### SYLLABI FOR MASTER OF TECHNOLOGY (POLYMERS)
#### EXAMINATIONS 2014-2015
#### SCHEME OF TEACHING AND EXAMINATION

<table>
<thead>
<tr>
<th>Paper</th>
<th>Subject</th>
<th>Teaching Hrs. per Week</th>
<th>End Term</th>
<th>Mid Term</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS 1.1</td>
<td>Polymer Physics</td>
<td>4 - - 4</td>
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<tr>
<td>PS 1.2</td>
<td>Polymer Chemistry &amp; Characterization</td>
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<td>PS 1.3</td>
<td>Macromolecular Hydrodynamics</td>
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<tr>
<td>PS 1.4</td>
<td>Polymer Materials</td>
<td>3 - - 3</td>
<td>40</td>
<td>35</td>
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<tr>
<td>PS 1.5</td>
<td>Numerical Methods</td>
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<td>40</td>
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<tr>
<td>PS 1.6</td>
<td>Chemical Engineering Fundamentals*</td>
<td>2 - - NC</td>
<td>Qualifying</td>
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### Practicals

<table>
<thead>
<tr>
<th>Paper</th>
<th>Subject</th>
<th>Teaching Hrs. per Week</th>
<th>End Term</th>
<th>Mid Term</th>
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<td>PS 1.7</td>
<td>Polymer Science Laboratory-1</td>
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<tr>
<td>PS 1.8</td>
<td>Computer Applications</td>
<td>- - 2 1</td>
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| Total | 20 - 4 20 | 230 | 270 | 500 |

*This course is compulsory for students not possessing Engineering/Technology degree.

L: Lectures/Week  
P: Practical Hours/Week  
C: Number of Credits  
NC: No Credits

**Note:** Mid Term include: Evaluation towards two minor tests (60% of the marks), Assignments (20% of the marks), Class surprise tests, presentations etc. (20% of the marks).
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<tr>
<th>Paper</th>
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<th>Mid Term</th>
<th>Total Marks</th>
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<td>PS 2.5</td>
<td>Process Modeling &amp; Simulation in Polymer Systems</td>
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### SCHEME OF TEACHING AND EXAMINATION (2014-2015)

<table>
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<td>THIRD SEMESTER</td>
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<td>PS 3.2</td>
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<td>PS 3.3</td>
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### Practicals

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<th>Total Marks</th>
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</table>

## Preliminary thesis will be evaluated on the basis of seminar presentation and discussions and the candidate shall be awarded ‘S’ grade i.e. satisfactory for continuation or else ‘X’ grade i.e. unsatisfactory.

** List of Elective (PS 3.1)
1. Specialty Polymers
2. Structure & Properties of Polymers
3. Mold & Die Design
4. Colloid & Surfactant Science

* List of Open Elective (PS 3.2)
1. Research Methodology
2. Project Management
3. Optimization Techniques
4. Safety & Hazards
5. Analytical Techniques
### FOURTH SEMESTER

<table>
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<tr>
<th>Paper</th>
<th>Subject</th>
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<th>Mid Term</th>
<th>Total Marks</th>
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<tr>
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<td><strong>Total</strong></td>
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<td></td>
<td><strong>30</strong> 15</td>
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**NOTE:**
The student is required to make seminar presentation(s) of the results achieved before the submission of the thesis.

1. The Post Graduate Student Research Committee (PGRC) of the Institute will evaluate the Thesis. The constitution of the committee is as under:
   a. Chairperson of the institute
   b. Senior professor of the institute
   c. Supervisor(s)
   d. External examiner

2. The PGRC will evaluate the final thesis based on an open house presentation by the student, which will be attended by the faculty members, PG students and other research scholars of the institute.

3. No marks are assigned to Preliminary Thesis and Thesis evaluation work. On successful completion and presentation of Research Seminars, the candidate will be awarded ‘S’ grade i.e. satisfactory or else ‘X’ grade i.e. unsatisfactory.

4. Requirement for the award of M.Tech. (Polymers) degree is 75 credits with minimum CGPA of 6.0 and successful completion of thesis work.
SYLLABUS FOR
MASTER OF TECHNOLOGY (POLYMERS)
FIRST SEMESTER

Paper Title: POLYMER PHYSICS (Theory)
Paper Code: PS 1.1     Max. Marks 50   Credits: 4   Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Principals underlying the physics and physical chemistry of polymers in solution and in the solid state. Topics include conformation and molecular dimensions of polymer chains, thermodynamics of polymer solutions, and examination of the glassy, crystalline, and rubbery elastic states of polymers.

SECTION-B

Kinetics and thermodynamics of crystallization, liquid crystallinity in polymers, thermodynamics of rubber elasticity. The electrical, optical, transport and mechanical properties of polymers to be analyzed with respect to the above topics.

Books Recommended:

Paper Title: POLYMER CHEMISTRY & CHARACTERIZATION (Theory)
Paper Code: PS 1.2     Max. Marks 50   Credits: 4   Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A


SECTION-B
Principle and instrumental details of techniques for polymer characterization and testing for molecular weight and its distribution, mechanical strength, tensile, compression, flexural, impact, torsion, electrical properties, optical properties, thermal properties, structure determination-NMR scanning electron microscopy, etc.

Books Recommended:

Paper Title: MACROMOLECULAR HYDRODYNAMICS (Theory)
Paper Code: PS 1.3 Max. Marks 50 Credits: 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A
Types of flow, viscosity measurement, flow curve, zero-shear viscosity, activation energy of flow, effect of different parameters on viscosity; Boltzmann principle, Linear Viscoelastic models.

SECTION-B
Time-temperature superposition principle, WLF equation and its applications, master curve and its use, Flow of Non Newtonian fluids through pipes and channels. Thermodynamics in Polymer Processing.

Books Recommended:
Paper Title: POLYMER MATERIALS (Theory)

Paper Code: PS 1.4     Max. Marks 40     Credits: 3     Time: 3 hours
Course Duration: 35 Lectures of one hour each.

Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A
Important polymer materials, their raw materials. Production technologies and application in different polymer based industries: Polyolefins (LDPE, HDPE, LLDPE, PP), polystyrene, polyvinylchloride.

SECTION-B

Books Recommended:

Paper Title: NUMERICAL METHODS (Theory)

Paper Code: PS 1.5     Max. Marks 40     Credits: 3     Time: 3 hours
Course Duration: 35 Lectures of one hour each.

Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

SECTION-B

Books Recommended:

**Paper Title: CHEMICAL ENGINEERING FUNDAMENTALS (Theory)**
**Paper Code : PS 1.6** Only Qualifying Exam.  Credits : NIL
**Course Duration:** 22 Lectures of one hour each.

Basic principles of material and energy balance. Simple problems related to vapour pressure laws, humidity, thermo-chemical, adiabatic reaction temperature.

Fluid flow and Heat transfer, types of flow, Bernoulli’s equation, friction losses in flow measurement, modes of heat transfer and general definitions, steady and unsteady state conception, radiation, insulation.
Mass transfer, general definitions, Fick’s law of diffusion, mass transfer by molecular diffusion, membrane separation, principles of drying.

**Books Recommended:**

**Paper Title: POLYMER SCIENCE LABORATORY- I (Practical)**
**Paper Code : PS 1.7** Max. Marks 25  Credits : 1
Experiments broadly aimed at acquainting students with the range of properties of polymers, methods of synthesis and physical chemistry.
Solution polymerization of acrylamide, bead polymerization of divinylbenzene, interfacial polymerization of nylon 6, 10, Evaluation of elastic networks by tensile and swelling experiments.

**Paper Title: COMPUTER APPLICATIONS (Practical)**
**Paper Code : PS 1.8** Max. Marks 25  Credits : 1
Errors analysis, Solution of linear and non-linear algebraic equations.
Numerical differential & integration.
Interpolation.
Least squares approximation.
Ordinary, partial differential equations.
Development of computer programmes based on the above topics using Matlab and their applications in chemical process computations.
Books Recommended:


SYLLABUS FOR
MASTER OF TECHNOLOGY (POLYMERS)
SECOND SEMESTER
Paper Title: POLYMER PROCESSING TECHNIQUES (Theory)
Paper Code : PS 2.1     Max. Marks 50     Credits : 4     Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Basic principles, description of different processing techniques such as extrusion, blow molding, wire coating, calendering including equipment, detailed discussions of parameters affecting the processing, problems and troubleshooting during processing, compounding and mixing of polymers and additives.

SECTION-B

Description of different processing techniques such as molding compression, injection, transfer, reaction-injection, thermoforming including equipment details and discussion on parameters affecting the processing, problems and troubleshooting during processing, reinforced polymers and their processing.

Books Recommended:

Paper Title: POLYMER REACTION ENGINEERING (Theory)
Paper Code : PS 2.2     Max. Marks 50     Credits : 4     Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Polymerization reaction kinetics for polycondensation, addition polymerization, copolymerization, ziegler-Natta Polymerization, emulsion polymerization reactions, most probable molecular weights and distributions
SECTION-B

Control of molecular weight and distributions, gelation phenomena, techniques of polymerization, and design of reactors for polymerization reactions, viscosity build up and heat and mass transfer effects in polymer reactors.

Books Recommended:

Paper Title: COMPOSITE MATERIALS (Theory)
Paper Code: PS 2.3 Max. Marks 50 Credits: 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Concepts underlying formation, characteristics and behavior of plastic-based composites such as fiber glass laminates, structural sandwiches, plywood and load-bearing adhesive joints. Typical components such as metals, glass, synthesis and natural adhesives, plastics, foams, wood, paper, fabrics and rubber.

SECTION-B

Correlation between adhesion principles and physical behavior,. Methods of design, analysis, fabrication and testing. Discuss failure mechanisms of chemical and mechanical types.

Paper Title: POLYMER PRODUCT DESIGN (Theory)
Paper Code: PS 2.4 Max. Marks 40 Credits: 3 Time: 3 hours
Course Duration: 35 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Product selection and feasibility determination, product specifications, material selection.

SECTION-B

Product design; design producers for static and dynamic loading, design examples.
Books Recommended:


Paper Title: PROCESS MODELING & SIMULATION IN POLYMER SYSTEMS (Theory)

Paper Code: PS 2.5  Max. Marks 50  Credits: 4  Time: 3 hours

Course Duration: 45 Lectures of one hour each.

Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

SECTION-A

Modeling fundamentals, use of Mathematical models, Principles of formulation, fundamental Laws, Model characteristics, Development of mass, energy and momentum balance-equations; Development of models, solution of linear and non-linear equations; development and non-linear equations; development of models for surge tanks, stirred tanks with and without heating jacket.

SECTION-B

Reaction systems: Batch reactor, CSTR: iso-thermal and non-isothermal systems polymerization reactors.

Development of models for: Multistage Absorption, Extraction and Binary Distillation Columns; case studies for simulation: Polycondensation, addition polymerization and emulsion polymerization.

Books Recommended:


Paper Title: MODELING & SIMULATION OF POLYMER SYSTEMS (Practical)

Paper Code: PS 2.6  Max. Marks 25  Credit: 1

Practicals based on theory covered in Paper PS 2.5.

Paper Title: Seminar  Max Marks: 25  Credit: 1

Paper Code: PS 2.7
SYLLABUS FOR
MASTER OF TECHNOLOGY (POLYMERS)
THIRD SEMESTER

Paper Title: Elective (Theory)
Paper Code: PS 3.1 Max. Marks 50 Credit: 4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.

Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

1. SPECIALITY POLYMERS

SECTION-A
Various types of Speciality polymers, their raw materials and production technologies, speciality polymers for different specifications such as conducting polymers.

SECTION-B
Bio-medical polymers, polymers in telecommunications, space, defence, transport industry etc.

Books Recommended:

2. STRUCTURE & PROPERTIES OF POLYMERS

SECTION-A
Review of polymer molecular and bulk morphology, survey of molecular and morphological influence on bulk physical properties including Non-Newtonian flow.

SECTION-B
Macromolecular diffusion, gas transport in polymers, electrical and optical properties, solid-state deformation, and toughness. Case studies for product design.

Books Recommended:

3. OLD & DIE DESIGN

SECTION-A
Materials used, design consideration and basic concept of design.

SECTION-B
Detailed design procedures for molds and dies for various polymer processing techniques.
Books Recommended:


4. COLLOID & SURFACTANT SCIENCE

SECTION-A

Introduction to theory and applications of colloidal dispersions and surfactant science. Monolayer adsorption at interfaces, electrical double layers, dispersion forces electrokinetic phenomena and stabilization of dispersion.

SECTION-B

Chemistry, structure, and classification of surfactants, critical micelle concentrations, micellar solubilization and catalysis. Detergency and wetting phenomena. Emulsion technology and applications.

Books Recommended:


Paper Title: Open Elective (Theory)
Paper Code : PS 3.2 Max. Marks 50 Credit:4 Time: 3 hours
Course Duration: 45 Lectures of one hour each.
Note for the Paper setter: The question paper should be divided into Section A and Section B Total of 8 questions. 4 questions from section A and 4 questions from section B are to be set. The students will be required to attempt 5 questions selecting at least 2 from each section.

1. RESEARCH METHODOLOGY

SECTION-A

Introduction: Meaning, Features, Objectives/Motives & types of Research; Attributes of good Research, Research Methods and Research Methodology; Research Process, Significance of Research in Managerial decision making.

Research Design: Meaning, Characteristics and various concepts relating to research design and classification of research design, Importance.

Measurement and Scaling: Data Types Nominal, Ordinal and Ratio scale; scaling techniques.

Formulation of Hypothesis: Meaning, Characteristics and concepts relating to testing of Hypothesis (Parameter and statistic, Standard error, Level of significance, type-I and Type-II errors, Critical region,
one tail and two tail tests); Procedure of testing Hypothesis. Numerical problems based on chi-square test and F test (variance ratio test only).

SECTION – B

Data Collection: Sources of Data-Primary/Secondary Methods of collecting data; direct personal interview, indirect oral interview, information through local agencies, mailed questionnaire method, schedule sent through enumerators; questionnaire and its designing and characteristics of a good questionnaire.

Sampling Design: Meaning and need of Sampling, Probability and non-probability sampling design, simple random sampling, systematic sampling, stratified sampling, cluster sampling and convenience, judgment and quota sampling (non-probability), determination of sample size.

Data Analysis & Interpretation: Introduction to Multivariate analysis- Multiple and partial correlation, multiple regression analysis (with two independent variables), specification of regression models and estimation of parameters, interpretation of results. Analysis of Variance (ANOVA)-One way and Two way ANOVA. Introduction to discriminant analysis and Factor Analysis (Numerical not to be asked)

Report writing: Style/format, contents and essential steps for report writing.

Suggested Readings:
2. Ranjit Kumar: Research Methodology, Pearson Education 2009-02-20
3. Donald R. CooperPamela S. Schindler: Business Research Methods, Tata McGraw Hill
5. R. Pannerselvam: Research Methodology, Parentice Hall of India Limited.
7. William G.Zikmund :Business Research Methods, Thomson South Western Publication

2. PROJECT MANAGEMENT

SECTION-A

Project Management: concept of project management, project management systems, responsibilities and qualities of a project manager, project management team-composition, functions and responsibilities, co-ordination procedures. Manpower planning; recruitment and selection job description, specification and evaluation, performance appraisal, basis of remuneration and incentives. Project Identification: Principles of project identification, importance of capital investment, decision making industrial policy resolution, industrial development and regulation act, supply and demand analysis, incentives for industrially backward areas and small scale industries, foreign collaboration and foreign exchange regulations. Appraisal criteria and selection of investment: Non discounting criteria, discounting criteria, appraisal and selection in practice.

SECTION-B

Feasibility studies: Preparation of techno-economic feasibility report, feasibility analysis technical economic, commercial and financial planning: Network analysis, PERT/CPM Bar chart.
Preconstruction Planning. Project Scheduling control and Monitoring: Resource Scheduling, manpower scheduling, multi project scheduling, cost scheduling, PERT/Cost scheduling optimisation, crash costing and updating and leveling of resources, Implementation of Project schedules. Financial Control: Budgeting and cost control, sources of long term funds for business, Planning and capital structure, problems of working capital management and liquidity.

Books Recommended:


3. OPTIMIZATION TECHNIQUES

SECTION-A

Introduction to system analysis and Modelling with reference to chemical engineering problems. Differential Method for solving one and two variable problems, with and without constraints, application of Langranian Multiplier method, Linear Programming Modelling, Graphical method, Single Phase Simplex method, Two Phase Simplex method, Duality, Sensitivity analysis:

SECTION-B

Geometric Programming: as applied to chemical Engineering problems with degree to difficulty equal to zero and one , with and without constraints; Search Methods: Sequential Search method, Golden Section method, Dichotomous Search method; Introduction to Dynamic Programming as applied to discrete multistage problems like Cascade of CSTR, Train of Head exchangers etc.

Books Recommended:

3. Hadley : Linear Programming.

4. SAFETY & HAZARDS

SECTION-A

Definitions, identifications, Classifications and assessment of various types of hazards in work-place environment. Protective and preventive measures in hazard control. Toxic chemicals: Maximum allowable concentrations and other standards. Biological threshold limit values. Mechanical and electrical hazards, personal protective equipments.

SECTION-B
Standard safety procedures and disaster control. Indian legislation on safety and prevention of hazards and safety code.
Case study of typical hazardous industry.

**Books Recommended:**


### 4. ANALYTICAL TECHNIQUES

**SECTION-A**

*Complexometric titrations:* Complexes-formation constants; chelates – EDTA, Chelon Effect, EDTA equilibria, effect of pH on EDTA equilibria, EDTA titration curves, endpoint – detection and indicators; Importance of complexometric titrations.

*Solvent Extraction:* Distribution law, extraction process, factors effecting extraction, technique for extraction, quantitative treatment of solvent extraction equilibria, classification of solvent extraction systems. Advantages and applications of solvent extraction.

*Chromatography:* Introduction to chromatography, principles, classification of chromatographic techniques, thin layer and paper chromatography – principle and technique.


**SECTION-B**

*IR Spectroscopy:* Origin, rigid rotor model, harmonic oscillator model, principle, modes of vibrations of atoms in polyatomic molecules, instrumentation, selection rules, identification of organic compounds on the basis of infrared spectra.


*NMR:* Principle, chemical shift, spin-spin coupling shift reagents, instrumentation, spectra and molecular structure, identification of organic compounds on the basis of NMR.

*Thermoanalytical methods:* Principle, classification of methods.

  - TGA – Instrumentation, factors affecting results and analysis of data. applications.
  - DTG – Instrumentation, analysis of data and applications.
  - DTA – Principle, Instrumentation and applications.

**Books Recommended:**

Development and testing of Composites: using GP resin and fillers like fibre glass, flyash etc. Experiments on Polymer Processing: Moulding, extension; Characterization of Polymers using Physical methods: tensile, Impact and flexure tests, Thermal Conductivity determination, resistivity measurement and water adsorption.

FOURTH SEMESTER

PS 4.1 Thesis