

SARDARPATELUNIVERSITY
FACULTY OF SCIENCE
COURSE OF STUDY
RULES OF DEGREE OF THE MASTER OF SCIENCE
M.Sc. POLYMER SCIENCE AND TECHNOLOGY

R.PG.Sc.1: A candidate who has obtained the degree of Bachelor of Science of the University or of any other University recognized as equivalent thereto with Industrial Chemistry, Industrial Chemistry(vocational), Chemistry, any branch of chemistry or Chemistry as one of the major subject may, after successful completion of the course work etc. prescribed for the M.Sc. degree examination, for a period of two years subsequent to his passing the B.Sc. degree examination, be admitted to the examination for the degree of M.Sc. in the respective subject as per the regulation prescribed in that behalf.

The degree of Master of Science will be taken by papers and practicals only.

R.PG.Sc.2: The examination of the various theory papers and laboratory work will be conducted under semester system. For this purpose each academic year will be divided into two semesters.

R.PG.Sc.3: Candidates will be examined in each Theory paper for 100 marks and practicals for 200 marks wherever prescribed at the end of each semester. There shall be a viva-voce examination of 50 marks at the end of each semester to be held by the university.

For deciding result of M.Sc. examination in each semester the ratio between the internal assessment and external assessment will be 30:70.

1. Theory:

There are four theory courses in a semester each of 100 marks. Of these 30 marks are assigned to internal assessment. The breakup of these 30 marks of each course shall be as under:

- | | |
|------------------------|----------|
| • Tests | 20 Marks |
| • Quiz | 5 Marks |
| • Seminar + Assignment | 5 Marks |

2. Practicals:

The practical courses in each semester carry 200 marks. Of these 60 marks are assigned to internal assessment.

The breakup of these 60 marks for internal assessment shall be as under

- | | |
|------------------------------------------------------|----------|
| • Tests | 40 Marks |
| • Weekly attendance, Regularity, Lab. Skill, Journal | 10 Marks |
| • Viva | 10 Marks |

R.PG.Sc.4: Candidate shall be required to attend at least 75% of total theory, lectures and practicals under each of the courses during the semester.

R.PG.Sc.5:

- i) The Head of department in consultation with other teachers if the department will prepare in the beginning of the year a detailed scheme of seminars, home work, quizzes, etc. and the programme for the test examinations and the same will be announced to the candidates.
- ii) The records of the test examinations as well as seminars, home work, quizzes, etc. will be maintained by the department concerned.
- iii) Every candidate shall maintain a regular record of his/her practical work which shall be duly certified by his/her teacher(s) from time to time.

R.PG.Sc.6: Candidates will be required to obtain at least 33% marks in the internal evaluation separately in each head of passing. A candidate who fails to obtain 33% marks in not more than two heads of passing, may be allowed to appear at the university examination by the head of department concerned on the recommendation of the committee appointed by him/her to assess the candidate's overall performance.

(Note: A head of passing will mean a course in theory or practicals)

R.PG.Sc.7: A candidate desirous of appearing at each semester examination may forward his application in the prescribed form to Registrar through the Head of the University Post-Graduate Department concerned on or before the date prescribed for the purpose under the relevant ordinances.

R.PG.Sc.8: The final result for the award of the degree will be declared on the basis of the grand total marks of all the Theory papers, Practicals and viva-voce prescribed for all semesters examinations for the said degree.

R.PG.Sc.9: Only those students who fail in not more than two heads of passing at each semester examination be allowed to keep terms at the next semester. No Candidate will be allowed reappear in course in which he/she has already passed.

R.PG.Sc.10: The standard of passing:

The standard of passing at the M.Sc. degree examination will be as under:

- a) To pass any semester for the M.Sc. degree, a candidate must obtain at least 40% marks at the University Examination and 40% marks in the aggregate of University and Internal examination in each course of theory, practical and 40% marks in viva-voce Examination.
- b) Award of Classes:
 - 1) Those successful candidates will be placed in Second Class if they obtain at least 50% or more marks in the aggregate of all semesters examinations taken together.
 - 2) Those successful candidates will be placed in First Class if they obtain at least 60% or more but less than 70% marks in the aggregate of all semester's examinations taken together.

- 3) Those successful candidates will be placed in First Class with Distinction if they obtain 70% or more in the aggregate of all semester's examinations taken together will be declared to have passed the examination in First Class with Distinction.

R.PG.Sc.11:

i) A candidate who fails in more than two courses (any two of the total heads of passing in the particular semester) in a particular semester will not be admitted for further study at a subsequent semester and will be required to repeat the courses in which he/she has failed by joining the department as a regular student in the semester in which these courses are again offered. A candidate failing in not more than two courses at any semester examination will be promoted to the subsequent semester according to the following scheme.

ii) A candidate failing in the First Semester will be permitted to pursue his/her study up to the Third Semester will not be permitted to go to the Fourth Semester even though he/she may have passed in the Second and/or Third Semester. A candidate failing in the Second Semester will be permitted to pursue his studies up to the Fourth Semester.

Semester 1(Total 650 marks)

Course No	Paper	Hours per week	Credits	Internal Marks	External Marks	Total Marks
PS01CPST01	Technology of polymer processing	3+1Seminar= 4hrs	4	30	70	100
PS01CPST02	Organic & Polymer Chemistry	3+1Seminar= 4hrs	4	30	70	100
PS01CPST 03	Industrial Management& Psychology	3+1Seminar= 4hrs	4	30	70	100
PS01EPST 01 PS01EPST 02	Industrial Chemistry-1 Material Science	3+1Seminar= 4hrs	4	30	70	100
PS01CPST04	Identification &Characterization of raw materials & polymers	6 hrs	4+4	60	140	200
PS01CPST05	Engg operation Practicals	6 hrs				
PS01CPST06	Viva Voce				50	50

Semester II (Total 650 Marks)

Course No	Paper	Hours per week	Credits	Internal Marks	External Marks	Total Marks
PS02CPST01	Petrochemicals	3+1Seminar= 4hrs	4	30	70	100
PS02CPST02	Polymer Characterisation	3+1Seminar= 4hrs	4	30	70	100
PS02CPST 03	Industrial Polymers	3+1Seminar= 4hrs	4	30	70	100
PS02EPST 01 PS02EPST02	Industrial Chemistry-2 Industrial Process Chemistry	3+1Seminar= 4hrs	4	30	70	100
PS02CPST04	Analysis of Industrial Chemicals	6 hrs	4+4	60	140	200
PS02CPST05	Polymer processing practicals	6hrs				
PS02CPST06	Viva-Voce				50	50

Semester 1III (Total 650 Marks)

Course No	Paper	Hours per week	Credits	Internal Marks	External Marks	Total Marks
PS03CPST01	Polymer Composites, Blends &Adhesives	3+1Seminar= 4hrs	4	30	70	100
PS03CPST02	Rubber Technology	3+1Seminar= 4hrs	4	30	70	100
PS03CPST 03	Fiber technology	3+1Seminar= 4hrs	4	30	70	100
PS03EPST 01 PS03EPST02	Sophisticated instrumental analysis Polymer processing tool design	3+1Seminar= 4hrs	4	30	70	100
PS03CPST04 PS03CPST05	Synthesis of polymers Advanced Polymer Processing Advanced polymer processing	6 hrs 6 hrs	4+4	60	140	200
PS03CPST06	Viva-Voce				50	50

Semester 1V (Total 650 Marks)

Course No	Paper	Hours per week	Credits	Internal Marks	External Marks	Total Marks
PS04CPST01	Polymer Rheology	3+1Seminar= 4hrs	4	30	70	100
PS04CPST02	Polymer Additives	3+1Seminar= 4hrs	4	30	70	100
PS04CPST 03	Specialty polymers	3+1Seminar= 4hrs	4	30	70	100
PS04EPST 01 PS04EPST02	Industrial hygiene & Safety Selected topics in Industrial Chemistry	3+1Seminar= 4hrs	4	30	70	100
PS04CPST04	Practicals–Project	16 hrs	8	60	140	200
PS04CPST05	Viva-Voce				50	50

SEMESTER 1

CORE COURSES

PS01CPST01: Technology of Polymer Processing

Principles of Polymer processing: Introduction to Polymer Processing, Melt processing of thermoplastics and melt processing of thermosetting polymers, Introduction to mixing, Types of mixers- Twin drum tumbler, ribbon blender, high speed mixer, ball mill and Cowles dissolver, two roll mill, Banbury mixer,

Compression & Injection Moulding: Fundamental principles, Melt processing of thermoplastics and melt processing of thermosetting polymers, Materials- factors to be considered while processing, Techniques of preheating, Types of compression & injection moulding, Comparison with transfer moulding, Specifications of injection moulding machine – injection & clamping unit.

Extrusion, Calendering & Blow moulding: Fundamental principles, operation of single screw & twin screw extruder, Extrusion blow moulding, Injection blow moulding and Stretch blow moulding, calendaring process.

Thermofoming, Rotational moulding, Casting processes & Polymer foam: Fundamental principles, Materials, general production method, Types, processes, applications.

Reference Books:

1. Polymer Processing, Morton & Jones, Chapman & Hall.
2. Plastics Engineering, R. J. Crawford, Maxwell Macmillan International.
3. Plastics Engineering Handbook, M.L. Berins, Van Nostrand Reinhold, New York.
4. Plastics Engineering Handbook, Joel Frados, Van Nostrand Reinhold, New York.
5. Plastics Processing Data Hand Book, Dominick. V. Rosato and Donald V. Rosato, Van Reinhold Nostrand, New York.
6. Plastics materials & Process, H. Goodman, Van Nostrand Reinhold Company, New York.
7. Plastics materials and processes, Seymour S. Schwartz and Sidney, H. Goodman, Van Nostrand Reinhold.
8. Principle of Polymer Processing, R.T. Fenner, Maxwell McMillan International Edn, London.
9. Plastics Extrusion Technology Handbook, Sidney Levy and James F. Carley, Industrial Press, New York.1989.
10. Plastics Extrusion Technology, FriedhlmHanser, Hanser Publications, New York.
11. Dies for plastics extrusion, M.V. Joshi, Macmillian India Ltd, India.
12. Mixing in Polymer Processing, Chris Rauwendaal, Marcel Dekker, New York.
13. Blow Moulding Handbook, Dominic Rosato and Donald Rosato, Nostrand Reinhold, New York.

PS01CPST02: Organic & Polymer Chemistry

Preparations and applications of following reagents: Aluminium tertiary butoxide, BF₃, DCC, Ozone, Per benzoic acid, Pt & Pd, Selenium, Per iodic acid, PPA, Di azo acetic ester.

Selected Name reactions and Rearrangements: Aldol condensation, Arndt-eistert, Cannizzaro, Darzen, Dakin, Diels-alder, Elbs persulphate, HoubenHoesch, Knoevenagel, Leucarts, Meerwinpondorffverely, Pechmann, Perkin, Wurtz, Reimertiemann, Wolfkishner, Wurtz-fittig.

Introduction to Polymer Science: Importance of polymers, Basic concepts, Classification of polymers, Thermoplastics, thermosetting behavior, tacticity in polymers, average molecular

weight concept, Polydispersity and molecular weight distribution, Crystallization of polymers, degree of crystallinity, glass transition temperature (T_g). Chemistry of polymerization and its techniques: Addition polymerization- free radical, ionic, co-ordination polymerization, Condensation polymerization, Copolymerisation, Polymerization techniques.

Polymer Degradation: Introduction, Types of degradation- thermal degradation, mechanical degradation, degradation by ultrasonic waves, photo degradation, degradation by high-energy radiation, oxidative degradation and hydrolytic degradation and biodegradation.

References:

1. Organic Synthesis based on Name reaction and unnamed reaction, A.Hassner&C.Stummer, Pergamon press. 2nd edition
2. Advanced Organic Chemistry- Reaction Mechanism & Structure, J.March, John Wiley & Sons. 4th edition
3. Organic Chemistry Vol 1 &Vol 2, I.L.Finar, Long man Scientific. 5th edition
4. Reaction mechanism and reagents in organic chemistry, G.Chatwal, Himalaya publishers.
5. Organic chemistry, warren, oxford university press.
6. Polymer Science, V.R.Gowarikar, New age International, Mumbai
7. Introduction to polymer Chemistry, P.J.Flory, Asian Books
8. Polymer Technology, Miles&Briston, J.G.Chemical Publishing Company, New York

PS01CPST03- Industrial Management & Psychology

Human Resource Management: Introduction, Acquisition of Human resources, Development of human resources, Motivation of human resources.

Financial & Marketing Management: Nature and scope of financial management, financial statement and analysis, funds flow, cash flow, cost concepts, financial planning, investment planning and analysis, budgeting and business plan. Introduction, analyzing marketing opportunities, developing marketing strategies, planning marketing programmes.

Psychology In Industry: Causation in behavior. Attitude, Frustration, Morale and group processes, Causes of stress, duration and intensity of stress. Stress and job performance, stress threshold, personality and stress. Stress Management.

Psychological Tests: Design of jobs. Industrial training. Motivation. Fatigue.

References:

1. Marketing Management, Philip Kotter, Prentice- hall India 9th edition.
2. Personal or Human Resource & Personnel Management, D.A Decenzo, S.P. Robbins, PH India pub. 3rd edition.
3. Industrial Marketing Strategy, Fredrick Webster, 3rd edition, John wiley& Sons.
4. N. R. F Maier, Psychology in industry, Oxford and I B H Publishing co.
5. T. W. Harwell., Industrial Psychology, Oxford and I B H Publishing co.
6. Keith Davis & John . W. Newsyrom, Human Behaviour at work, 8th Edn. McGraw Hill
7. V.O. Jenks, Human Relations in Organizations Haper& Row (1990)
8. M. L. Blum, J. C. Naylor, Industrial Psychology, CBS Publishers

ELECTIVES

PS01CPST 01: INDUSTRIAL CHEMISTRY 1

Distillation: Enthalpy concentration diagrams, Use of Ponchon Savarit method in the design of multistage tray towers and packed towers. **Gas Absorption:** Choice of solvent for absorption, Minimum Liquid- Gas ratio for Absorbers, HETP in continuous contact equipments.

Liquid- Liquid Extraction: Choice of solvent for extraction, Binodal solubility curves, Calculations for single stage and multi stage cross & countercurrent extraction, Differential Extractors. **Drying:** Rate of batch drying, calculations for cross and through circulation drying, Rate of drying for continuous driers, Hold up in rotary driers. **Filtration:** Theory of Filtration, Filtration Calculations, Filtration in centrifuges.

Boundary layer concept, Calculations for reciprocating and centrifugal pumps, Use of air vessels in pumps, Vapour locking and NPSH. Design of flow meters. Pressure and Vacuum producing devices. Dimensionless analysis using Rayleighs and Buckingham Π method.

Motion of particles through fluids: Terminal settling velocity of particles settling under Stokes, Intermediate and Newton's range in free & hindered settling, Mechanism of fluidization, Design of fluidized bed columns

References :

1. Mass Transfer Operations, Robert Treybal, Mc.Graw Hill Co. 3rd Edition.
2. Unit Operations of Chemical Engineering, W. Mc.Cabe, J. Smith, Mc.Graw Hill Co 7th edition.
3. Chemical Engineering., Vol. 1 to VI , Coulson & Richardson, Pergamon Press. 3rd edition.
4. Fundamentals of Engg. Heat & Mass Transfer, R.C. Sachieve, Wiley Ltd.
5. Basic Principles and Calculations in chemical engg., D. Himmelblau, Prentice Hall
6. Chemical Engg. Handbook, Robert Perry. 7th edition.

PS01EPST02: Materials Science

Crystalline Solids: Crystal symmetry, crystal systems, crystal planes X-ray and neutron diffraction from crystals – structure determination. Bonding in crystals – ionic, covalent, metallic and molecular bonds, bond energies, imperfection in crystals – defects dislocations.

Mechanical Properties: Elastic deformation, Anelastic deformation, viscous deformation, plastic deformation, mechanical testing, fracture, fatigue, creep and environment assisted cracking.

Metals and Alloys: Solid phases, solid solutions-alloys-Hume Rothery Rules, phase rule, phase diagram, binary system, iron and cast iron – sheet- alloys for high temperature.

Ceramic and Polymers: Classification of ceramics – structure of ceramics electrical properties of ceramics, thermal and mechanical properties, refractories and glasses – polymers properties of polymers in relation to other material.

Reference Books:

1. Materials Science & Processes – S.K. HajraChoudhury
2. A first course in Materials Science – V.Raghavan
3. Materials Science – J.C.Anderson&K.D.Lever
4. Introduction to solid state Physics – C.Kittel
5. Introductory Materials Science – M.J.Starfird&A.M.Sharanger

Practicals

PS01CPST04: Identification & Characterisation of raw materials & polymers

PS01CPST05: Engineering Operation practical

SEMESTER 2

CORE COURSES

PS02CPST01: Petrochemicals

Introduction: Petrochemical, Development of petrochemical industry, Petroleum refining, Petrochemical feed stocks from petroleum refining, The basic building block processes, Petrochemical process technology, Costs in chemical processing, Primary raw materials for Petrochemicals like Natural gas, Crude oils, coal, oils shell, tar sand and gas hydrates.

Crude Oil Processing and Production of Hydrocarbon: Introduction, Physical separation Processes, Conversion Processes, Production of Olefines, Paraffinic hydrocarbon, olefins hydrocarbons, dienes, aromatic hydrocarbons, liquid petroleum fraction and residues.

Alkanes and higher Paraffin based Chemicals: Introduction, Chemical based on synthetic gases, Chemical based on direct reaction of methane, ethane, propane and naphtha based chemicals from high molecular weight n-paraffin.

Chemicals based on olefin diolefin and aromatic hydrocarbon: Introduction, Chemicals from n-butenes, isobutylenes, butadiene, benzene, toluene, xylene.

Reference Books:

1. Chemistry of Petrochemical Process, Sami Matar, Lewis F. Hatch, Gulf Professional Publishing, Boston.
2. Fundamental of Petroleum Chemical Technology, P. Belov, Mir Publications, Moscow.
3. Advanced Petroleum Refining, G. N. Sarkar, Khanna Publishers, Delhi
4. Petrochemicals, Peter Wisheman, John Wiley & Sons, New York.

PS02CPST02: Polymer Characterization

Importance of Quality control and Characterization of molecular weight: Importance of specification & standards in quality control of polymers, Preparation of polymer test specimens and conditioning, determination of molecular weight by Ultra Centrifugation, Gel Permeation Chromatography. End Group Analysis, Ebulliometry, Cryoscopy, Osmometry, and viscometry.

Material Characterization test: Introduction, Melting point, Softening point, Thermal conductivity, Shrinkage, Melt Flow Index test, Particle size, Density, and bulk factor, Water and Moisture absorption.

Mechanical, Electrical and Flammability test: Introduction, Hardness, Tensile strength, Compression strength, Flexural strength, Impact strength, Dielectric strength, Dielectric constant, Insulation resistance and arc resistance, Ignition properties, Oxygen index test and smoke generation tests.

Chemical and Weathering properties: Immersion test, Stain resistance test, Solvent stress cracking resistance test, Environmental stress cracking resistance test, Accelerated weathering test, Outdoor weathering of polymers.

Reference Books:

1. Handbook of plastics test method, R. P. Brown, Longman Scientific and Technical.
2. Handbook of plastics testing technology, Vishu Shah, John Wiley & Sons, New York.
3. ASTM, BIS, ISO standards.
4. Instrumental methods of Analysis, Will and Merritt, CBS Publisher, New Delhi.
5. Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler and Timothy A. Nieman, Harcourt Brace Coolege Publishing, Philadelphia.
6. Encyclopedia of Polymer science and Engineering, Wiley Inter science, New York.

PS02CPST03: Industrial Polymers

Thermoplastics materials: Synthesis of monomers, Polymerization, Structure related properties, general properties and applications of various thermoplastics materials like polyolefin's, viz. Polyethylene, Polypropylene, olefinic copolymers, Vinyl polymers, Fluorine-containing Polymers, Poly(vinyl acetate) and its derivatives, Acrylic plastics, plastics based on Styrene and Cellulose plastics.

Engineering thermoplastics: Intermediates for Polyamides, polymerization of aliphatic polyamides, their structure and applications, Polyimide. Structure, properties and applications of Polyacetals and Polycarbonates.

Thermosetting materials: Manufacture, curing and application of Epoxide resins, Unsaturated Polyester resins, Polyurethanes, Phenolic resins, Urea-formaldehyde resins, Melamine-formaldehyde resins, Furan resins.

Thermoplastics elastomers: Introduction, Structure related properties, general properties and applications of various TPE like styrenics, polyesters, thermoplastics poly urethanes (TPU), polyamides and thermoplastics olefinic elastomers (TPO).

Reference books:

1. Fundamental principles of polymer materials practices for engineers, Plastics Materials, Stephen L. Rosen, Barnes & Noble, New York.
2. Plastics Materials, J. A. Brydson, Butterworths, London.

3. Polymer Technology, Miles & Briston, J. G, Chemical Publishing company, Inc, New York.
4. Plastics Materials and Processes, Seymour S. Schwartz S.H. Goodman, Van Nostrand Reinhold, New York.
5. Plastics Technology, R. V. Milbey, McGraw Hill, Book Company New York,
6. Polymer science and Technology of Plastics and Rubber, P. Ghosh, McGraw hill, New York.
7. Engineering Plastics, R.W. Dyson, Chapman & Hall, New York.

ELECTIVES

PS02EPST01- Industrial Chemistry-2

Introduction to heat transfer modes, heat transfer equipments used in polymer industry

Calculations for heat transfer equipments

Mass balance with and without chemical reaction

Energy balance with and without chemical reaction

References

1. Unit Operations of Chemical Engineering, W.Mc.Cabe, J. Smith, Mc.Graw Hill Co 7th edition
2. Chemical Engineering, Vol 1 to VI, Coulson & Richardson, Pergamon Press. 4th edition
3. Engineering Heat Transfer, C.P. Gupta, R. Prakash, Nomchand & Bros., Roorkee. 7th edition.
4. Process Heat Transfer, D.Q. Kern, Mc.Graw Hill Co.
5. Fundamentals of Engg. Heat & Mass Transfer, R. C. Sachieve, Wiley Ltd.
6. Basic Principles and Calculations in chemical engg., D. Himelblau, Prentice Hall
7. Stoichiometry, H. T. Bhatt, S. M. Vora, Tata Mc.Graw Hill Co. 3rd edition.
8. Chemical Process Principles, Vol I, Houghen, Watson, Asian Pub. House

PS02EPST02- Industrial Process Chemistry

Study of following processes with special emphasis on chemistry & chemical engineering principles of following processes:

Halogenation, Alkylation,

Oxidation, Hydrogenation, Nitration, Sulphonation,

Hydrolysis, Esterification, Hydration.

Synthesis Based On Carbon Monoxide and Hydrogen.

References:

1. Unit processes in organic synthesis, Groggins, Tata McGraw Hill pub. 5th edition
2. Chemistry of petrochemical processes, Sami Mater, Lewis Hatch, Gulf Professional pub. 2nd edition
3. Industrial Organic Chemistry, K. Weissermal, H.J. Arpe, Wiley VCH. 4th edition
4. Chemistry and technology of basic organic and petrochemical synthesis, N.N. Lebedev, Mir pub.

Practicals

PS02CPST04: Analysis of Industrial Chemicals

PS02CPST05: Polymer Processing practicals

SEMESTER 3

CORE COURSES

PS03CPST01-- Polymer Composites, Blends & Adhesives

Composites: Introduction to composite materials, definitions, classifications, applications, advantage and disadvantages of composites, types of mold for composites and preparation of molds, release agents, core materials, coupling agents, fillers and pigments, gel coats, equipments and tools used for preparation of composites, Sheet moulding compounds (SMC), Dough moulding compounds (DMC) and Prepregs.

Processing of composites: Composites processes like Hand lay up, Spray lay up, Vacuum bag, Pressure bag, Autoclave moulding, Cold press, Hot press moulding, Resin injection, Resin transfer moulding, Foam reservoir, Filament winding, Centrifugal casting, Pultrusion, continuous laminations, Troubleshooting and remedies for composite processing.

Compatibilization: Practical compatibilization, factors affecting miscibility, compatibilization by Physical processes, Physical additives, polymer modifications for physical compatibilization, reactive compatibilizers and reaction mechanism.

Adhesives: Concepts and terminology, Classification of adhesives, advantages and disadvantages of adhesives bonding, joint design, adhesive selection, adhesive properties surface preparation and bonding process. Solvent cementing of thermoplastics, cementing of thermosetting Polymer, Welding of thermoplastics, Ultrasonic assembly.

Reference Books:

1. Polymer blends and Composites, L.H. Sperling, Published by Plenum Press.
2. Handbook of Plastics Elastomers and Composites, Charles A Harper, McGraw Hill, New York.
3. Plastics Engineering, R.J. Crawford, Maxwell Macmillan International, New York.
4. FRP technology- Fiber reinforced Resin systems, Weatherhead, Applied Science, and London.
5. Handbook of Reinforcements for plastics, Milewski Katz, Van Nostrand Reinhold, New York.
6. Polymer Engineering Composites, M.C. W Richardson, Published by Applied science, London.
7. Multi component polymer systems, I.S. Miles and S. Rostami, Chapman & Hall, New York.
8. Polymer blends and Alloys, G.O. Shonaike and G.P. Simon, Marcel Dekker Inc, New York.
9. Polymer Blends, Vol 1& 2, D.R. Paul and Seymour Newman, Published by Academic Press, New York.
10. Adhesives Handbook, Butterworth's, J. Shields.

PS03CPST02:Rubber Technology

General Introduction to Individual Rubbers:Introduction & general poroperties of rubber, Manufacture, structure, properties and application of Styrene butadiene rubber(SBR), Isoprene rubber, Butadiene rubber(BR), Ethylene – propylene rubber, Chloroprene rubber, Acrylonitrile – butadiene rubber, Butyl rubber.

Specialty rubber: polyurethanes, Fluorocarbon rubbers, Epichlorohydrin rubber, Polysulphide rubber, Silicon rubber Manufacture, properties, and application of different thermoplastics elastomers.

Rubber processing: Processing of field latex, preserved filed latex, latex concentrate, Ribbed smoked sheets, technically classified rubber, superior processing rubber etc.

Rubber Compounding and Chemistry of vulcanization: Introduction, vulcanizing agents, Vulcanizing accelerators, Fillers, antidegradents, softners, plasticizers, processing aids etc. relation between curing system and properties.

Reference Books:

- 1) Basic Compounding and Processing of Rubber, Harry Long, American Chemical Society, New Jersey.
- 2) Rubber Handbook, Vanderbilt, Vanderbilt World trade cooperation, New York.
- 3) Rubber Technology and Manufacture, C.M. Blow, Butterworth, London.
- 4) Rubber Technology Handbook, Hofman.
- 5) High Polymer Latices, D.C. Blackly
- 6) Applied science of Rubber, William, and J.
- 7) Polymer Processing, Morton Jones. Chapman & Hall.
- 8) Polymer Processing, McKelvey.

PS03CPST03: Fibre Technology

Introduction to fibre Technology:Defination of fibres, Classification and nomenclature of fibres, Definition of various textiles terms, structure principles of fibre forming polymers, Principles of finishing and dyeing of manmade fibre.

Natural & Synthetic fibre:Introduction, Cotton, Rayon, Cellulose acetate, Wool, Polyamide, Acrylic fibre, Polyethylene terephthelate, Polyolefines, Spandex, Glass, Asbestos, Steel fibres.

Spinning & Finishing of fibre: Introduction, Melt spinning, Solution spinning, Dry spinning, Gel spinning, Wet spinning

Textile Material for Rubber Reinforcement: Introduction, Basic classification, Definition of fundamental concepts and properties of textile reinforcing material, Production of cord and fabrics, Adhesive and heat treatment, Reinforcing system of individual rubber products, Testing methods for cord and fabrics.

Reference Books:

1. Manmade fibres by R.W. Moncrieff

2. Modern Textiles by Dorothy Lyle
3. Essentials of Textiles by M.J. Joseph
4. Physical Methods of Investigating textiles by R. Meredith and J.W.S. Hearle
5. Textile fibres and their use by K.P. Hess
6. Textile – Fibre to Fabric by B.P. Corbman
7. Dying and chemical technology by E.R. Trotman
8. International fibre science and technology series Vol. 5.

ELECTIVES

PS03EPST01: Sophisticated Instrumental Analysis

Elementary principles, Instrumentation, sampling methods and application of FTIR, ¹HNMR, ¹³C NMR ,

Mass Spectrometry for the structural elucidation of organic compounds. Introduction to 2D-NMR and LC-MS/MS

Theory, Instrumentation and applications of HPLC, HPTLC

Introduction and instrumentation of Atomic Absorption spectroscopy, XRD & SEM with special emphasis on polymer products

References:

1. Organic Spectroscopy, William Kemp, ILBS 3rd edition
2. Spectrometric identification of organic compounds, Silver stein, John Wiley pub. 6th edition.
3. Applications of absorption spectroscopy of organic compounds, J.R. Dyer. 10th reprint.
4. Instrumental methods of chemical analysis, B.K. Sharma, Goel pub., 26th edition.
5. Instrumental Methods of analysis, Willard and Dean, CBS, 7th edition.
6. Spectroscopy of organic compounds, P.S. Kalsi. Willey eastern ltd.
7. HPTLC, D. Sethi, CBS 2nd edition.

PS03EPST02: Polymer Processing Tool Design

Mould making: Introduction, Common machine tools, Processes employed for mould making, machine tools, Casting, Electro-deposition, cold hobbing, pressure casting, spark machining, bench fitting, Materials for mould making, CAD/CAM.

Injection mould Design: General Mould construction, Basic terminology mould cavities, Materials and process employed for mould making, General mould construction- types of injection moulds, cavities and core, bolsters, ancillary items, mould mounting, attachment of mould to the plate, Ejection: Ejector grid, ejector plate assembly, Ejection techniques, Sprue pullers.

Feed system- runners and gates design. Venting and Parting surfaces, Mould cooling and shrinkage allowances on moulds: Cooling of integer moulds, insert moulds, insert -bolster

assembly and mould cooling plates, Runner less moulds- nozzle types, hot runner unit mould, insulated runner mould and hot runner plate mould, Runner less injection moulding.

Die Design: Screw extruder fundamentals, general features of die, Material and process for die making, design features of dies, Design procedure, Die geometry, Extruder –Die operations, heating systems, temperature control, ease of maintenance and cleaning, fabrication, and cost estimation.

Reference Books:

1. Injection moulding Handbook, Dominick. V. Rosato and Donald .V. Rosato, CBS Publishers &, New Delhi.
2. Plastics Extrusion Technology Handbook, Sidney Levy and James F. Carley, Industrial Press, New York.1989.
3. Polymer Processing, Morton & Jones, Chapman & Hall.
4. Dies for Extrusion, M.V. Joshi, Mcmillan Ltd.
5. Injection mould Design, R.C. W. Pye, Longman Scientific & Technical.

Practicals

PS03CPST04: Synthesis of polymers

PS03CPST05: Advanced Polymer Processing

SEMESTER 4

CORE COURSES

PS03CPST01: Polymer Rheology

Introduction to Rheology: Different parameters, Rheological equation of state, Newtonian and Non-Newtonian, Importance aspects of rheology, Importance of rheology on polymer processing, shear thinning behavior, influence of temperature and molecular structure. Flow properties- flow through circular tube, flow between parallel plates, Die Swell, and Melt fracture, Sharkskin, Orientation and Shrinkage, Frozen in orientation, Weissenberg effect, and entrance effect.

Rheology in polymer processing: Introduction, Low flow process, Mixing process, Constrained flows, Free surface flows, Bulk deformations, Injection moulding, Blow moulding, Film blowing and Sheet extrusion.

Measurements of flow properties & Individual polymers: Mixing equipments, concentric cylinder rheometer, Cone and plate rheometer, Capillary rheometer, Parallel disc rheometer, torque rheometer, rheo-optics.

Rheology of Individual polymers: Individual polymers like polyethylene, propylene, polystyrene, poly vinyl chloride, nylons, poly acetals, poly tetrafluoroethylene, polycarbonates and rubbery materials.

Reference Books:

1. Polymer and Composite Rheology, Rakesh K. Gupta Marcel Dekker Inc., New York
2. Polymer Melt Rheology, F. N. Cogswell, George Godwin Ltd., London
3. Rheology of Polymer Systems, Carreau, De Kee, Chhabra, Hanser Gardner Publication Inc., Cincinnati.
4. Flow of high polymers, Stanley Middleman, Inter science publishers.
5. Melt Rheology and its role in Plastics processing, John M. Dealy and Kurt. F. Wissbrun, Van Nostrand Reinhold, New York.
6. Plastics Rheology in Plastics Quality Control, John M. Dealy and Peter C. Saucier, Hanser Gardner Publication Inc., Cincinnati.

PS04CPST02: Polymer Additives

General aspects of Additives: Technical requirements of Additives, unavoidable side effects, Deterioration of properties and methods of incorporation of Additives into plastics.

Lubricants internal and external: General principles, external and internal lubricants of plastics to processing, thixotropic agents, mold releasing agents, evaluation of lubricants and effects on plastics properties. Plasticizers, Theory of plasticization, primary and secondary plasticizers, classification of plasticizers, plasticization efficiency and their evaluation, plasticizers anomalies and anti-plasticization, loss of plasticizers and effects on plastics properties.

Fillers and reinforcements: Introduction, general characteristics of fillers and reinforcements, mechanical and thermal properties of filled polymers. Classification of fillers and semi reinforcements, source, properties and application in plastics processing. Principles of filler selection, incorporation of filler into plastics matrix. Coupling agents, types, and action mechanism, evaluation of fillers and reinforcement and effects on plastics properties.

Specific Purpose Additives: Stabilizers- Primary, and secondary stabilizers, Metal deactivators, Light stabilizers, synergistic stabilizers, Evaluation of processing stabilizers and effects on plastics properties. **Anti-ageing additives** - Introduction, antioxidants, classification, action mechanism, synergistic and antagonistic effects of antioxidants combination. Ultra violet protective agents- types, action mechanism and effects on plastics properties. **Optical property modifiers** - Brightening agents, Inorganic and Organic pigments, Criteria for selection of pigments,

Reference Books:

1. The role of additives in plastics, L. Mascia, Edward Arnold.
2. Additives of plastics, Stepek, Springer Verlag, New York.
3. Plastics additives and modifiers, Jesse Edenbaum, Van Nostrand Reinhold, New York.
4. Plastics materials, J.A. Brydson, Butterworth Science, London.
5. Additives for Plastics Handbook, Elsevier Advanced Technology, John Murphy.
6. Polymer modifiers and additives, Marcel Dekker, John T. Lutz, Richard F. Grossman.
7. Plastics Additives Handbook, 5th Ed., Hans Zweifel, Hanser Gardner
8. Comprehensive polymer science, Pergamon, New York.
9. Engineering materials Handbook, Vol, 1-3, ASTM International, USA.
10. Plastics Engineering Handbook, Joel Frados, Van Nostrand Reinhold, New York.

PS04CPST03 :Specialty Polymers

High temperature and fire resistant polymers: Introduction, Improving low performance plastics for high temperature use, Polymers for low fire-hazards, Polymers for high temperature resistance—Fluoropolymers, Aromatic polymers, Poly ethers, Polyphenylenesulphide, Polysulphones, Polyketones and Heterocyclic polymers.

Hydrophilic polymers: Natural polymers—Carbohydrates, Proteins, Semi-synthetic polymers, Synthetic polymers— Hydrogel polymers, Polyacrylamide hydrophilic polymers, Polyvinyl alcohol, Polyvinyl pyrrolidone, Superabsorbent polymers.

Ionic polymers: Introduction, synthesis, physical properties and applications.

Polymers with electrical & electronic properties: Conducting polymers—conducting mechanisms, Polyacetylene, Polyparaphynelenes, Polypyrroles, Polyaniline, Photoconducting polymers, Polymers in optoelectronics, Polymers with piezoelectric, pyroelectric and ferro electric properties, Photoresists for semiconductor fabrication.

Reference Books:

1. Engineering Polymers, R.W. Dyson, published by Chapman and Hall, New York.
2. Specialty Polymers, R.W. Dyson, published by Chapman and Hall, New York.
3. Encyclopedia of polymer science and Engineering, Wiley Inter science, New York.
4. Comprehensive polymer science Sir, Geoffrey Allen and Sunder L. Aggrawal, Pergamon press, New York.
5. Engineering materials Handbook, Vol, 1-3, ASTM International, USA.
6. Plastics Materials, J. A. Brydson, Butterworth, London.
7. Inorganic Polymers, James E. Mark, Harry R. Allcock, Robert West, Prentice Hall, NJ, USA.

ELECTIVES

PS04EPST01- Industrial Hygiene & Safety

Concept of Industrial safety, Accident causes & prevention, Safety committee and policies, Accident Investigation and Analysis.

Types of chemical hazards and control, Control techniques, Process flow chart and its importance for safety inspection, Interpretation, use and training of MSDS, UN, HAZCHEM classification of chemicals, chemistry of fire.

Transportation of hazardous chemicals, storage hazards and controls, hazards & control in unit processes and unit operations. safety work permit, safety of pipe lines, transportation of hazardous chemicals, safe start up & shut down procedures, emergency shut down.

Personnel protective equipments, house keeping, toxicology. Safety in Chemical Industry: General; Type of chemical hazards

References:

1. Accident prevention manual for industrial operations, national safety council, Chicago, 10th edition.
2. Safety and accident prevention in chemical operation, 2nd edition, Howard H.,
3. Handbook of occupational safety and health, Lawrence S.
4. MSDS, your guide to chemical safety
5. Engg design for control of work place hazards, Richard A.
6. Safety managers Handbook, J.J.Keller and Associates Inc. USA.
7. Supervising safety for Hazardous Processes, Dr.K.U.Mistry, Safety Health and Environment Association, 1st edition.

PS04EPST02- Selected topics in Industrial Chemistry

GMP & GLP

Green Chemistry: Principles, tools and examples of green chemistry

Metabolism of carbohydrates, lipids and protein molecules

Forensic Science chemistry: Introduction, forensic chemistry, illicit drugs, forensic toxicology

References:

1. Green Chemistry: Theory and Practice, Anastas, Warner, Oxford Univ. Press
2. Forensic Science-the basics, Jay Siegal
3. Good manufacturing practices for pharmaceuticals, Willing, S.H., Marce Dekker Pub., 1st edition
4. Modern Organic Chemistry, Sharma & Jain, Goel Publishers

PS04CPST 04: PROJECT

A project report based on literature survey and laboratory work conducted on topics related to POLYMER SCIENCE & TECHNOLOGY/CHEMISTRY is to be submitted and presented as a seminar by each student to the institute.