M Tech POLYMER SCIENCE and ENGINEERING

CURRICULUM STRUCTURE AND SYLLABI

(BASED ON OUTCOME BASED EDUCATION)

For

M Tech POLYMER SCIENCE and ENGINEERING

(Under the CSS Regulations 2021 of Mahatma Gandhi University w.e.f. 2022 Admission Onwards)

International Unit on Macromolecular Science and Engineering (IUMSE),

International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)

Mahatma Gandhi University Kottayam, Kerala

PREFACE

Polymer Science and Engineering is a demanding field of interest in the current scenario of frontier materials for today's civilization. This is because polymers are increasingly important in many different areas of modern life. The fundamental objective of this program is the provision of possibilities for students interested in acquiring advanced technological knowledge in the field of Polymer Science to satisfy society's requirements. The course will cover fundamental aspects of polymer science, such as characterization, characteristics, applications, processing technology, and more advanced polymeric materials, among other topics. Another highlight of this programme is that during the student's last two semesters, they are encouraged to undertake their project work in various national and international R&D organisations as part of the curriculum. So, it is pleased to present the curricula and syllabi of the M Tech Polymer Science and Engineering programme of the International and Inter University Centre for Nanoscience and Nanotechnology in accordance with the OBE concept (with effect from 2022 admission onwards) for favour of approval by the Faculty and Academic Council of the University.

Outcome Based Education (OBE) is an educational approach that bases each part of the educational system with respect to the goals set for the students. OBE aims to equip the students (learners) with knowledge, competency, and orientations required for achieving their goals when they depart the institution. Further OBE empowers students to choose what they would like to study and how they would like to study it. The teaching methodologies and the evaluation system are also modified in accordance with the outcome-based approach. The Programme Specific Outcomes (PSOs) and the Course Outcomes (COs) are presented in the beginning of the syllabus. The correlation of PSOs and the COs are shown in the syllabus for each course.

Mahatma Gandhi University

Vision

''Mahatma Gandhi University envisions to excel in the field of higher education and cater to the scholastic and developmental needs of the individual, through continuous creation of critical knowledge base for the society's sustained and inclusive growth."

Mission

- ♣ To conduct and support undergraduate, postgraduate and research-level programmes of quality in different disciplines
- ♣ To foster teaching, research and extension activities for the creation of new knowledge for the development of society
- ♣ To help in the creation and development of manpower that would provide intellectual leadership to the community
- ♣ To provide skilled manpower to the professional, industrial and service sectors in the country so as to meet global demands
- ♣ To help promote the cultural heritage of the nation and preserve the environmental sustainability and quality of life
- ♣ To cater to the holistic development of the region through academic leadership.

International and Inter University Centre for Nanoscience and Nanotechnology

The Centre for Nanoscience and Nanotechnology was established as a nodal research centre of Mahatma Gandhi University in the year 2009. The Centre focus on the enhancement of research and higher studies in the cutting-edge areas of nanoscience and nanotechnology. Considering the achievements in its academic and research pursuits in the past years since its inception, the state Govt. of Kerala has elevated the status of the Centre to International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN) in the year 2013. The Centre is motivated to thrust its research and development focusing on developing novel materials and devices prospering the outrage of nanoscience. The Centre also take up

the social, ethical, legal and environmental issues related to nanoscience and nanotechnology. Thus, IIUCNN intends to act as a prime point to provide training and research in various interdisciplinary areas.

Vision

To emerge as an international premier nano-research and learning Centre to cater the industrial needs of Nanoscience and Nanotechnology for societal development.

Mission

- Promote and coordinate interdisciplinary research programs in Nanoscience and Nanotechnology leading to the technological development and fabrication of nano-devices.
- To serve as a centre of educational excellence for students and researchers by offering academic programs to generate intellectual manpower in specialized areas for societal needs.
- To initiate and establish strong collaborations with industries and R&D sectors of the country and abroad by providing consultancy services and research projects in Nanoscience & Nanotechnology.
- To pave more attention in studies focused on Social, Ethical, Legal and Environmental (SELE) issues related to Nanoscience & Nanotechnology.

REGULATIONS, SCHEME & SYLLABUS OF M. TECH. PROGRAMME IN POLYMER SCIENCE and ENGINEERING

DEFINITIONS

Programme refers to the previous concept of degree carried out in a time-bound academic period.

Course means the curricular content for teaching and learning or seminar in a specific area or theme of knowledge.

Core Course means a compulsory course in a subject related to a particular programme.

Elective course means an optional course which can be selected from among a group of electives provided in the Programme.

Semester system the M.Tech. Programme will have four semesters. There shall be a minimum of 540 hours distributed over 90 working days in each semester spread over l8 five day working weeks.

Credit (c) is the unit by which a course is measured. It is the measure of total numbers of hours of training received in a course during a semester.

Grade means a letter symbol (e.g. A, B, C. etc) which indicates the broad level of performance of a student in an answer/course/semester/programme.

Weight is a numerical measure quantifying the comparative range of an answer or the comparative importance assigned to different components like theory (internal and internal examinations) Internship, Dissertation etc.

Grade point (G) is the weightage allotted to Grade letter

Credit point (C) refers to the product of number of credits of a course and grade point obtained by a student for a given course

Semester Grade Point Average (SGPA) refers to the performance of the student in a given semester. SGPA is a weighted average based on the total credit points earned by a student in all the courses in the semester divided by the total number of credits offered in a semester. SGPA will be computed as and when a student completes all the

required courses of a semester with a minimum required grade as per the respective curriculum.

Cumulative Grade Point Average (CGPA) refers to the performance of the student for all semesters of the programme. CGPA is a weighted average based on the SGPA earned by a student in all semesters of the programme and the total number of credits required in the programme. CGPA is calculated on the basis of SGPA with the minimum required SGPAs of all semesters may not be sufficient to obtain the minimum fixed CGPA for pass in the programme.

Grade Point Average (GPA) is the value obtained by dividing the sum of the weighted grade points obtained by a student in an examination of a course in a semester by the total weightage taken in that examination. The grade point average shall be rounded off to two decimal places.

CONDITIONS FOR ADMISSION

Eligibility for Admission

The basic requirement for admission to M. Tech. Program will be

i) M. Sc in Nanoscience and Nanotechnology, Physics, Chemistry, Materials Science, Polymer science or an equivalent degree with not less than 50% Marks or

ii) B. Tech in Polymer Engineering/Technology or Nanoscience and Nanotechnology or Chemical Engineering/Technology or Electronics and Communication or Biotechnology or Material Science or Mechanical, an equivalent degree with not less than 50% marks.

iii) Subject to the regulation relating to prescribed minimum of the respective qualifying examination, the minimum marks for the admission to the course of studies shall be a pass in the case of SC/ST candidates.

iv) Candidates belonging to Socially and Educationally backward classes (SEBC) referred to GO(P)208/66 Edn dated 2-5-96 and subsequent amendments to the order issued by the Government shall be given a relaxation of 3% marks in the prescribed minimum for the admission A relaxation of 10% marks from the prescribed minimum shall be allowed in the case of physically handicapped persons.

v) Candidates who have passed the qualifying examination in more than one chance in the subject (excluding languages) will have their percentage marks de-rated at the rate of 5% for every additional appearance for the purpose of ranking.

MODE OF SELECTION

Admission shall be normally restricted to those with valid GATE score on merit basis. In case, seats remain vacant due to lack of candidates with valid GATE score, candidates will be considered on the basis of an entrance test (Candidates have to appear for the Common Admission Test (CAT) conducted by the Mahatma Gandhi University in April/ May of every year. The questions will be objective multiple-choice type. Any other conditions prescribed by Mahatma Gandhi University from time to time in this regard will be applicable.).

The proposed intake for each program is as follows.

M. Tech. in Polymer Science and Engineering:

Regular Students (Indian Citizens)	**10**
Other Nationalities	**02**

If suitable number of applicants under other Nationalities is not received, these seats will remain unfilled.

Reservation of Seats As per existing Government orders from time to time.

DURATION OF THE COURSE

The course shall extend over a period of two academic years consisting of four semesters.

COURSES AND CREDITS

Three kinds of courses are offered – Core Courses, Elective Courses and Laboratory courses. Core Courses and Laboratory courses are offered by the Centre conducting the programme. Elective Courses can be selected either from the parent Centre or from some other Schools. The Faculty Advisor in each School shall help the students in selecting Electives that are relevant to the programme for which they are admitted. Each course is allotted credits varying from 2 to 4 depending on the hours of instruction/practical. (A 4-credit course, in general, is one which normally involves four hours per week of class room teaching or lecture/seminar/practical lessons).

CREDIT REQUIREMENTS

The minimum total credits required for the successful completion of M.Tech. programme shall be

80. In the first Semester, a student has to secure minimum of **22 credits** [12 Credits (Core) + 4 Credits (Practical) + 6 Credits (Elective)]. In the Second Semester a **student** has to secure minimum of **22 credits** [12 Credits (Core) + 2 Credits (Practical) + 6 Credits (Elective) + 2 Credits (Minor project & Viva)].

In **Semester III and IV** of this programme, the student has to acquire **36 credits** exclusively dedicated for the project dissertation; viva and thesis defense and Comprehensive Viva voce upon successful completion of 2 semesters. Also there is Internal evaluation of project in the end of semester III.

A student can with the permission of his/her Department/School and with the consent of the faculty concerned, audit a course in any other School/ Department. The student, however, cannot earn any credit from the audited courses.

The Compulsory project/dissertation shall be prepared by the student under the guidance of a member of the faculty or, in the case of subjects, which so demand, with an guide, to be decided by the school's faculty council, The project shall generally be offered in the last semester, though the faculty council can decide to have it in one of the earlier semesters. The topic for the project shall be selected by the student in consultation with the guide. The topic thus chosen will have to be approved by the school's faculty council before the student can start work on it. In the case of projects done out of the school one of the examiners shall be experts.

FACULTY COUNCIL

The Faculty Council shall consist of all the regular and permanent teachers of the Department / Centre. The Head of the Department shall be the Chairman of the Faculty Council. He/She shall preside over the meetings. The Faculty Council shall have a secretary, elected from among the teachers of the Department. The teachers shall as a matter of duty attend the meetings of the Council. The Council shall meet at least once in every month.

FACULTY ADVISOR

Each student admitted to a course will be affiliated to a Faculty Advisor, who shall advise the student on the elective and other courses in the parent Department as well as in other Departments that he/she might choose.

COURSE TEACHING

Courses shall generally be taught by the faculty who designed the course, though it is possible for the Faculty Council to assign the teaching of a course to more than one faculty.

INTERNAL ASSESSMENT

The student's attendance and classroom performance as well as the feedback received from tests, tutorials, assignments and term papers shall form basis for internal assessment. The internal assessment will account for 40% of evaluation. The internal assessment marks shall be distributed as follows and as per regulation CSS regulations 2020.

a) Theory

a) Components % of internal marks

1)	Two test papers	60%
2)	Assignments/Book Review/Debates	20%
3)	Seminars/Presentation of case study	20%

b) Practical

Components % of internal marks

1)	Two test papers	40%
2)	Lab Skill	25%
3)	Records/viva	25%
4)	Attendance	10%

Evaluation

All work pertaining to the Examinations shall be held in the Schools/ Departments of study and research under the direct control and supervision of the Directors/ Heads of

the Departments. There shall be continuous internal assessment as well as end semester examinations for all the courses. Evaluation of the courses shall be conducted by the respective faculty members of International and Inter University Centre for Nanoscience and Nanotechnology. Indirect Grading is employed for the evaluation of courses. The performance of a student in each course is evaluated in terms of percentage of marks converted to grade points.

Test Papers:

For each course there shall be at least three class tests during a semester. Average of the marks obtained in the best two tests will be counted as the internal test component of CAs. Valued answer scripts shall be made available to the students for perusal within 10 working days from the date of the tests.

Assignments:

Each student shall be required to do 2 assignments for each course. Assignments after valuation must be returned to the students. The teacher shall define the expected quality of the above in terms of structure, content, presentation and the like, and inform the same to the students. Punctuality in submission of assignments/records is to be given a weightage in the internal evaluation.

Seminar:

Every student shall deliver one seminar as an internal component of every course and must be evaluated by the respective course teacher in terms of structure, content, presentation and interaction. The soft and hard copies of the seminar report are to be submitted to the teacher in charge.

Results of Continuous Assessment:

The results of the CA counter-signed by Head of the school/Centre shall be displayed on the notice board 5 days before the end semester examinations. The marks awarded for various components of the CA shall not be rounded off, if it has a decimal part. The total marks of the CA shall be rounded off to the nearest whole number. Relevant records of CA must be kept in the department and that must be made available for verification.

IMPROVEMENT COURSE

Viva-voce:

The viva-voce at the end of the programme, shall be conducted by a Board of Examiners constituted by the School's Faculty Council from among themselves. The

Board will in addition have an Internal Expert from outside the University to be appointed by the Department/School on the advice of the Faculty Council from a panel approved by the Vice Chancellor. The grading by the Board shall be by consensus.

A relaxation time of three months can only be given to those candidates with unexceptional delay in joining back after their overseas research programme. Students with extended delay after the relaxation time, he/she has to re-register for the entire semesters described in the program for completion of the course.

SCRUTINY AND REVALUATION

The answer scripts of examinations under CSS shall have provisions for scrutiny and revaluation. The application for scrutiny and revaluation of answer scripts shall be submitted to the Director of the concerned School within 15 days and 21 days respectively from the date of publication of the results.

READMISSION: Readmission will be permitted as per the existing University rules and orders.

GRADING SYSTEM:

The grading system followed is that of relative grading on a ten-point scale. The following table indicates the performance range and the value of the grades (grade points) on the scale.

Letter grade	**Performance**	**Grade point**
O	Outstanding	10
A plus	Excellent	9
A only	Very Good	8
B plus	Good	7
B only	Above average	6
C	Average	5
P	Pass	4
F	Fail	0
Ab	Absent	

The Grade Card given to the student at the end of each semester will indicate the grades he/she has obtained as well as the Semester Grade Point Average (SGPA) which is the weighted average of the numerical value (grade point) obtained by him / her in the semester. Weighted average is calculated by dividing the sum of the product of the grade point or numerical value obtained for each course and the credits that it

carriers by the total number of credits earned. The Cumulative Grade Point Average (CGPA) for the whole programme will be calculated in the same way, which will also be indicted in the Grade Card. The minimum graduating CGPA for all programme shall be 5.0

PERCENTAGE EQUIVALENCE OF GRADE

Wherever an examination awards marks, either in the assessment or in the end semester examination, percentage of marks awarded will be converted into grades according to the following formula:

Range of % of Marks	Grade
95 -100	O
85-<95	A Plus
75-<85	A only
65-<75	B Plus
55-<65	B only
45-<55	C only
40-<45	P only
Below 40	F
Absent	Ab

CONSOLIDATION AND DECLARATION OF RESULTS AND ISSUE OF GRADE CARDS

All work pertaining to the Examinations shall be held in the Schools/ Departments of study and research under the direct control and supervision of the Directors/ Heads of the Departments. The Director of each School will, in consultation with the Faculty Council, nominate a senior teacher as the Chief Examiner who will help him/her in the matter. The marks awarded for internal assessment will be displayed in the Centre's notice board at the end of each semester. The Pass Board will consist entirely of the faculty of the Centre and will be constituted by the director on the advice of the Faculty Council. The tabulated Grade sheets will be forwarded after each end – semester examination to the office of the Controller of the Examinations. The CSS section in the Controller's office will check the Grade Card for any errors and notify the results after consolidating them.

On completion of the final semester a consolidated Grade Card showing the details of all the courses taken during the programme will be issued to the students. The consolidated Grade Card will contain the details of all the courses with their titles, credits, grades obtained, the total credits earned, the SGPA and the CGPA.

REQUIREMENTS OF ATTENDANCE AND PROGRESS

A candidate will be deemed to have completed the requirements of study of any semester and permitted to appear each University end semester examinations (ESE) only if,

a) The candidate has not less than 75% of attendance in each of the subjects of the total number of working days of the concerned semester.
b) His/her progress has been good
c) His/her character and conduct has been good
d) She/he has minimum of 50 % of sessional marks for each subject.

A student who has an attendance and sessional marks lower than 75% and 50% respectively will not be permitted to appear for the ESE and he/she has to redo the semester at the next available opportunity. However, a candidate can repeat the course or avail condonation of attendance for temporary break of study, only once during entire programme as per existing University rules

PROCEDURE FOR COMPLETING COURSE

The academic year will be divided into four semesters, the odd semester normally commencing at the beginning of the academic year and even semester ending with the academic year.

A candidate can proceed to the course of study of any semester (other than first semester) if and only if he has completed the course in the previous semester and has registered for the examination of the previous semester.

A candidate who is required to repeat the course of any semester for want of attendance/progress or who desires to rejoin the semester after a period of discontinuance or who upon his own request is specially permitted to repeat the semester in order to improve his performance, may join the semester for which he is eligible or permitted to join.

On discontinuation of the course, the student should refund the entire stipend he/she received from the Centre within one year. The transfer certificate and other certificates will be issued only after refunding the stipend.

FACULTY

Upon successful completion of two years in the programme the candidates will be awarded a Master's Degree under the faculty of Engineering and Technology.

SCHOLASTIC PROBATION AND REPEATING OF COURSE AND EXAMINATIONS

As per the provisions laid down in CSS Regulations.

REVISION OF REGULATIONS

The University may from time to time revise, amend or change the regulations, curriculum, scheme of examinations and syllabi. These changes unless specified otherwise will have effect from the beginning of the semester following the notification by the University.

CSS Regulations

Notwithstanding anything contained in this regulation, CSS Regulation 2020 will be binding and final.

Programme Outcomes (PO) of M. Tech. Programme

PO 1: Critical Thinking and Analytical Reasoning Capability to analyse, evaluate and interpret evidence, arguments, claims, beliefs on the basis of empirical evidence; reflect relevant implications to the reality; formulate logical arguments; critically evaluate practices, policies and theories to develop knowledge and understanding; able to envisage the reflective thought to the implication on the society.

PO 2: Scientific Reasoning and Problem-Solving Ability to analyse, discuss, interpret and draw conclusions from quantitative/qualitative data and experimental evidences; and critically evaluate ideas, evidence and experiences from an unprejudiced and reasoned perspective; capacity to extrapolate from what one has learned and apply their competencies to solve problems and contextualise into research and apply one's learning to real life situations.

PO 3: Multidisciplinary/Interdisciplinary/Transdisciplinary Approach Acquire interdisciplinary/ multidisciplinary/transdisc*i*plinary knowledge base as a consequence of the learning they engage with their programme of study; develop a collaborative- multidisciplinary/ interdisciplinary/transdisciplinary-approach for formulate constructive arguments and rational analysis for achieving common goals and objectives.

PO 4: Communication Skills Ability to reflect and express thoughts and ideas effectively in verbal and nonverbal way; Communicate with others using appropriate channel; confidently share one's views and express herself/himself; demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner and articulate in a specific context of communication.

PO 5: Leadership Skills Ability to work effectively and lead respectfully with diverse teams; setting direction, formulating a goal, building a team who can help achieve the goal, motivating and inspiring team members to engage with that goal, and using management skills to guide people to the right destination, in a smooth and efficient way.

PO 6: Social Consciousness and Responsibility Ability to contemplate of the impact of research findings on conventional practices, and a clear understanding of responsibility towards societal needs and reaching the targets for attaining inclusive and sustainable development.

PO 7: Equity, Inclusiveness and Sustainability Appreciate equity, inclusiveness and sustainability and diversity; acquire ethical and moral reasoning and values of unity, secularism and national integration to enable to act as dignified citizens; able to understand and appreciate diversity, managing diversity and use of an inclusive approach to the extent possible.

PO 8: Moral and Ethical Reasoning Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work and living as a dignified person in the society.

PO 9: Networking and Collaboration Acquire skills to be able to collaborate and network with scholars in an educational institution, professional organizations, research organizations and individuals in India and abroad.

PO 10: Lifelong Learning Ability to acquire knowledge and skills, including "learning how to learn", that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling.

Total credits	: 80 (for 4 semesters) [Core: 68; Elective: 12;]

*The student has to choose two elective courses for semester I, two elective courses for semester II.

**Open courses- this course can be designed for master's students who belongs to other departments

*** In the evaluation process internal - Continuous Assessment (CA) - accounts for 40% and the End- Semester Examination will account for the remaining 60%.

Program Specific Outcomes:(PSOs): At the completion of the M.Tech. Polymer Science and Engineering program, the students will be able to:

PSO	Programme Specific Outcome	MGU PO No.
1	Provide a strong foundation in Polymer Chemistry that emphasizes scientific reasoning and analytical problem solving.	1,3
2	Provide students with the skills required to succeed in MTech., also enrich the students with a basic skill to perform in Chemical industry especially in the field of Advanced Polymeric Materials.	1,2,6
3	Promote research interest in students and enable them towards planning and execution of research in frontier areas of Polymer Industry.	3,8
4	Expose the students to a level of experimental techniques using modern instrumentation.	1,2
5	Demonstrate teamwork, communication, Time management and leadership skills across multicultural contexts.	4,5,7,9
6	Acquire the ability to synthesize and characterize compounds using sophisticated instrumental techniques and related soft-wares, for the in-depth characterization of Polymer materials	1,2
7	Develop solid knowledge, understanding and expertise in the domain of Advanced Polymeric Science.	1,2,10
8	Inspire the students to be committed to deliver good to the society by judicious application of scientific skill sets they acquire doing polymer research.	3,7,8,9
9	Nurture the quality of rationality and inquisitiveness, so that the students are capable of free and critical thinking to steer clear judgmental and social biases.	2,4,5,9

Scheme and Syllabi

Programme: M.Tech. POLYMER SCIENCE and ENGINEERING

First Semester

SEMESTER I (22 credits)						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
CORE COURSES						16
INM22C01	Polymers Synthesis and their Structure Property Relationships	2	2	-	3	
INM22C02	Physical properties of Polymers	2	2	-	3	
INM22C03	Polymer Material Characterization Techniques	2	2	-	3	
INM22C04	Polymer Compounding and Processing	2	2	-	3	
INM22C05	Laboratory I- Synthesis and Characterization of Advanced Polymeric materials.			5	2	
INM22C06	Laboratory II- Fabrication of Polymer Blends, Composites and Nanocomposites			5	2	
***ELECTIVE COURSES (Choose any two)**						6
INM22E01	Adhesives and Adhesion	2	2	-	3	
INM22E02	Research Methodology	2	2	-	3	
INM22E03	Advanced carbon-based nanomaterials	2	2	-	3	

SEMESTER II (22 credits)						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
CORE COURSES						16
INM22C07	Polymer Blends, IPNs, Polymer Electrolytes and Gels	2	2	-	3	
INM22C08	Polymer Composites and Nanocomposites	2	2	-	3	
INM22C09	Polymer Product Design and Product Engineering	2	2	-	3	
INM22C10	Theory, Modelling and Simulation of Advanced Polymeric Materials	2	2	-	3	
INM22C11	Laboratory III- Characterization of Polymer Blends, Composites and Nanocomposites			5	2	
INM22C12	Minor Project & Viva Voce				2	
*ELECTIVE COURSES (Choose any two)						6
INM22E04	Elastomer Technology and Advanced Products	2	2	-	3	
INM22E05	Advanced Biopolymer Systems	2	2	-	3	
INM22E06	Statistical Mechanics	2	2	-	3	
INM22E07	Industrial Internship	2	2	-	3	

Third & Fourth Semesters

SEMESTER III & IV (36 credits)						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
INM22C13	Main Project Work and thesis defence & Comprehensive Viva Voce				36	36

****Open Courses offered by International and Inter University Centre for Nanoscience and Nanotechnology (SEMESTER III)**						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**Total credits**
		L	T	P		
INM23O01	Waste Management	4	-	-	**4**	**4**

	MAHATMA GANDHI UNIVERSITY
	INM22C01 - Polymer Synthesis and their structure property relationships
School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech Polymer Science and Engineering**
Course Name	**Polymer Synthesis and their structure property relationships**
Type of Course	**Core**
Credit Value	**3**
Course Code	**INM22C01**

Course Summary & Justification	This course will introduce and discusses the basic principles of polymer chemistry. Specifically, it well stress upon the fundamentals of important polymerization reactions and the principles that governs the structure of the resulting polymers. Synthesis and structural property relation of several industrial important polymers will be discussed illustrating the applications of these principles.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic, Collaborative learning	40	40	-	40	120
Pre-requisite	Basic understandings of bonding in metals, Crystalline, amorphous materials, Chemistry of material synthesis					

COURSE OUTCOMES (CO)

CO No.	**Expected Course Outcome** **Upon completion of this course, students will be able to;**	**Learning Domains**	**PSO No.**

1	Various polymeric structures, factors of crystallization and distinction between amorphous and crystalline materials (Module 1)	U	1,2
2	Different physical properties of polymers and advanced polymeric structures (Module 1)	U, A	3
3	Synthesis methods of advanced polymeric structures and their applications on different field (Module 2)	A, An, S,I	2,4
4	Engineering biodegradable polymers and co polymers which found applications in medicine as well (Module 2 &3)	A, An, E,S	5, 6
5	Types of polymerization techniques (Module 3)	U	2,3,6
6	Distinction between various thermoplastic polymers, their structure difference, synthesis routes and applications (Module 4)	U,A,E, S,I	2,7
7	Elastomer, Fibre synthesis methods and their applications (Module 4)	U,A	1,3,4,5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**History and fundamentals of polymers** Classification of polymers, polymer structures (glassy and amorphous structure, theories of glass transition, physical ageing, viscoelastic behaviour, factors affecting the glass transition temperature, crystallization, factors affecting crystallization and melting point, thermal characterization of polymers), properties of polymers (thermal, mechanical, chemical electrical and optical properties, evolution of polymers to advanced polymeric materials. Photoconducting, piezoelectric, electrostrictive, magnetostrictive, electrochromic, electroluminescent, electro-optic, magneto-optic, photochromic, thermochromic, mechanochromic, electro-rheological fluids, magneto-rheological fluids, shape memory, negative Poisson's ratio, pH responsive, thermo-responsive, chemical responsive, reversible hydrogels, self-oscillating gels, Biopolymers/Biodegradable polymers/Biomedical applications, Polymeric gels, Inorganic & organometallic polymers, Engineering plastics.	**20**	**1,2**

2	**Polymer chemistry and kinetics** Introduction, molecular weight and degree of polymerization, polydispersity, size of polymer molecule, determination of molecular weights by various techniques, types of polymerization, chain and step growth polymerizations (types in detail), polymerization techniques and kinetics of polymerization, chemistry and kinetics of co-polymerization, polymer reaction chemistry, new trends in the synthesis of advanced polymers.	**15**	**3,4**
3	**Polymerization techniques and Mechanisms** Addition and condensation polymerization, Living Radical chain polymerization, Atom transfer radical polymerization, Living cationic polymerization, living anionic polymerization, Group transfer polymerization, co-ordination polymerization, Ring opening metathesis polymerization, Zeigler-Nata polymerization, Co-polymerization, Control radical polymerization, plasma polymerization, metathesis polymerization, Group transfer polymerization.	**15**	**3,4,5**
4	**Polymer synthesis and its structure property relationships** **Plastic Synthesis**: characterization, properties and applications of thermoplastics polymers.(LDPE, LLDPE,HDPE, cross-linked PE, chlorinated poly ethylene, polypropylene, poly vinyl chloride (PVC), poly vinylidene chloride, Poly vinyl alcohol, poly vinyl acetate, chlorinated PVC, plastisols, poly vinyl pyrrolidiene, Polystyrene, HIPS, EPS. Acrylic Polymers, poly methyl methacrylate. polybutylene terephthalate - polyacetals and copolymers – polycarbonates. Fluoro polymers - Polytetrafluoroethylene, Polychlorofluoroethylene, thermoplastic polyurethanes, poly ξ–caprolactone and copolymers, high performance thermoplastics, Poly sulphone, polyether sulphone, polyimides, PEEK, Poly amides and polyimides, thermosetting polymers (phenolic resins, Amino plastics, polyesters, Epoxide resins, Polyurethanes, Silicon based polymers and heat resistant polymers, and Elastomers. **Elastomers Synthesis:** Monomers – Preparation and properties of the monomers-styrene, butadiene, isoprene, Isobutylene, ethylene, propylene-structure of Diene monomers-Detailed study of SBR,PBD ,IR,EPDM,& IIR-Monomers – Preparation and properties of the monomers-Acrylonitrile , chloroprene ,-SBR, NBR, Butadiene hydroxy terminated SBR, NBR, Butadiene. – Thermo Plastic Eleastomers-Thermo plastic elastomers, definition, Advantages, modification of elastomers to thermoplastic elastomers. Study of thermoplastic SBR, Ethylene Vinyl acetate, **Fiber Synthesis**: Polymerization of nylon-6, nylon-66, poly (ethylene terephthalate), polyacrylonitrile and polypropylene; Melt Spinning processes, characteristic features of PET, polyamide and	**20**	**6,7**

	polypropylene spinning; wet and dry spinning of viscose and acrylic fibres; post spinning operations such as drawing, heat setting, tow-to-top conversion and different texturing methods.		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** Surprise test Internal Test – Objective and descriptive answer type Submitting assignments Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

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	MAHATMA GANDHI UNIVERSITY **INM22C02: Physical properties of Polymers**

School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE), International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech. Polymer Science and Engineering**
Course Name	**Physical properties of Polymers**
Type of Course	**Core**
Credit Value	**3**
Course Code	**INM22C02**

Course Summary & Justification	This course is aimed at equipping students with a basic level of knowledge of the terminology and mathematics involved in the physical understanding of polymers. Most of the topics deal with post 1970 concepts involving the statics and dynamics of polymeric materials. The course is intended for masters students who would like to gain an understanding of modern approaches to polymer physics. The course will closely follow the books of PJ. Flory (Nobel laureate). Flory's intent is similar to that of this course, "...to present a framework to masters students in a concise and self-contained manner..." The overall objective is to develop a clear understanding of the principles of polymer physics and to learn to solve polymer physics problems. Physical properties are described and analyzed via structure-property relations.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40	-	40	120
Pre-requisite	A knowledge of graduate-level statistical mechanics.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Account for different descriptions of size and shape of a polymer, and being able to predict phase properties and aggregate structure from the chemical properties and structure of the monomers, using the Flory-Huggins theory.	R, U, A, E	1, 2,3,7
2	Account for the molecular theory of rubber elasticity and apply this on relevant problems	U, A, A, E, S	2, 6, 7, 8
3	Account for the origin of deformation and fracture of polymeric materials from a molecular basis	U, E	2, 7,9
4	Suggest and motivate choice of polymeric materials in different products and practical applications, especially regarding rheology and strength	S, I. Ap	2,3,4,5, 9
5	Independently being able to plan experiments and use advanced apparatus for characterising viscous and viscoelastic materials.	An, S, I, C	4,5,7,9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Configuration and confirmation of macromolecules** Pseudo chirality, stereoregular polymers, tacticity, monotactic and ditactic polymers, geometrical isomerism, experimental methods for the determination of configuration, Conformation of single polymer molecule, free rotation, rotation about single bonds, average chain dimensions, freely jointed chains, random flight model, derivation of end-to-end distance, real polymer chains, bond angle restrictions, steric restrictions, conformation in crystals, micro conformation in solution, ideal coil molecules in solution, compact molecules, optically active polyolefins, polyaminoacids, proteins, conformational transitions.	**15 hrs.**	**1,3**
2	**Thermodynamics of polymer solution** Lattice theory and its advantages and limitations. Flory-Huggins and Flory-Kingbaum theories and their advantages and limitations. Flory temperature, polymer-solvent interaction parameter, the unperturbed polymer chain, expansibility factor,	**15 Hrs.**	**1,3**

	entropy, enthalpy and free energy of mixing of polymer solution, phase separation in polymer systems, De Gennes and Edwards tube models, self-avoiding random walk, scaling concepts in polymer systems, pearl model.		
3	**Crystallization in polymers** Amorphous State-Transition temperatures-Glass transition temperature Theory-Factors influencing glass transition Temperature-Crystalline State-polymorphism-Polymer single crystals, lamellae, spherulites-Crystallinity-factors affecting crystallinity-X-ray diffraction. Thermodynamics of crystallization and melting, Crystallization during polymerization, crystallization induced by orientation, crystallization under quiescent condition. The fringed micelle model, Lamellar models, random re-entry and switchboard folded model, Gibbs-Thomson equation, Lauritzen-Hoffman secondary nucleation theory, Primary nucleation, spherulite, Bulk crystallization kinetics-avrami analysis. Determination of polymer crystallization.	**10 Hrs.**	**1,2,3**
4	**Visco-elastic properties of Polymers** Behavior of elastic solids, viscous fluids and viscoelastic materials under dynamic loading, dynamic mechanical analysis (DMA), storage modulus, loss modulus, tan δ, damping, creep and stress relaxation: Maxwell's Model, Voigt Model and Standard Linear Solid Model; Boltzmann's superposition theorem; Temperature dependence of Viscosity; Intrinsic viscosity of polymer solutions; Viscosity molecular weight relationships for polymers, Viscosity-temperature relationship for polymers, Viscosity-pressure relationship for polymers. Rubber elasticity, molecular requirements of rubber-like elasticity, Gough-Joule effect, Thermoelastic experiment, difference in the elasticity of metals and rubbers, energy driven elasticity, entropy driven elasticity, thermodynamics of rubber elasticity.	**15 Hrs.**	**1,4,5**

5	**Polymer Rheology and Rheometry** Basics of polymer rheological response, processing behaviour of polymers based on their rheology. Polymer solutions and thermodynamics, Classification of Flow: Steady shear flow, unsteady shear flow, Extensional flow, Newtonian flow, non-Newtonian flow (examples), Viscoelastic behaviour of polymers, creep and stress relaxation in polymers**.** **Rheometers:** Viscometers, cone and plate viscometer, parallel disc viscometer, capillary rheometer, constant capillary rheometers, constant plunger speed circular orifice capillary rheometer, constant plunger speed slit orifice capillary rheometer, constant speed screw extrusion type capillary rheometers, constant pressure circular orifice capillary rheometer (melt flow indexer); extensional viscometers: filament stretching method, extrusion method.	**15 Hrs.**	**2,4,5**
6	**Transport properties of polymers** Mechanisms for diffusion. General trends of diffusivity and solubility. Diffusion in elastomers, diffusion in plastics, semicrystalline and amorphous polymers and thermosets. Concentration-dependent diffusion and swelling, measuring methods, membranes and barrier properties. Diffusion coefficient, penetration through polymers, factors affecting permeability of polymers, polymer diffusion models, Kinetics of fluid flow and deformation, stress in fluids and solids, Momentum transport, Mass transport, Energy Transport (heat, mass transfer with and without phase change).	**10 hrs.**	**2,3,4,5**
Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student		
Assessment Types	**Mode of Assessment** **C. Continuous Internal Assessment (CIA)** - Surprise test - Internal Test – Objective and descriptive answer type - Submitting assignments - Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **D. Semester End examination**		

REFERENCES

1. P. J. Flory, Principles of Polymer Chemistry Cornell University, Ithaca, 1953.
2. P. J. Flory, Statistical Mechanics of Chain Molecules, Interscience, New York, 1969.
3. H. Tompa, Polymer Solutions (Butterworths, London, 1956.
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5. M. Doi, Introduction to Polymer Physics, Clarendon Press 1996.
6. H. Yamakawa, *Modern Theory of Polymer Solutions*, Harper, New York, 1971.
7. Young, R. J., and P. A. Lovell. *Introduction to Polymers*. 2nd ed. Boca Raton, FL: CRC Press, 2000
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9. R.G Larson, "The Structure and Rheology of Complex Fluids", Oxford.1998.
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11. T.S Montgomery, "Introduction to Polymer Rheology", John Wiley and Sons. 2011.
12. J. M Piau. and J.F Agassant, "Rheology of Polymer melt processing", Elsevier. 1996
13. A. V. Shenoy, "Rheology of Filled Polymer Systems" Kluwer Academic Publishers 1999
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	MAHATMA GANDHI UNIVERSITY **INM22C03: Polymer Material Characterization Techniques**
School/Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M. Tech. Polymer Science and Engineering**
Course Name	**Polymer Material Characterization Techniques**
Type of Course	**Core**
Credit Value	**3**
Course Code	**INM22C03**

Course Summary & Justification	This course provides a basic level of knowledge and understanding of the various polymer material characterization techniques. Most of the topics deal with fundamental principles, instrumentation, and application of these techniques. The course is intended for masters' students who would like to gain an understanding of modern approaches to polymeric materials. The course will closely follow current trends in material characterization. The overall objective is to develop a clear understanding of the principles of polymer characterization techniques and analysing mechanism. Different techniques are described in detail to analyse various properties of polymeric materials.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40	-	40	120
Pre-requisite	A basic knowledge of various properties of polymers and analysing techniques.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Account for analysing different polymeric properties, and being able to predict the behaviour and performance of different polymeric materials.	R, U, A, An, E	1,2,3,4, 6
2	Account for the better understanding of the instrumentation.	U, A, An, E, S	2,6,7,8
3	Account for the understanding structure property relation in accordance with the application.	An, U, E	2,7,9
4	Suggest and motivate choice of polymeric materials for different products and practical applications based on their analysis report.	A, E, S, I,	2,3,4,5, 9
5	Independently being able to plan experiments and use advanced instruments and characterization techniques to evaluate their applicability.	A, An, E,S, I, Ap	4,5,7,9
Remember I, Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Spectroscopic methods** UV-visible spectroscopy- Beer's law, Instrumentation, Quantitative analysis; Vibrational spectroscopy: Raman and Infrared, Principles of vibrational spectroscopy, Infrared and Raman activity, Fourier transform infrared spectroscopy, Raman spectroscopy, instrumentation, Applications, Micro Raman, Photoluminescence Spectroscopy, Electrochemical Impedance Spectroscopy, Polarized neutron Reflectivity **Electron spectroscopies** X-ray photoelectron spectroscopy (XPS), Ultra-violet photoelectron spectroscopy (UPS), Auger electron spectroscopy (AES), Atomic model and electron configuration, Principles of XPS and AES, Chemical shift, Depth profiling, Instrumentation, Applications **Scattering techniques for polymers** X-ray diffraction (XRD), small-angle X-ray scattering, wide-angle Xray scattering, synchrotron, dynamic light scattering, neutron scattering, electron scattering,	**15 hrs.**	**1,3,5**

2	**Optical Microscopy** Image formation, Resolution, Aberrations, Imaging modes, Specimen preparation, Confocal microscopy. **Electron microscopy:** Scanning electron microscopy (SEM), Field Emission Scanning Electron Microscopy, Instrumentation, Electron beam-specimen interaction, Specimen preparation, Energy dispersive spectroscopy (EDS) in electron microscopes; Transmission electron microscopy (TEM) – Basics of TEM, Electron sources, Preparation of samples for electron microscopic studies, Image modes, Image contrast. **Scanning Probe Microscopies:** Scanning Tunnelling microscope (STM) and Atomic force microscope (AFM) – Working principles, working modes, Image artifacts	**15 Hrs.**	**1,2,4,5**
3	**Thermal analysis** Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Dynamic mechanical analysis (DMA), Thermomechanical analysis (TMA) and Dynamic mechanical thermal analysis (DMTA), Basic theory, Instrumentation and applications Pyrolysis techniques, polymer degradation. Dynamic viscoelasticity measurements for characterization of different relaxations. Molecular motions responsible for different relaxations. WLF equation and predicting transition temperature.	**10 Hrs.**	**1,2,4,5**

4	**Mechanical Characterizations** Determination of Short term stress-strain properties such as Tensile strength, elongation at break, tensile modulus, compression, flexural etc. Different types of Impact tests: Determination of impact tests for different polymeric materials. Study of creep, relaxation, set and fatigue. Vibrating sample Magnetometer, Vector network Analyzer, vibrating Sample Magnetometer, Brunauer-Emmett Teller surface areas, Zeta sizer, **Solid state properties** – Thermo-mechanical properties, DMA creep, ultimate properties, thermal relaxations. Optical, electrical and mechanical properties. Surface properties, contact angle measurements. **Statistical properties of polymer chain**, conformation of polymers, the ideal chain, fundamental properties of Guassian chain, coil-helix transition, hydration of polymer chain. Classical theory of gelation, thermodynamics of rubber elasticity, structure of polymer networks. **Non-destructive testing:** Radiography, Ultrasonic, Acoustic emission, Thermography, Holography, Basic principles, Applications in airframe and rocketry.	**15 Hrs.**	**2,3,4,5**
5	**Electrical Properties** Their importance and significance, effect of temperature and humidity on electric properties. Different types of electrical properties such as: Determination of dielectric strength, surface and volume resistance. Power factor and permittivity. Tracking resistance, arc resistance **Dielectric measurements**, conductivity, resistivity. **Separation techniques** – GPC, HPLC, mol. Wt and mol. Wt distribution measurements. X–ray studies for polymers.	**15 Hrs.**	**2,4,5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **E. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **F. Semester End examination**

REFERENCES

01. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.
02. S. Zhang, Lin Li, A. Kumar, Materials Characterisation Techniques, CRC press, 2008.
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05. W. W. Wendlandt, Thermal Methods of Analysis, John Wiley, 1974.
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	MAHATMA GANDHI UNIVERSITY
	INM22C04 Polymer Compounding and Processing
School/Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech. Polymer Science and Engineering**
Course Name	**Polymer Compounding and Processing**
Type of Course	**Core**
Credit Value	**3**
Course Code	**INM22C04**

Course Summary & Justification	This course provides detailed knowledge to the students on Polymer Compounding and Processing. Polymer Compounding and Processing is an important topic that needs to be studied by the student of Polymer science and technology. This course includes different additives added to different polymers to enhance the property and processibility of the polymers. Different additives need to add to the polymers to tune the properties of polymers to engineer the polymer for different applications. From an application point of view, the topic of Polymer Compounding and Processing is very important and should be studied by the students to know the processing parameters and engineer different products from polymers. For the proper mixing/ incorporation of different additives to the polymers, suitable compounding techniques should be followed, and this course also includes different compounding techniques (techniques used for the proper mixing of different additives with polymers) used. Depending upon the nature of the polymer and additives different compounding techniques need to be used. So, clear knowledge of the compounding of polymers is required for a polymer technologist. Polymer products are very much interested today because of their excellent properties. Depending upon the nature of the polymer and product required different processing techniques (techniques to make products) need to be followed for polymer. So, deep knowledge in this area is required. Therefore, this course also included different processing techniques for polymers. After the completion of this course, students will be able to formulate the compounding ingredients and will be able to do the compounding and processing of different polymers.

Semester	I					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		80	40	-	20	140
Pre-requisite	Basic knowledge of Polymer Science and Technology (graduate-level)					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	To Acquire sound knowledge about the fundamentals and importance of Additives and compounding for Polymers.	R, U, An	1,2,7
2	To compare and correlate various additives for polymers.	U, A, An	3,4,5
3	To understand and explore properties and applications of different polymers in diverse areas through the incorporation of different additives.	U, A, An, E	1,3,7
4	To understand different compounding and processing techniques for Polymers.	U	1,4,5,6
5	To understand and analyse the formulation of different polymers for the different products.	U, An	1,5,6,7
6	To understand the different processing techniques (product-making process) for different polymers for making different products.	U, I	1,5,6,7
7	Compare different polymer compounding and processing techniques	A, An, E, A	1,2,3,7
8	Select different polymer compounding and processing techniques for different polymers for different product manufacturing.	A, C, S, I, Ap	1,2,3,7
Remember I, Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Polymer additives** Additives: fillers, reinforcements, modifiers, lubricants, blowing agents, flame retardants, plasticizers, pigments, nucleating agents, antistatic agents, anti blocking agents, peptizers, antioxidants, accelerators, activators, fillers, carbon black reinforcement, chords and fabrics, blowing agents, colorants, Processing aids like tackifiers, plasticizers,	**30**	**1,2**

	softeners, extender oils, their function, level of addition and stage of addition. Additives for rubber compounding, vulcanizing agents, Sulphur and non-Sulphur vulcanization, accelerators, activators, Basics of processing, compounding techniques. Compounds for specific purposes.		
2	**Polymer compounding** Latex compounding, Advanced latex products manufacturing, diene and non-diene elastomers, Rubber compounding, vulcanization, advanced rubber products manufacturing, recent advances in rubber manufacturing, compounding of plastics, additives for plastic compounding.	**15**	**3,4**
3	**Polymer processing equipments** Extrusion, Blow molding, Fiber spinning, Compression molding, Injection molding, Transfer molding, single screw, extrusion process, twin screw extrusion process, rotational molding, 3D printing, electrospinning technology, Reactive extrusion, Thermofoaming, extrusion blow molding, Injection molding, reaction injection molding, hand lay-up, spray, lay-up, filament winding, pultrusion, resin transfer molding, vacuum resin infusion/transfer.	**25**	**5,6**
4	**Polymer process equipment design** Pressure vessel, design of heat exchangers for polymer processing, Condensors and evaporators, storage tank, design of compression moding, Injection molding, calendaring and extrusion.	**10**	**7,8**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **A. Continuous Internal Assessment (CIA)** Surprise test Internal Test – Objective and descriptive answer type Submitting assignments Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **B. Semester End examination**

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1. Zehev Tadmor. Principles of polymer processing, Second edition, John Whiley & Sons. Inc., Publications.

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05. G.Towler and R.K Sinnot., 'Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design', 2nd Ed., Butterworth- Heinemann.

	MAHATMA GANDHI UNIVERSITY **INM22C05: Laboratory I- Synthesis and Characterization of Advanced Polymeric Materials**
School/Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech Polymer Science and Engineering**
Course Name	**Laboratory I – Synthesis and Characterization of Advanced Polymeric Materials**
Type of Course	**Core**
Credit Value	**2**
Course Code	**INM22C05**

Course Summary & Justification	To have hand-on experiences on the preparation of polymeric materials and its characterizations					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning, collaborative learning, independent learning	0	0	40	40	80
Pre-requisite	Basic knowledge about different polymerization methods					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Understand the principles behind synthesis of polymeric materials	U, A, An, E	1,4,5
2	To study mechanical and thermal properties of polymeric materials	A, An, E, C,I	1,4,5,7
3	To study differential scanning calorimetry and electrical properties of polymeric materials	C, S, I	1,2,6,7
4	Students will be able to interpret the results of analysis	An, E, I, Ap	1,5,6,7

Remember I, Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C), Skill (S), Interest (I) and Appreciation (Ap)

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	Synthesis of polymeric materials such as PMMA, PS, nylon 6, PU, PF, UF, epoxy, PLA	**20 hrs**	**1,2**
2	Characterization of the prepared advanced polymeric materials – mechanical analysis, thermogravimetric analysis, differential scanning calorimetry, electrical property analysis	**20 hrs**	**3,4**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** **A.** Lab/Experiment skills **B.** Lab record/Report **C.** Viva-voce **D.** Lab Discipline (participation, punctuality, accuracy) **E. Semester End examination**

	MAHATMA GANDHI UNIVERSITY
	INM22C06: Laboratory II -Fabrication of Polymer Blends, Composites and Nanocomposites

School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE), International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech Polymer Science and Engineering**
Course Name	**Laboratory II -Fabrication of Polymer Blends, Composites and Nanocomposites**
Type of Course	**Core**
Credit Value	**2**
Course Code	**INM22C06**

Course Summary & Justification	To have hand-on experiences on the fabrication of polymer blends, polymeric composites and nanocomposites					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning, collaborative learning, independent learning	0	0	40	40	80
Pre-requisite	Basic knowledge about composites and preparation methods					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Students will be able to optimize the preparation of polymer blends	U,A, An,S	1,2,5,6,7
2	Preparation of various composites of carbon fiber, natural fiber, and glass fiber composites. Also able to prepare hybrid fiber composites	A, An, C, I	3,4,5
3	Preparation of polymer nanocomposites and hybrid nanocomposites	U, E, A, An, Ap	2,5,6
Remember I, Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	Fabrication of Polymer Blends	**20 hrs**	**1, 2**
2	Fabrication of carbon fiber composites, natural fiber composites, glass fiber composites, and hybrid fiber composites Preparation of polymer nanocomposites and hybrid nanocomposites	**20 hrs**	**2, 3**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** **A.** Lab/Experiment skills **B.** Lab record/Report **C.** Viva-voce **D.** Lab Discipline (participation, punctuality, accuracy) **E. Semester End examination**

	MAHATMA GANDHI UNIVERSITY
	INM22E01: Adhesives and Adhesion
School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Center for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech Polymer Science and Engineering**
Course Name	**Adhesives and Adhesion**
Type of Course	**Elective**
Credit Value	**3**
Course Code	**INM22E01**

Course Summary & Justification	This course provides functions of adhesives, advantages and disadvantages of adhesive bonding, and various theories of adhesion. This course aims to impart basic knowledge on the types of adhesives, phenolic adhesives and modifiers, specialty adhesives, adhesives in aerospace, automobile industry, building construction, and electrical industry. Through this learning, it is possible to acquire knowledge about surface coatings and components of paints, pigments, pigment properties, different types and factors affecting pigment dispersion, and preparation of pigment dispersion. It will help the students to know the different types of paints, epoxy coatings, polyurethane, silicones, formaldehyde based resins, chlorinated rubbers, hydrocarbon resins. Classification based on application, fluropolymers, vinyl resins, appliance furnishes, automotive finishes, and different coatings.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning, collaborative learning, independent learning	40	40	0	40	120
Pre-requisite	Basic knowledge about adhesives, paints, and coatings					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Understand the functions of adhesives, advantages and disadvantages of adhesive bonding, and various theories of adhesion	U,R	1,2
2	The student should be able to understand the types of adhesives, phenolic adhesives and modifiers, automobile industry, building construction, and electrical industry	U, A, An	2,3,4
3	Able to acquire the knowledge about surface coatings and components of paints, pigments, and different types and factors affecting pigment dispersion	U, A,C	1,5,6,7
4	Learn about how the different types of paints, epoxy coatings, polyurethane, silicones, formaldehyde based resins, chlorinated rubbers, hydrocarbon resins	R, U, A	2,3,7,9
5	Get thorough knowledge of fluropolymers, vinyl resins, appliance furnishes, automotive finishes, and different coatings	U, A, Ap, S	1,2,4,6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Adhesives – concepts and terminology** Functions of adhesives, advantages and disadvantages of adhesive bonding, theories of adhesion – mechanical theory, adsorption theory, electrostatic theory, diffusion theory, weak-boundary layer theory, Requirements for a good bond, criteria for selection of adhesives	15 Hrs	**1,2**
2	**Types of Adhesives** Adhesives types: Structural adhesives, Urethane structured adhesives, Modified acrylic structural adhesives, phenolic adhesives and modifiers, anaerobic adhesives, cyanoacrylate adhesives, Hot melt adhesives, pressure sensitive adhesives, RTV Silicone adhesives, sealants, water based adhesives. Specialty adhesives, adhesives in aerospace, adhesive in automobile industry, conductive adhesives, adhesives in building construction, adhesive in electrical industry.	**15 Hrs**	**1,2**

3	**Surface Coatings** Introduction to surface coatings: Components of paints, Pigments, pigment properties, different types, extenders, solvents, oils, driers, diluents, lacquers, varnishes, paint preparation, formulation, factors affecting pigment dispersion, preparation of pigment dispersion.	**15 Hrs**	**3,4**
4	**Surface coating methods** Different types of paints – classification based on polymeric resin, emulsion, oil and alkyd paints, acrylic paints, epoxy coatings, polyurethane, silicones, formaldehyde based resins, chlorinated rubbers, hydrocarbon resins. Classification based on application, fluropolymers, vinyl resins, appliance furnishes, automotive finishes, coil coatings, can coatings, marine coatings, aircraft coatings.	**15 Hrs**	**3,4,5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **C. Continuous Internal Assessment (CIA)** - Surprise test - Internal Test – Objective and descriptive answer type - Submitting assignments - Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **D. Semester End examination**

REFERENCES

1. Gerald L. Schreberger, "Adhesive in manufacturing", Marcel Dekker Inc., New York, 1983.
2. W.C. Wake, "Adhesion and the formulation of adhesives" Applied Science Publishers, London, 1976.
3. Swaraj Paul, "Surface Coatings", John Wiley & Sons, NY, 1985.
4. George Mathews, "Polymer Mixing Technology", Applied Science Publishers. London, 1982.
5. Sheilds, "Hand book of adhesives", Butterworth's, 1984
6. Progress in Adhesion and Adhesives, K.L. Mittal, 31 July 2015, ISBN:9781119162346 |DOI:10.1002/9781119162346

	MAHATMA GANDHI UNIVERSITY
	INM22E02: RESEARCH METHODOLOGY
School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Center for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech. Polymer Science and Engineering**
Course Name	**RESEARCH METHODOLOGY**
Type of Course	**Elective**
Credit Value	**3**
Course Code	**INM22E02**

Course Summary & Justification	This course provides introduction, meaning, objectives and motivation of research. It also helps the students to understand how research is done, research process, criteria of good research, and problems encountered by researchers in India. Students will be able to study the formulation of hypothesis and review of literature. Learning this course will provide a strong foundation in sampling theory, types and steps in sampling and advantages and limitations of sampling. The course will also provide a deep awareness on computer applications spreadsheet tool, data storing, and features for statistical data analysis. The students will learn about the presentation tool, features and functions, creating presentation, customizing presentation, showing presentation and also about use of Internet, WWW, search engine like Google, Yahoo etc, advanced search techniques. It also describes about interpretation and report writing, presentation of tables and figures, research-scientific misconduct, plagiarism, impact factor, and h-index.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning, collaborative learning, independent learning	40	40	0	40	120
Pre-requisite	Basic knowledge about conducting research works					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Understand the meaning, objectives, types, significance of research, and importance of knowing how research is done	R,U	1,2,3
2	Able to acquire the knowledge about sampling technique and computer applications	U,A	2,3,4
3	Learn about presentation tool, features and functions, creating presentation	A,C,An	2,3,5
4	Gather information about use of Internet, WWW, search engine and advanced search techniques.	U,An,E	1,6,7
5	Learn the interpretation, significance of report writing, different steps in writing report	An,S,I	2,3,9
Remember I, Understand (U), Apply (A), Analyse (An), Evaluate I, Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Research methodology** An Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India Questions-Research design- Formulation of hypothesis- Review of literature.	15 Hrs	**1,2**
2	**Sampling technique** Sampling theory, Types of sampling, Steps in sampling-Sampling and Non-sampling error, Sample size, Advantages and limitations of sampling.	**15 Hrs**	**1,2**

	Computer applications: Spreadsheet Tool: Introduction to spreadsheet application, features and functions, using formulas and functions, Data storing, Features for Statistical data analysis, Generating charts/ graph and other features. (Microsoft Excel or similar tool).		
3	**Presentation tool** Introduction to presentation tool, features and functions, creating presentation, customizing presentation, showing presentation. (Microsoft Power Point) **Web Search:** Introduction to Internet, Use of Internet and WWW, Using search engine like Google, Yahoo etc, advanced search techniques.	**15 Hrs**	**2,3,4**
4	**Interpretation and report writing** Meaning of Interpretation, Why Interpretation? Technique of Interpretation: Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Indexing, presenting footnotes, abbreviations, Presentation of tables and figures, Contents, Styles of reporting, Referencing, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Research-Scientific misconduct, Plagiarism, impact factor, h-index.	**15 Hrs**	**2,4,5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **E. Continuous Internal Assessment (CIA)** Surprise test Internal Test – Objective and descriptive answer type Submitting assignments Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **F. Semester End examination**

REFERENCES

1. Montgomery, C Douglas (2007), 5/e, Design and Analysis of Experiments, (Wiley India).
2. Montgomery, C Douglas. &Runger, George C. (2007), 3/e, Applied Statistics &Probability for Engineers (Wiley India).
3. C.K Kothari. (2004), 2/e, Research Methodology- Methods and Techniques (New Age International, New Delhi).
4. B.L Garg,.,RKaradia., F Agarwal,. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
5. C.R Kothari., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
6. S.C Sinha. andA.K Dhiman,., 2002. Research Methodology, Ess Publications. V2.
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8. B.L Wadehra,. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing. How to write a Technical report – AlamSmithee, Fictitious Institute of Technology, 1999.
10. Hering Lutz, Hering Heike, Springer, 2010How to write technical reports- Understandabble structure, Good Design, Convincing presentation

	MAHATMA GANDHI UNIVERSITY
	INM22E03: ADVANCED CARBON-BASED NANOMATERIALS
School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech Polymer Science and Engineering**
Course Name	**ADVANCED CARBON-BASED NANOMATERIALS**
Type of Course	**Core**
Credit Value	**3**
Course Code	IN**M22E03**

Course Summary & Justification	This course provides information about advanced carbon-based nanomaterials including fullerenes, carbon nanotubes (CNT), graphene and other carbon nanomaterials towards various applications. Will be able to gather information about fundamentals of carbon molecules and their classifications. The students will learn about structure, growth, and characterization of various properties of carbon nanomaterials. Discusses about Mechanical, Thermal, Electronic and biological Applications of Fullerene, CNT, Graphene and other carbon nanomaterials.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic, Collaborative learning	70	10	30	10	120
Pre-requisite	Basic understanding of chemistry and properties of nanomaterials					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Fundamentally understand the structure, chemistry and bonding related carbon molecules	U, R	1,2,3
2	Learn the different allotropes of carbon and classification of nanomaterials	U, R, S	1,2,7
3	Get thorough knowledge of fullerenes, carbon nanotubes (CNT), graphene and other carbon nanomaterials.	U, R, An, S, Ap	3,4,5,6,7
4	Critically understand the structure and growth of standard carbon nanomaterials	U, R, C	3,4,5
5	Learn about Physical Properties, Spectroscopic Properties, Thermodynamic Properties. Chemical Properties, its characterization techniques.	U, R, I	1,3,4,7
6	Understand the wide range of applications of Fullerene, CNT, Graphene and other carbon nanomaterials.	S, A, An	1,3,4,6,7,8
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Introduction** Carbon molecules, nature of carbon bonds, structure and chemistry of different carbon allotropes. Classification of carbon nanomaterials: fullerenes, carbon nanotubes (CNT), graphene and other carbon nanomaterials.	**15**	**1,2**
2	**Introduction to Fullerenes** Structure of Higher Fullerenes, Growth Mechanisms; Production and Purification: Pyrolysis of Hydrocarbons, Partial Combustion of Hydrocarbons, Arc Discharge Methods, Resistive Heating, Rational Syntheses. Physical Properties, Spectroscopic Properties, Thermodynamic Properties. Chemical Properties: Hydrogenation, Halogenation, Nucleophilic Addition to Fullerenes.	**15**	**3,4**

3	**Introduction to Carbon nanotubes (CNT)** The Structure of Carbon Nanotubes, Single Walled Carbon Nanotubes, Multiwalled Carbon Nanotubes. Electrical, Vibrational, Mechanical Properties of CNTs, optical properties & Raman Spectroscopy of CNTs. Purification and Functionalization of CNTs by Flame, CVD, Laser & Arc-discharge process, Fluidized bed reactor.	**10**	**3,4**
4	**Introduction to graphene:** Structure of graphene, synthesis of graphene: Modified Hummer's method, electrochemical exfoliation and CVD method., Electronic Properties Band structure of Graphene - Mobility and Density of Carriers - Quantum Hall Effect - Spectroscopic Properties of graphene.	**10**	**4,5**
5	**Applications** Applications of Fullerene, CNT, Graphene and other carbon nanomaterials. Mechanical, Thermal, Electronic and biological Applications of carbon nanomaterials.	**10**	**6**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **G. Continuous Internal Assessment (CIA)** □ Surprise test □ Internal Test – Objective and descriptive answer type □ Submitting assignments □ Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **H. Semester End examination**

REFERENCES

1. Encyclopaedia of Nanotechnology, M.Balakrishna rao and K.Krishna Reddy, Vol I to XCampus books (2006).
2. Nano:The Essentials – Understanding Nano Scinece and Nanotechnology, T.Pradeep; TataMc.Graw Hill (2008).
3. Carbon Nanotubes: Properties and Application, Michael J. O'Connell, CRC Press (2018).
4. Nanotubes and Nanowires, CNR Rao and A Govindaraj, RCS Publishing (2005)
5. Carbon Nanotechnology: Recent Developments in Chemistry, Physics, Materials Science and Device Applications, Liming Dai, Elsevier Science (2006)

SEMESTER II

	MAHATMA GANDHI UNIVERSITY **INM22C07: Polymer Blends, IPN's, Polymer Electrolytes, and Gels**
School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE), International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech Polymer Science and Engineering**
Course Name	**Polymer Blends, IPN's, Polymer Electrolytes, and Gels**
Type of Course	**Core**
Credit Value	**3**
Course code	**INM22C07**

Course Summary & Justification	This course is designed at providing students with concepts of polymer blends, IPN's, Compatibilization of polymer blends, its characterization, polymer gels and polymer electrolytes. In depth knowledge on blending techniques, miscibility, compatibility, compatibilization techniques. Concept on polymer gels and electrolytes. This course aims to impart basic knowledge on blends, composites, IPN's, polymer gels and polymer electrolytes materials. To introduce the basic concepts on IPN's, blends, compatibilization of blends and characterization techniques. To familiarize different types of blends based on their morphology. To give the concept of improvement of material properties by blending. Understanding the concept of blending and also the preparation of polymer gels and polymer electrolytes as it is important to develop various products for different applications.				
Semester	**II**				
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	60	40	60	120
Pre-requisite	Basic knowledge about chemistry at the Bachelors level				

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the concept of blends, IPN's, polymer gels and polymer electrolytes	U, R, A	1, 2, 3,4, 7
2	To learn about various blending techniques	U, R, An, A	5,7
3	Understand the concept of improving material properties by blending.	U, An	1,2,7
4	To impart knowledge on different blending techniques, concept of solubility and different theories associated and phase behavior of polymer blends	U, R, E, S, I, An, Ap, C	6, 7
5	Understand the need of Flory-Huggins theory, blend morphology and commercial application of blends	U, R, I, E	6, 7
6	Know about compatibilization of polymer blends followed by different characterization techniques used for polymer blends.	U, R, S, I, Ap	1,2,7
7	Be familiar with interpenetrating polymer networks, its classification and synthesis	U, R, S, I	6, 7
8	Know specifically about polymer gels which includes its application in various fields.	U, R, A, An, Ap	7, 8
9	Understand the essentials of polymer electrolytes and Get a general view on its characterization.	U, S, I	7, 8
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Introduction** Definition and importance of blending, blending techniques, solution mixing, mechanical mixing, latex blending, mechano chemical blending, compatibility of polymer in solution, determination of mutual solubility of polymers, miscibility through specific interactions, copolymer effect, phase diagrams of polymer-polymer systems, LCST and UCST behavior, binodal and spinodal curves, critical point, thermodynamic treatment of phase behavior of polymer mixtures, Flory-Huggins theory, blend morphology- generation and control, capillary number, characterization techniques, commercial blends and their applications	**10**	**1,2,3,4**
2	**Compatibilization of polymer blends** Compatibilization of immiscible blend: addition of graft or block copolymers, reactive compatibilization by low molecular weight additives, types of compatibilizers, in situ-formed, separately added copolymers, compatibilization theory.	**10**	**1,2,3,4,5,6**
3	**Characterization of polymer blends** Characterization of polymer blends; Methods for determining polymer-polymer miscibility, criteria for establishing miscibility, dielectric microscopic, mechanical, cloud point, rheological, dialatometric and viscosity methods, free volume measurement, volume of mixing, fluorescence spectroscopy, IR, FIR, NMR, mutual solvent method, heat of mixing,	**10**	**1,2,6**

	melting point depression, inverse gas chromatography.		
4	**Interpenetrating polymer networks** Differences of IPNs, polymer blends and alloys, Types of IPNs, Semi IPNs and Pseudo IPNS, Preparation methods, Characterization of IPN, Applications of IPN.	**10**	**1,2,7**
5	**Polymer Gels** Polymer hydrogels, aerogels, macro, micro and nanogels, fundamental synthesis and structure property relationships of polymer gels. Polymer hydrogel composites, cellulose based polymer gels, polysachride based polymer gels, graphene oxide based polymer gels, Functional polymer gels, polymer gels for biomedical applications, polymer gels for energy, polymer gels for optoelectronics.	**10**	**1,2,3,8**
6	**Polymer Electrolytes** Common polymers included as polymer electrolytes**,** Metal-polymer interaction, solid-solid interfacing, types of polymer electrolytes (Gel, Glass, Ceramic and Polymer composite), ion-transfer mechanism, potential gradient, temperature dependence, concentration and polymer mobility, properties, electrochemical stability, electrochemical characterization by cyclic voltammetry and electrochemical impedance spectroscopy.	**10**	**1,2,3,9**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **I. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **J. Semester End examination**

REFERENCES

1. D.R. Paul, S. Newman, Polymer Blends Vol 1-2, Academic Press, 1978
2. O. Olabisi, L.M. Robeson, M.T. Shaw, Polymer-Polymer Miscibility, Academic Press, 1979.
3. K.K. Chawla, Composite Materials, 2nd Edn., Springer, 1998.
4. L A Utracki ,Polymer Blends Handbook, Springer, 2003.
5. F.W. Billmeyer, Text Book Of Polymer Science, 3rd Edn., Wiley, 1984.
6. I. Teraoka, Polymer Solutions: An Introduction to Physical Properties, Wiley-Interscience, 2002.
7. J.M.G. Cowie, V. Arrighi, Polymers: Chemistry and Physics of Modern Materials, 3rd Edn., CRC Press, 2008.
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9. Fundamentals of Polymer Engineering, Third Edition, By Anil Kumar, Rakesh K. Gupta
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	MAHATMA GANDHI UNIVERSITY
	INM22C08-Polymer Composites and Nanocomposites

School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE)** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Program	**M.Tech.** Polymer Science and Engineering
Course Name	**Polymer Composites and Nanocomposites**
Type of Course	**Core**
Credit Value	**3**
Course Code	**INM22C08**

Justification of Course in Programme	This course is designed to understand the basics of polymer science and their property change at nanoscale and its effective combination in a composite. Their importance and application are also elaborately discussed.					
Course Summary	This course is designed at providing students with concepts of polymer Composites and Nanocomposites. Concept on short fibre composites ,long fibre composites and critical fibre length. Knowledge on composite fabrication techniques, nanocomposite preparation and characterization techniques. This course aims to impart basic knowledge on composites and nanocomposites materials. To introduce the basic concepts on composite materials and manufacturing processes. Understanding the preparation of composites is important as it helps to develop various products for different applications. The brief synthesis, characterisation and property of all polymer composites and nanocomposites along with their application is discussed. The physical and chemical science of all polymer composites and nanocomposites are discussed.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Hours
	Others include: Research, Fieldworks, Independent Learning etc.	40	40	0	40	120
Pre-requisite	Basics of nanoscience.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand the concept of composites and nanocomposites	U,S,I,R	1,2
2	To learn about various composite manufacturing techniques	U,A,An,S,I,R	1,2,4,5,6
3	Understand the concept of improving material properties by composite formation. To learn about particulate polymer composites	U,I,R,E	1,2,3
4	To understand the concept of short and continues polymer composites, learn about FRP systems, various manufacturing process and characterization techniques	U,I,R,C,S	1,2,7
5	To learn the limitations of Processing and manufacturing, Mechanical and thermal properties of continues FRP composites, Applications: Characterization of FRP composites	U,I,R,C	1,2,3,4,8
6	To gain ability to design nano systems, component or process as per need and specification.	A,An,E,C,S	1,2,3,6,9
7	To understand the role of nanotechnology in polymer and nano-composites.	U,I,R,S,Ap	1,6,7,8,9
8	To gain knowledge of polymer and nano composites used in recent advances of polymer.	U,R,I,Ap	6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No:	Module Content	Hrs	CO. No.
1	**Introduction to composites**: Polymer composites, particulate, short fiber and Continuous fiber reinforced polymer composites (FRP), polymer nanocomposites.	**10**	**1,2,3,4**
2	**Particulate polymer composites** Particulate polymer composites: Characteristics for a particulate reinforcer, its selection and its surface coatings, mineral, metallic and organic particulate reinforcers, processing of particulate polymer composite and product development, mechanics, models and equations for Young's Modulus of the	**10**	**1,2,3,4**

	composites, applications of particulate composites.		
3	**Short and continues polymer composites** Synthetic FRP composites, natural FRP composites; Short fiber composites; processing of short FRP composite, product development and manufacturing, collimated fiber compounds, fiber length distribution on the composites, short natural FRP composites, processes and manufacturing, applications, hybrid composites, Mechanical properties of short FRP composites. Continues FRP composites; Natural, inorganic and synthetic continuous FRP composites, processing and manufacturing of thermoset FRP composites by Vacuum Bag Molding, Vacuum infusion Molding, Resin Transfer Molding, Pultrusion and Filament Winding, structural and other applications of thermoset composites. Limitations of Processing and manufacturing, Mechanical and thermal properties of continues FRP composites, Applications: Characterization of FRP composites	**10**	**1,2,3,4,5**
4	**Polymer nanocomposites** Introduction to nanocomposites, types of nanoparticles, synthesis of nano particles (with example), selection of nanoparticles for various applications, processing and manufacturing of polymer nanocomposites, nanoparticles in organic polymer matrices, nanoparticles in synthetic polymers, limitations in processing, physical and chemical modification of nanoparticles, advanced functional polymer nanocomposites, characterization, applications.	**10**	**1,2,6,7**
5	**Characterization of Polymer Composites and Nanocomposites** Microstructure evaluation by scanning electron and optical microscopes. Structure evaluation by FTIR, NMR, C-13 NMR, UV. Elemental analysis – qualitative and quantitative, Dielectric measurements, Diffusion properties, Thermo-mechanical properties, DMA creep, ultimate properties, thermal relaxations. mechanical properties. Surface properties, contact angle measurements.	**10**	**1,2,3,6,7,8**

Reference

1. K.K. Chawla, Composite Materials, 2nd Edn., Springer, 1998.
2. F.R. Jones, Hand Book of Polymer-Fibre Composites, Longman Scientific and Technical, 1994.
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4. L A Utracki ,Polymer Blends Handbook, Springer, 2003.
5. Vajtai, Robert, Handbook of Nanomaterials, Springer 2013
6. Larson R.G., "The Structure and Rheology of Complex Fluids",Oxford.
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10. Shenoy A.V., "Rheology of Filled Polymer Systems" Kluwer Academic Publishers
11. Han C.D., "Rheology and Processing of Polymeric Materials" Vol-1, Oxford University Press
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	MAHATMA GANDHI UNIVERSITY **INM22C09: Polymer Product Design and Product Engineering**
School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech. Polymer Science and Engineering**
Course Name	**Polymer Product Design and Product Engineering**
Type of Course	**Core**
Credit Value	**3**
Course Code	**INM22C09**

Course Summary & Justification	This course aims to impart knowledge design of polymers for various engineering applications. To introduce the basic concepts on composite materials, advanced designing and applications. Understanding the concept of the preparation of composites is important as it helps to develop various products for different applications. This course is designed at providing students with concepts of advanced polymer design. In depth knowledge on advanced materials for fabricating energy storage materials such as solar cells and polymer electrolytes. In addition more deep study on structural applications.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Research, Fieldworks, Independant Learning etc.	40	40		40	120
Pre-requisite	Basics of crystal structures					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	To understand the concept of advanced polymeric materials design and fabrication	U, R, I	1,2,6,7
2	To understand the methods, instruments and testing for electronics, photonics and magnetic polymeric materials	U,R,S	2,3,7
3	To understand the various polymers for energy storage and structural applications.	A,Ap, S	1,2,5.7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Polymers for Energy Storage** Structure, properties of polymers used in energy storage, principals of energy storage: Li-ion batteries, supercapacitors and fuel cell, mechanism of ion conduction and diffusion in polymers. **Lithium Polymer Electrolytes:** Metal-polymer interaction, solid-solid interfacing, types of polymer electrolytes (Gel, Glass, Ceramic and Polymer composite), properties, electrochemical stability, electrochemical characterization by cyclic voltammetry and electrochemical impedance spectroscopy. **Polymers for solar cell:** Solar cell: principal and design, application of polymer electrolyte in dye sensitized solar cell, nano-composite polymer electrolytes: synthesis and characterization of dye sensitized polymer electrolyte.	**15 Hrs.**	**1**
2	**Electronics, photonics and magnetic polymeric materials** Basics- electronic, magnetic and optical properties in metals, semiconductors, ceramics and polymers; Electronic properties- dielectric properties, Concept of doping- high, very high and ultra-high frequency fields; Organic semiconductors, π-conjugated polymers; Magnetic domains- magnetic materials, thin films, nanoparticles, magnetoresistive materials, magnetic recording, magnetic polymers; Optical properties- optics-ray, electromagnetic, guided wave optics; Physics of light-matter interactions, Photoactive and photorefractive polymers; Radiation sensitive resisters, Second order nonlinear optical properties; Applications, Electro active, Conductivity, Electronic applications, Diodes, Transistors, Photodetector, Solar cells, Displays, Lasers, Optical fibers, Photonic devices, Magnetic data storage and spintronics	**15 Hrs.**	**1,2**
3	**Application of polymers for space** Carbon based materials- carbon fiber, carbon-carbon composites, carbon aero-gels, carbon foams, oxidation protection of carbon based materials; Ceramic materials-	**10 Hrs.**	**2,3**

	polymer derived ceramics, ceramic fibers, ceramic matrix composites, thermal barrier coatings , thermal protection systems, porous ceramics and ceramic foams, Ultrahigh temperature ceramics; materials with zero thermal expansion-glass ceramics, Metallic materials- super alloys, titanium alloys, intermetallics and metal matrix composites; High temperature polymers- aromatic liquid crystalline polyesters, polyamide, phenolics, polyimide, bismaleimide, poly etherether ketones; Materials for cryogenic application, Materials for space environment, Functionally graded materials, Evaluation of materials for extreme environment, Materials processing and manufacturing in zero gravity.		
4	**Structural applications** Introduction to Adhesives, Sealants and Coatings: History of adhesive, industry, types of polymeric adhesives, theory and mechanism of adhesion, advantages and disadvantages of adhesive bonding over conventional joining techniques, adhesive coating equipment's, Introduction to sealants, caulks and mastics, advantages and disadvantages of sealant bonding over conventional joining techniques, nano coatings, Paint Application. applications in civil engineering, aerospace engineering, marine engineering, wind.	**10 Hrs.**	**1,2,3**
5	**Polymeric textiles** Textile fibers and structure property relationship, chemical processing of textile fibers, additives for textile processing, textile fibers testing, Yarn formation, Design of fabrics, testing of fabrics, technologies based on silk. Wool, jute, nanoparticles in polymeric textiles, polymeric textiles for biomedical applications, advanced textile products as biomaterials.	**10 Hrs.**	**2, 3**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **K. Continuous Internal Assessment (CIA)** Surprise test Internal Test – Objective and descriptive answer type Submitting assignments Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **L. Semester End examination**

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4 Gao Q, Thermosets: Structure Properties and Applications by Guo Q, Woodhead Publishing.

5 T.A. Skotheim, R.L. Elsenbaumer, J.R. Reynolds, Hand Book of Conducting Polymers, 2nd ed., Marcel Dekker, New York, Vol.1-2, 1998.

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8. M. Bikales, Overberger, Menges, Encyclopaedia of Polymer Science and Engineering, 2nd ed. Vol.5, John Wiley & Sons, 1986.

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	MAHATMA GANDHI UNIVERSITY **INM22C10: Theory, Modelling and Simulation of Advanced Polymeric Materials**
School/ Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M. Tech.** Polymer Science and Engineering
Course Name	**Theory, Modelling and Simulation of Advanced Polymeric Materials**
Type of Course	**Core**
Credit Value	**3**
Course Code	**INM22C10**

Course Summary & Justification	This course provides the students to get knowledge about theory modelling and simulation of Advanced polymer materials.					
Semester	**I**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Research, Fieldworks, Independant Learning etc.	40	40		40	120
Pre-requisite	Basics of Numerical methods.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Understand the concept of theory and simulations	U, R, I	1,2,3
2	Understanding the concept of simulation and modelling of polymer chain	U,A, I	2,3,5
3	Knowledge on the fundamentals of theoretical modeling on polymers and polymer composites.	S, I, Ap	1,2,7
4	Understand the theoretical basis on the polymer processing.	U, R, S	2,3,4,5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Basic Principles of Quantum Mechanics** Postulates of Quantum Mechanics, Wavefunctions, Probability Densities, Schrodinger Equation, Expectation Values. Time Dependent and Time Independent Equations, Solutions of the Schrodinger Equation, Free Particle, Particle in a Box – One and Three Dimensions, Particle in a Finite Well, Penetration Through a Barrier, Tunnel Effect.	15	1,2
2	**The Born-Oppenheimer Approximation** Hartree-Fock Molecular Orbital Theory, Self-Consistent-Field (SCF) Procedure; Anti-symmetry Principle, Variational Method, Basis Sets - Slater and Gaussian Functions, Density Functional Theory; Software for Geometry Optimization, Gaussian09, Vibrational Frequency Analysis, Symmetry Analysis, Harmonics, Fundamental Frequencies, Zero-Point Vibrational Energies. Potential Energy Surfaces, Local and Global Minima, Transition States. Introduction to Molecular Mechanics, Stretching, Bending, Torsional Energies; Force Field Methods, Comparison of Popular Force Fields.	15	1,2,3
3	**Introduction to Theoretical Models and Simulations of Polymer Chains** The Freely Jointed Chain, the Freely Rotating Chain, Chains with Fixed Bond Angles, and Independent Potentials for Internal Bond Rotation. Polymer Clay Nanocomposites and Coarse-Grained Models Basics Electronic, Magnetic and Optical Properties in Polymer Materials, Semiconductors, and Ceramics. Electronic Properties, Dielectric Properties, and Concept of Doping in Polymers. Organic Semiconductors, Conjugated Polymers. Classification of Semiconductors, Review of Energy Bands, Fermi Level in Intrinsic and Extrinsic Semiconductors. Nanomaterials; Size and Shape	15	2,3

	Dependant Properties and their Uniqueness; Energy at Nanoscale, Quantum Confinement - Zero Dimensional, one Dimensional and Two Dimensional Nanostructures.		
4	**Computational Modeling and Simulation for Polymer Material Science,** Multiscales Modeling and Simulation in Polymer and Energy Materials, Ab Initio Methods, Statistical Machanics, Monte Carlo Simulation, Molecular Dynamics, Modeling and Simulation of Nanomaterials: Nanotubes, Fullerenes, Sensors-Gas Sensors, and Biosensors, Smart Materials, Modeling of Fuel and Solar Cells, Modeling of Drug Delivery Systems and Optoelectronic Devices, Modeling of Hydrogen Production and Storage Hybrid Materials. COMPUTATIONAL POLYMER SIMULATION LAB.	**15**	**3,4**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **M. Continuous Internal Assessment (CIA)** Surprise test Internal Test – Objective and descriptive answer type Submitting assignments Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **N. Semester End examination**

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1. Purushottam D Gujrati, Arkadi I Lenov. Modeling and Simulation in Polymers, April 2010
2. Sharma S. An Introduction to Molecular Dynamics Simulation of Polymer Composites, 2020
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	MAHATMA GANDHI UNIVERSITY
	INM22C11: Laboratory III- Characterization of Polymer Blends, Composites and Nanocomposites

School / Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Program	**M.Tech. Polymer Science and Engineering**
Course Name	Characterization of Polymer Blends, Composites and Nanocomposites
Type of Course	Core
Credit Value	**2**
Course Code	INM22C11

Justification of Course in Programme	This lab course is designed to acquire the basic laboratory skills in polymer blends, composites and nanocomposites, synthesis, testing and analysis thereby enable the students to work in frontier areas of polymer sciences.					
Course Summary	This comprises of the hands on training session on various composites and blends fabrication techniques followed by necessary characterization/analyses approaches. This lab course also offers detailed understanding and skill generation in polymer blends, composites, nanocomposites and processing techniques. After the completion of this course, students will be able to acquire sufficient knowledge and experimental skill in fabrication and characterization techniques of polymer blends and composites. Knowledge on composite fabrication techniques, nanocomposite preparation and characterization techniques. This course aims to impart basic knowledge on composites and nanocomposites materials. Synthesis and characterization. Understanding the preparation of composites is important as it helps to develop various products for different applications.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Seminars, Independant Learning etc.	0	0	40	40	80
Pre-requisites	Knowledge on composite fabrication techniques, nanocomposite preparation and characterization techniques.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Undertake hands on lab work and practical activities on polymer blends and composites synthesis which develop problem solving abilities	A, S	1,2,7
2	Apply the theoretical concepts while performing experiments	A, An	1,2,4,5,7
3	Acquire practical skill in blends, composites and nanocomposites, processing, and characterization techniques	S, I	2,5,6
4	Design, carry out, record, and analyze the results of chemical experiments	An, E	2,3,6,7
5	To acquaint the students with modern instrumental techniques and their applications in characterization of polymer blends composites and nanocomposites	E, I, Ap	1,2,6,7,8
6	Understand safety of chemicals, transfer, and measurement of chemicals.	U, A	1,2,5,6

**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Study of miscibility of polymer blends by any three methods** ● To study the miscibility of the polymer blend using ultrasonic method. ● To study the miscibility of the polymer blend using viscosity method. ● To study the miscibility of the polymer blend using refractive index method. ● Determination of miscibility of polymer blends by density measurement method.	**10**	**1,2**
2	**Experiments from the following (any three)** ● To determine the intrinsic viscosity and molecular weight of the given polymer using Ubbelhod viscometer. ● Elastic properties of polymers. ● To determine the flexural strength of polymer nanocomposites ● Determine the refractive indices of polymer blends by using abbe's refractometer	**10**	**3,4**
3	**Synthesis (any three) experiments from the following** ● To prepare polymer blends by melt, solution and latex blending. ● Preparation of polymer nanocomposites by any of the following methods	**10**	**5**

	● melt intercalation, ● template synthesis, ● exfoliation adsorption ● in situ polymerization intercalation		
4	**Characterization(any two)** ● Evaluate the effect of filler loading on mechanical properties of a composites and nanocomposites. ● Characterization (thermal) of blends composites and nanocomposites. ● Characterization (mechanical) of blends composites and nanocomposites	**10**	**6**

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	MAHATMA GANDHI UNIVERSITY
	INM22C12: Mini Project & Viva Voce

School / Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**					
Programme	**M. Tech Polymer Science and Engineering**					
Course Name	**Mini Project & Viva Voce**					
Type of Course	Core					
Course Code	**INM22C12**					
Course Summary & Justification	Train the student to assimilate research problems and research attitude by acquiring hands-on experience in either experimental/ computational polymer materials or both. Relevance of scientific literature in knowledge addition and problem identification would be emphasised. Encourage the student to initiate the process of literature review and use of online research repositories. Research literature documentation and rudimentary research writing is envisaged in this course.					
Semester	2		**Credit**		2	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning			40	40	80
Pre-requisite	Fundamental understanding and knowledge of polymeric materials.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Conceive a research problem in the area of polymer science by the application of scientific methodologies	U, C	1,2,3,4,5,7
2	Apply scientific methodologies to solve the problem either through experiments or simulation or applying both.	C, A	1,2,3,4, 7,8
3	Perform experiment or simulation or both to accomplish the outcome of the research.	An, E	4,7
4	Analyse results and arrive at inferences and conclusions drawn out of it. Also understand the documentation procedure for project report writing.	An, E	3, 7
5	Present the scientific insight and knowledge derived by performing research work before a board of experts in the field of polymer science.	S, An, Ap, I	3, 5,9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	**Mode of Assessment** 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – prepare mini project/review report and present in the seminar

	MAHATMA GANDHI UNIVERSITY **INM22E04: Elastomer Technology and Advanced Products**
School / Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M. Tech. Polymer Science and Engineering**
Course Name	**Elastomer Technology and Advanced Products**
Type of Course	**Elective**
Credit Value	**2**
Course Code	**INM22E04**

Course Summary & Justification	This course provides basic knowledge and understanding of the important class of polymers - elastomers. The course deals with various types of elastomers, their properties and applications. The course is intended for masters' students who would like to gain an understanding of approaches to polymeric materials' selection criteria and their specific applications. The course will closely follow current trends in elastomer characterization and development of advanced products. The overall objective is to develop a clear understanding of the elastomers, processing, and application. Different types of elastomers, their properties, processing techniques and various applications are described in detail.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		80	40	-	20	140
Pre-requisite	A basic knowledge of elastomers and elastomer based products.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Account for understanding various elastomer materials, their properties, and being able to predict the behaviour and performance.	R, U, A, E	1,2,3,4,6
2	Account for the better understanding of various applications of elastomers.	U, A, An, E,	2,6,7,8
3	Account for the understanding structure property relation in accordance with the application.	An, U, E	2,7,9
4	Suggest and motivate choice of elastomer materials for different products and practical applications.	A, E, S, I,	2,3,4,5, 9
5	Independently being able to select an elastomer, plan experiments and use advanced instruments and characterization techniques to evaluate their applicability.	A, An, E,S, I, Ap	4,5,7,9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Introduction to elastomers** Introduction to Latex, Definition of elastomers and requirements of polymer to be elastomer: effect of molecular weight and glass transition temperature (Tg), Interpreting the properties of Elastomers.	**15 hrs.**	**1,3,5**
2	Definition of Latex, classification, Comparison between latices and polymer solution; Natural rubber latex - origin, tapping, bulking and preservation, composition of field latex, properties, preservation, methods of concentrating latex – creaming, centrifuging, and evaporation,-Specification and testing- (National and ISO) for latex, DRC testing, latex stage compounding, Solution compounding, dipped products. Principle and Manufacture of latex elastic threads; latex tubing; latex casting process specification and testing, defects. Synthetic latex- Types, properties, and application- surface coatings, adhesives, paper industries.	**15 Hrs.**	**1,2,4,5**

Module 3	**Essential properties of specific diene elastomers** Natural Rubber, Styrene Butadiene Rubber, Nitrile rubber, Ethylenepropylene rubbers, Polychloroprene rubber, Butyl rubber, Polybutadiene Rubber. **Essential properties of specific non-diene elastomers:** Fluorocarbon Rubber, Polyurethane rubber, Chlorosulfonated polyethylene, Polyurethanes, Silicone rubber, Ethylene-Vinyl Acetate copolymer, Ethylene-Acrylic Rubber, Polysulphide Rubber and thermoplastic elastomers system.	**10 Hrs.**	**1,2,4,5**
Module 4	**Rubber compounding** Equation of state and properties of ideal gas mixtures; Change in entropy on mixing; Partial molal properties for non-ideal gas mixtures; Equations of state. Vulcanization of elastomers: Principles and theory of vulcanization, Definitions of different terms like scorch, cure/ over cure & study of curing, Different types of vulcanization systems, Sulfur and its role in vulcanization. Measurement of Mooney viscosity and state of cure for rubber compound.	**15 Hrs.**	**2,3,4,5**
Module 5	**Engineering rubber products** **Tyre :**Classification of tyre, Tyre production components, use of textile in tyres, design, tyre building and manufacturing, tyre inner tubes and inner liner for tubeless tyre, performance requirements of tyres. Concept of green tyres. Concept of blending in tyre production, Advanced nanoscale rubber compounding. **Other engineering rubber products:** Manufacturing techniques of conveyer belt technology, rubber products for space crafts and aerospace applications, sealing ring technology, V-belt, footwear technology, hose technology, rubber coated roll, cable technology, vibration isolation and mounts.	**15 Hrs.**	**2,4,5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **O. Continuous Internal Assessment (CIA)** Surprise test Internal Test – Objective and descriptive answer type Submitting assignments Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **P. Semester End examination**

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	MAHATMA GANDHI UNIVERSITY **INM22E05: Advanced Biopolymer Systems**

School / Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE), International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech. Polymer Science and Engineering**
Course Name	**Advanced Biopolymer Systems**
Type of Course	**Elective**
Credit Value	**3**
Course Code	**INM22E05**

Course Summary & Justification	This course provides information about biodegradable polymer classes, natural, synthetic and modified naturally biodegradable polymer. Will be able to gather information about non-biological and biological degradable polymer and introduction to Life Cycle Assessment. The students will learn about raw materials for polymers, polymer recycling and environmental issues and Life cycle assessment. Discusses about proteins, hemicellulose and cellulose based biopolymers and surface and chemical modifications of cellulose fibers. It also describes the applications of biopolymer in agriculture and advantages and disadvantages. This course will give a basic concept of biopolymers, different methods preparation of nanofillers and potential application in biomedical field.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40	0	40	120
Pre-requisite	Basic understanding of chemistry and properties of polymers and biomolecules.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	The student should be able to understand the classes, natural and synthetic and modified naturally biodegradable polymer. Non-biological and bio derived polymers are also included	U, A, An	1,2
2	Learn the biodegradation and standards for biodegradation of packaging materials and life cycle assessment	U, A, E	1,2,3
3	Able to acquire the knowledge of polymer raw materials, sustainability of petroleum resources, alternate sources for polymers and recycling	U, A, An	1,3,4
4	Learn about biodegradation, its evaluation techniques and standards for biodegradation, and life cycle assessment	U, An, E, Ap	1,5,6,7

5	Get thorough knowledge of plant and animal based proteins and processing of proteins as plastics	U, An, E, I	1,2,4,
6	Critically understand the preparation and properties of hemicellulose, and its composites	U, An, E, S	2,3,7
7	Get thorough knowledge of biopolymer films- advantages and disadvantages and applications of biopolymers in horticulture	U, A, C	2,3,7,8
8	To understand the basic concepts of biopolymers, differen mehods of preparation of nanofillers	U, A	1,2,4
9	To study polymers as biomaterials, micro computed tomography and radiopaque polymers and potential application in biomedical field	U,A, An	2,5,6,7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Polymer biodegradation** Biodegradable polymer classes, Natural biodegradable polymer, Synthetic biodegradable polymer and modified naturally biodegradable polymer. Non-biological and biological degradable polymer, Bio derived Polymers – Biodegradation and its Evaluation techniques – Standards for biodegradation – Need for biodegradation of packaging materials – Introduction to Life Cycle Assessment – Monomers from biosources.	**15 Hrs**	**1,2**
2	**Green chemistry for polymers** Raw materials for polymers – Sustainability of Petroleum resources – Need for Alternate Sources for Polymers -Polymer Recycling and Environmental Issues – Bio derived Polymers – Biodegradation and its Evaluation techniques – Standards for biodegradation – Need for biodegradation of packaging materials – Introduction to Life Cycle Assessment – Monomers from biosources.	**15 Hrs**	**2,3**
3	**Proteins, hemicellulose and cellulose based biopolymers** Plant and animal based Proteins – Solution casting of proteins – Processing of proteins as plastics – preparation and properties of hemicellulose – Cellulose based Composites -Surface and Chemical modifications of Cellulose fibers.	**15 Hrs**	**3,4,5,6**
4	**Biopolymer applications in agriculture**	**15 Hrs**	**7,8,9**

	Biopolymer Films – Biodegradable mulching – Advantages and Disadvantages – Chemical sensors – Biosensors – Functionalized Biopolymer Coatings and Films – Applications of biopolymers in horticulture **Polymer based bio nanocomposites as advanced biomaterials:** Basic concepts of biopolymers, Nanofillers, Preparation: solvent casting, electrospinning, freeze drying, 3D printing, properties, characterization and applications, biodegradability of polymers. Polymers as biomaterials, Micro computed tomography and radiopaque polymers which have potential application in biomedical field including pace maker ,total artificial heart, tissue regeneration, where stimuli responsive, biodegradable/bioactive/radiopaque polymers		

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **Q. Continuous Internal Assessment (CIA)** Surprise test Internal Test – Objective and descriptive answer type Submitting assignments Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **R. Semester End examination**

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MAHATMA GANDHI UNIVERSITY

INM22E06: STATISTICAL MECHANICS

School / Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE) ,** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**
Programme	**M.Tech. Polymer Science and Engineering**
Course Name	**STATISTICAL MECHANICS**
Type of Course	**Elective**
Credit Value	**3**
Course Code	**INM22E06**

Course Summary & Justification	This course provides an introduction to the microscopic formulation of thermal physics. It starts with the fundamental concepts of thermodynamics and builds on its foundation, the principles of statistical mechanics					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		40	40		40	120
Pre-requisite	The basics of Thermodynamics and Quantum mechanics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome Upon completion of this course, students will be able to;	Learning Domains	PSO No.
1	Understanding of thermodynamic laws and Maxwell's equations	U	1,3,7
2	Contact between statistics and thermodynamics	U	3,4,5
3	Thermo dynamical relations in a canonical ensemble	U, A	2,3,7
4	Physical significance of statistical quantities	An	1,2,4,5,6
5	Behaviour of ideal gas in quantum mechanical micro canonical ensemble and other quantum mechanical ensemble	U,An	2,5,7

6	Thermodynamics of Black body radiation	A	2,5,6
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

COURSE CONTENT

Module No:	Module Content	Hrs	CO. No.
1	**Thermodynamics and Statistical theory** Laws of thermodynamics and their consequences. Thermodynamic potentials and Maxwell's relations. Chemical potential. Phase equilibriam. The macroscopic and microscopic states –contact between statistics and thermodynamics – the classical ideal gas – entropy of mixing and the Gibb's paradox – Phase space of a classical system – Liouville's theorem and it's consequences – The micro canonical ensemble – quantum states and phase space – The equipartition theorem The Virial theorem	**15**	**1,2**
2	**The Canonical and grand canonical ensemble** Equilibrium between a system and heat reservoir – a system in the canonical ensemble – thermo dynamical relations in a canonical ensemble – the classical systems – energy fluctuations in the canonical ensemble: correspondence with micro canonical ensemble – equilibrium between a system and a particle energy reservoir – a system in the grand canonical ensemble – physical significance of statistical quantities – density and energy fluctuations in the grand canonical ensemble	**15**	**3,4**
3	**Quantum statistics** Quantum mechanical basis – statistical distribution – an ideal gas in quantum mechanical micro canonical ensemble and other quantum mechanical ensemble – Partition functions and other thermodynamic quantities of monatomic and diatomic molecules. Thermodynamic behavior of a Bose gas – thermodynamics of Black body radiation – Bose Einstein condensation	**15**	**4**
4	**Theory of Phase transition and fluctuations** Problem of condensation -Ginzburg – Landau theory – Ising model and it's solution for a linear chain – equivalence of Ising model to other models – Lattice gas and binary alloy. Fluctuations – Brownian motion – Langevin equation	**10**	**5,6**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Tutorials, Seminar, Assignments, Authentic learning, Library work, independent studies, Presentation by individual student
Assessment Types	**Mode of Assessment** **S. Continuous Internal Assessment (CIA)** • Surprise test • Internal Test – Objective and descriptive answer type • Submitting assignments • Seminar Presentation – select a topic of choice in the concerned area and present in the seminar **T. Semester End examination**

REFERENCES

1. Introductory Statistical Mechanics, R. Bowley&M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chaptr 11& 12)
2. Statistical Mechanics, R.K. Pathria, & P.D. Beale, 2nd Edn, B-H (Elsevier) (2004).
3. Statistical Mechanics, Kerson Huang, John Wiley and Sons (2003).
4. Statistical mechanics and properties of matter – E S R Gopal
5. Statistical thermodynamics - M C Gupta
6. An introduction to thermodynamics- Y V C Rao
7. Fundamentals of Statistical Mechanics, B. B. Laud, New Age International.
8. Statistical Mechanics, B.K. Agarwal and M. Eisner, Wiley Eastern
9. Elements of Statistical Mechanic, Kamal Singh, S P. Singh, S. Chand & Co
10. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. Oxford University Press
11. Fundamentals of Statistical Mechanics, A.K. Dasgupta, New Central Book Agency Pub. (2005

	MAHATMA GANDHI UNIVERSITY
	INM22E07: Industrial Internship

School / Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE), International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**					
Programme	**M.Tech. Polymer Science and Engineering**					
Course Name	**Industrial Internship**					
Course Credit	**3**					
Type of Course	**Elective**					
Course Code	**INM22E07**					
Course Summary & Justification	The Industrial visit/ Review shall be conducted by the International and Inter University Center for Nanoscience and Nanotechnology. The students have to visit an industry in the presence of a faculty member of the Centre during the programme and submit a report on the same at the end of the second semester.					
Semester	**II**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Visiting the industry and interacting with the personnel	-	-	-	-	-
Pre-requisite	Basic knowledge in chemistry practicals and industrial chemistry					

1	Demonstrate the applications of chemical concepts and principles learned in classroom.	A	1, 2, 3
2	Illustrate processes and products manufactured in the chemical industries.	A	2, 4
3	Develop awareness of the principles and technological aspects in the chemical industries.	C	2
4	Improve interpersonal skill by communicating directly with industrial personnel.	S	5
5	Aware of the impacts of industrial processes on health, safety, environment and society.	E	6, 7

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Main aim of industrial visit is to provide an exposure to students about practical working environment. They also provide students a good opportunity to gain full awareness about industrial practices. Through industrial visit students get awareness about new technologies.
Assessment Types	**Mode of Assessment** The report shall be evaluated by the Examination Board consisting of the Chairman, the Internal Examiner.

SEMESTER III & IV

	MAHATMA GANDHI UNIVERSITY
	INM22C13: Main Project Work, Viva and thesis defense & **Comprehensive Viva Voce**

School / Centre Name	**International Unit on Macromolecular Science and Engineering (IUMSE),** **International and Inter University Centre for Nanoscience and Nanotechnology (IIUCNN)**					
Programme	**MTech. Polymer Science and Engineering**					
Course Name	**Main Project Work, Viva and thesis defense** & **Comprehensive Viva Voce**					
Course Credit	**36**					
Type of Course	**CORE**					
Course Code	**INM22C13**					
Course Summary & Justification	The candidate shall do a research project in any of the research institute. This follows discussion with the Examination Board consisting of the Chairman and the Internal Examiner. The comprehensive viva-voce shall be conducted by the Examination Board consisting of the Chairman and the Internal Examiner . The relevance and significant features will be analysed.					
Semester	**III & IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Library work, lab work, Team work, independent learning	-	-	-	-	-
Pre-requisite	Excellent Lab skills and knowledge of different characterization techniques; Basic as well as in-depth knowledge in the courses he/she studied					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course the students are expected to		
1	To clearly present and discuss the research objectives, methodology, analysis, results and conclusions effectively.	A	2, 3, 4, 5
2	Acquire a comprehensive knowledge of the area subject of study	Ap	1, 7
3	Gain deeper knowledge of methods in the topic of study.	A	6
4	Able to contribute to research and development work.	U	3
5	Undertake independent, original and critical research on a relevant topic.	U	5
6	Able to plan and use adequate methods to conduct specific tasks in given frameworks and to evaluate this work.	U	6,9
7	Create, analyse and critically evaluate different problems and their solutions.	C	7,8
8	Gain a consciousness of the ethical aspects of research.	E	6,9
9	Acquire more in-depth knowledge of the major subject of study	Ap	1,2,3,4,5,6,7
10	Deeper knowledge of methods in the major subject of study.	A	1,4,8

Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction:, Seminar, Authentic learning, , Library work, laboratory work, Team work, independent learning and Group discussion, Presentation of research work.
Assessment Types	**Mode of Assessment** Evaluation of the presentation by both internal and external examiners. The candidate will be asked questions based on the whole syllabus he/she studied in the entire programme. How he/she answered or responded the questions asked will be considered for evaluation.