, nature of intellectual property, industrial property, technological research, inventions and innovations – important examples of IPR.

UNIT 2: REGISTRATION OF IPRs **10 L**

Meaning and practical aspects of registration of copyrights, trademarks, patents, geographical indications, trade secrets and industrial design registration in india and abroad, rights of patentee procedure for granting a patent and obtaining patents grounds for opposition working of patents, compulsory license acquisition, surrender, revocation, restoration transfer of patent rights

UNIT 3: COPYRIGHT LAW AND PRACTICES **10 L**

Copyright and neighbouring rights concept and principles historical background and development of copyright law leading international instruments, berne convention, universal copyright convention, international copyright under copyright act WIPO phonograms and performances treaty copyright registrar and copyright board-power and procedure copyright societies, ownership, assignment, license, translation of copyright, compulsory licenses, infringement-criteria of infringement, infringement of copyright-films, literary and dramatic works, importation and infringement.

REFERENCES:

1. Vinod V. S., (2012) Managing Intellectual Property, Prentice Hall of India pvt Ltd.
2. Satakar S. V., (2002) Intellectual Property Rights and CopyRights, Ess Ess Publications, New Delhi.
3. Bouchoux D. E., (2012) Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets, Cengage Learning, Third Edition.

ADDITIONAL RESOURCES:

1. Ganguli P., (2011) Intellectual Property Rights: Unleashing the Knowledge Economy, McGraw Hill Education.
2. Bosworth, D., Webster, E., (2013) The Management of Intellectual Property, Edward Elgar Publishing Ltd. (Edited)

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Copyright, Importation and Infringement, Trademarks, Patents,WTO to WIPO –TRIPS.

11.5.2: POLYMER SCIENCE: ENTREPRENEURSHIP AND MARKETING STRATEGIES

(UPC:)

VAC – VAC Paper 2

Total Credits: 2 (Theory-2 Hrs/week)

(Total Lectures: Theory- 30 Hrs)

Total Marks: 50

COU

1.
2.
3. Learn from the experiences of real-life entrepreneurs
4. Solve the problem of "newness" as you develop the marketing plan

COURSE LEARNING OUTCOMES:

1. Understand entrepreneurship and the challenges of creating a new business.
2. Describe the role innovation can play in developing a market strategy, and how marketing can guide the development of new products and services.
3. Discuss the processes of market identification and market creation in entrepreneurial situations.
4. Explain the importance of relationship marketing and social networks, and understand the role played by content marketing agencies.

UNIT 1: INTRODUCTION OF ENTREPRENEURSHIP AND ENTREPRENEUR **10 L**

Meaning and concept of entrepreneurship, entrepreneurial motivation - factors & theories, government's policy actions, institutional support, entrepreneurship development programmes, role of entrepreneurship in economic development,Why to become entrepreneur, the skills/ traits required to be an entrepreneur, Creative and Design Thinking, the entrepreneurial decision process, skill gap analysis, and role models, mentors and support system, entrepreneurial success stories.

UNIT 2: CONDUCTING MARKETING AUDITS **10 L**

Customer and market audits, discussion of the product audit, discussion of setting marketing objectives and strategies, discussion of advertising and sales promotion, discussion of the sales plan, discussion of the pricing plan, distribution (place) plan, marketing information, forecasting and organizing for marketing planning.

UNIT 3: INITIATING MARKETING PLANNING 10L

Market research and its importance: research objectives & methodology, qualitative data and quantitative data- primary & secondary data gathering- arrangement, and data analysis preparation of marketing research reports.

Demand forecasting and its perils: forecasting sales of innovative product/service, survey based forecasting & model-based forecasting. rural and international market demand forecasting. overcoming financial, operational and organizational hurdles.

REFERENCES:

1. Baker, M.J. (2000), Marketing Strategy and Management, 3rd Edition, Macmillan.
2. Best, R.J. (2005), Market-Based Management: Strategies for Growing Customer Value and Profitability, 4th ed International Edition, Pearson Prentice Hall.
3. Bjerke, B. and Hultman, C.M., (2002) Entrepreneurial Marketing, Edward Elgar Morgan.
4. Ramchandran, K. (1996). Strategies of technology intensive firms.
5. Khanka, S. S. (2009). Entrepreneurial Development", S Chand & Company Ltd. New Delhi.

ADDITIONAL RESOURCES:

1. H.L., A. Kallianpur, and L.M. Lodish, "Entrepreneurial Marketing", lessons from Wharton's pioneering MBA course. Marketing for Entrepreneurs, 2nd Edition Frederick
2. G. Crane 2013 Edition SAGE Publications, Inc.
3. Brassington, F., & Pettitt, S. (2003). Principles of marketing. Harlow, UK: FT Prentice Hall.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Product audit, Entrepreneur, Creative and design thinking, Advertising and sales promotion

11.5.3: POLYMER SCIENCE: INDUSTRIAL SAFETY AND EQUIPMENTS MAINTENANCE

(UPC:)

VAC – VAC Paper 3

Total Credits: 2 (Theory-2 Hrs/week)

(Total Lectures: Theory- 30 Hrs)

Total Marks: 50

COURSE OBJECTIVES:

1. Developing the skills to plan, organize for the safety and prevent accidents and hazards while working in chemical and processing laboratory/industry.
2. To develop the skill to operate various industrial equipment with safety measures, their maintenance and significance.

COURSE LEARNING OUTCOMES:

After completion of this course students will be able to:

1. Aware and about the risks and hazards
2. Select the relevant safety measures and procedure to follow.
3. Use different hazard assessment techniques in the chemical industry.
4. Minimize the accidents in the work environment.
5. Be acquainted with the use of plant layout for safety
6. Identify the causes for the given accidents.
7. Explain the safety audit act for a given industrial process.

UNIT 1: SAFE USE OF MACHINES AND TOOLS 10 L

Preventive maintenance, periodic checks for safe operation, Associate hazards and their prevention, Workplace Inspection, type of workplace inspection.

Planning: Definition, purpose, nature, scope and procedure- Range & variety of planning methods Strategic planning and tools of implementation. - Management by Objectives (MBO) and its role in Safety, Health- and Environmental (SHE) functions. - Organizational Health & Safety Policy – Understanding its concept- Formulation and implementation along with review of its prevalent statutory provisions

UNIT 2:INDUSTRIAL HAZARDS 10 L

Hazards Definition, Risk Management, Hazards Control System, Fault tree Analysis, Failure mode and effect Analysis, Physical and chemical properties of hazardous materials, Major industrial hazards. various hazards in the process industries, hazards of electricity,

Types and consequences of major industrial hazard, effects on human body, stages of combustion, hazards of combustion, stability and inflammability, petrochemicals and other hydrocarbons, tank fire –storage tank, trucks, service stations, high pressure pipelines.

UNIT 3:ACCIDENT PREVENTION TECHNIQUES **10L**

Industrial safety, concepts of safety, organization for safety, organization, definition, need & principles organizing for health and environment, activities, organization structure, function & responsibilities, direction for safety. sop for safety, safety measures for the process industry

Accident and incident investigation : philosophy, purpose, process and types of investigations, factors and the immediate and basic causes, corrective action, accident investigating agencies. accident reporting : report forms, writing reports, elements of report. accident and incident analysis : standard classification of factors, methods of data collation and tabulating data, record keeping, injury, dangerous occurrence, unsafe act, explosives and transportation safety.

REFERENCES:

1. Frank P Lees - Loss of prevention in Process Industries, Vol. 1 and 2, ButterworthHeinemann Ltd., London (1991).
2. Jain, R. K., & Rao, S. S. (2008). Industrial safety, health and environment management systems. Romesh Chander Khanna.
3. Deshmukh, L. M. (2005). Industrial safety management. Tata McGraw-Hill Education.
4. Greene, R. (1980). Safe and Efficient Plant Operation and Maintenance. McGraw-Hill Publications Co., vii+ 419, 28 x 21. 5 cm, illustrated.
5. Stellman, J. M. (Ed.). (1998). Encyclopaedia of occupational health and safety (Vol. 1). International Labour Organization.

ADDITIONAL RESOURCES:

1. Industrial Safety - National Safety Council of India.
2. Sinclair, C. G. (1981). Loss prevention in the process industries: By Frank P. Lees, Butterworth & Co., London, two volumes, 1316 pp.
3. Slote, L. (1987). Handbook of occupational safety and health.
4. McElroy, F. E. (Ed.). (1980). Accident Prevention Manual for Industrial Operations: Engineering and Technology (Vol. 1). National Safety Council.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Risks and hazard, Accident and incident investigation, Stability and inflammability, Hazards in the process industries

11.6: DISSERTATION

DISSERTATION

Total Credits: 6 (12 Hrs/week)

One semester in-house project

Total Marks: 150

COURSE OBJECTIVES:

1. To identify a polymer product that can be manufactured in India or a research problem and conduct experiments.
2. To prepare a feasibility report for a project based on manufacturing of product.
3. To present a seminar on the topic on powerpoint format.
4. To improve the communication skill of the students.

COURSE LEARNING OUTCOMES: Identify and investigate a research problem

1. Apply an appropriate research design and associated methods rigorously
2. Conduct the research project in an ethical fashion

DISSERTATION BASED ON RESEARCH

PRESENTATION & VIVA-VOCE

1. Students will be divided among faculty members of the Department for the supervision of the research work (it may be in collaboration with other institutes/industry). For example –if there are sixty students and eight faculty members, each member will be assigned 7 or 8 students for supervision.
2. In the first week of Semester VII and VIII each faculty member will assign a suitable research topic to the students from the area of polymer science.
3. The students will work on assigned research topics during semester VII and VIII in regular consultation with his/her assigned teacher.
4. The students will write a dissertation based on research work carried out during semester VII and VIII and prepare five copies of the same and submit to the office of the principal of the college duly signed by the students and the supervisor in the last week of VII and VIII semester.
5. The office of principal will take a note of the submission of the dissertation and return the copies each to the student and supervisor for examination. When the examination is over the teacher's copy of the dissertation will be sent to the college library for the record.
6. The student will make a powerpoint presentation based on research work carried out and mentioned in the dissertation to the board of examiners appointed by the university for evaluation of project work.