Syllabus

For

M.Tech. (Plastic Engineering)

(Effective from the Session: 2016-17)
### Course Structure and Evaluation Scheme for M. Tech. Plastics Engineering Course

(To be effective from session 2016-17)

#### SEMESTER I

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Subject Code</th>
<th>Name of Subject</th>
<th>Periods</th>
<th>Credit</th>
<th>Evaluation Scheme</th>
<th>Subject Total</th>
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<tr>
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- **Credit Distribution:**
  - Theory: 20-10-70
  - Practical: 20-30-50
  - Total: 100-50
- **Periods:** L (Lecture), T (Theory), P (Practical)
- **Evaluation Scheme:**
  - Theory: CT (Continuous Test), TA (Term Average), ESE (End Semester Examination)
  - Practical: TA (Term Average), ESE (End Semester Examination)
### SEMESTER III

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### SEMESTER IV

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#### Departmental Elective I
1. MTPE-011: Mathematics
2. MTPE-012: Polymer Chemistry
3. MTPE-013: Biodegradable polymer

#### Departmental Elective II
1. MTPE-021: Computer Aided Engineering & Analysis of Plastics
2. MTPE-022: Polymer Nanocomposite
3. MTPE-023: Failure Analysis

#### Departmental Elective III
1. MTPE-031: Plastics Product & Tool design
2. MTPE-032: Advance Processing Techniques
3. MTPE-033: Bio Medical Polymers

#### Departmental Elective IV
1. MTPE-041: Additive, Blends, Alloys of Polymers
2. MTPE-042: Computational Fluid Dynamics & Heat Transfer
3. MTPE-043: Plastics Tool Engineering

#### Departmental Elective V
1. MTPE-051: Organisational Management
2. MTPE-052: Polymer Composite Techniques
3. MTPE-053: Plastics Waste Management & Recycling
Syllabus
M.Tech Semester I

DEPARTMENT SUBJECT

MTPT 101  Plastics Materials  
(3- 0 -0)

Unit I
Thermoplastics:
History, Sources and manufacture of raw materials, basic chemistry, Methods of manufacture, General properties and applications.
Olefin Polymers and Co-polymers , Vinyl chloride polymers and co-polymers, Styrene and Styrene co-polymers, Cellulose polymers, Polymers and co-polymers of Acrylic acid, PMMA.

Unit II
Engineering plastics:
Polyamides – Nylon 6, 66 etc., Acetal – Homopolymer & Co-polymer, Saturated Polymers – PETP & PVTP

Unit III
High performance & specialty plastics:
Polymers containing Fluorine – PTFE, PVDF etc., Polycarbonates, Polyphenylene Sulphide, Polyphenylene oxide, Polysulphones, Poly ether ether ketone

Unit IV
Thermosetting plastics:
History – Sources for raw materials- resin preparation – polymer structure additives – curing and cross linking- agents, processing behaviour, general properties and applications of Phenol formaldehyde, Urea formaldehyde, Melamine formaldehyde, Unsaturated polyesters, Epoxide resins, Polyurethanes, Silicones, etc.

Books –
1 Plastics Materials Hand Book -by A.S. Athalye
2 Plastics Materials -by J.A. Brydson
3 Plastics Materials and processing -by S.S. Schwartz & S.H. Goodman
4 Plastics Materials (Properties & Applications) -by Birley & R.G. Scott
5 Plastics Engineering Hand Book - by Society of the Plastic Industry Inc.
6 Hand book of Thermoset plastics - by S.H. Goodman
7 Technicians Hand Book of Plastics - by Peter A Grandilli
8 Polymer Products (Design, materials) - by David H. Mortonjones & John W Ellis
MTPT 102 PLASTICS PROCESSING

Unit - I
Basic Principles – Classification of processing methods – Definition – Effect of Polymer properties on processing behaviour.
Injection Moulding:
Principle – Definition of Terms – specifications – Types of machine used- parts and their functions. Cycle time, process variables & its effects on moulding quality, Cavity-pressure profile- factors influencing moulding shrinkage –Dimensional control, annealing, Types of clamping systems, start up and shut down procedures, precautions to be taken while processing of engineering plastics such as nylon, acetal polycarbonate etc. , Common moulding defects, causes and remedies.
Thermoset Injection moulding process- Machine description, parts and their functions-process parameters-merits and de-merits.

Unit - II
Transfer moulding: Principles –Types of process- machine used pot transfer, plunger transfer, screw transfer moulding techniques, theoretical calculation of pressures, trouble shooting.

Unit III
Twin screw extruder- principle – types- process- merits & demerits; Vented barrel extruder- hopper loading devices; Drying equipments.

Unit IV
Calendaring : Introduction – type of calendars – roll configuration – definition of terms such as calendar bank- calendaring process- process variables- application- troubleshooting.
Plastics Recycling : Introduction.

Books
Injection moulding Theory and Practice -By Irvin I Rubin
Injection Moulding Hand book -By D.V. Rosato
DEPARTMENTAL ELECTIVE -1

MTPE-011 MATHEMATICS (3-0-0)

Unit - 1
Differential Calculus & Integral calculus: Introduction, Functions and Models, Limits and Derivatives, Differentiation Rules, Applications of Differentiation, Integrals, Applications of Integration, Areas between Curves

Unit 2.
Partial differential equations: Linear and quasilinear first order partial differential equations, second order linear equations in two variables and their classifications, Cauchy, Dirichlet and Newman problems, Green functions; Solutions of Laplace, wave and diffusion equations in two variable and application to physical problems.

Unit 3.
Probability: Random experiment, event space, classical and statistical definition of probability, conditional probability, probability distribution (both one and two dimensions). Distribution Functions: Binomial, Normal Poisson, Uniform, Cauchy and Gamma, Mathematical Expectation, Introduction of Interpolation and Extrapolation.

Unit 4.

TEXT BOOKS

MTPE-012  POLYMER CHEMISTRY  (3-0-0)

Unit I
Basic fundamentals of chemistry related to polymers, The science of large molecules
Basic concepts of polymer science-history of Macromolecular science-Nomenclature of polymers-
Inter molecular forces and chemical bonding in polymers-Thermal transition.

Unit II
Polymerization - Mechanism and kinetics-molecular weight and molecular weight distribution and its measurements. Effect of molecular weight on processing and properties.

Unit III

Unit IV
Physical and Chemical method of modifying polymer properties.
Reaction of polymers : Reaction of polymer with other chemicals – degradation and stabilization of polymers

BOOKS
1. Brydson, J.A “Plastics Material”
2. Billmeyer, Fw “Text Book Of Polymer Science”
3. Principles Of Polymer Systems By Rodrigue
4. Principles Of Polymer Chemistry By Ravve
5. Introduction Of Polymer Science By Georgelias
6. Polymer Science & Technology By Fried
7. Kinetics Of Polymer Reaction By Schroder
Unit – I
Introduction – Chemistry and biochemistry of polymer degradation – Enzymes chemical degradation initiates biodegradation – Hydrolysis of synthetic biodegradable polymers.

Unit – II
Starch filled plastic – thermoplastic starch – starch based materials in the market – other additives for biodegradation.

Unit – III

Unit – IV

Text Book:
1. G.J.L. Griffin, Chemistry and Technology of Biodegradable Polymers, Blackie Academic Professional, 1994

References:
DEPARTMENTAL ELECTIVE -2

MTPE-021 COMPUTER AIDED ENGINEERING & ANALYSIS FOR PLASTICS (3-0-0)

Unit-I
Introduction- Basic concepts of Computer Aided Design – CAD and CADD system- Shape and size description. Parametric programming – Construction of Engineering drawing – Two dimensional drafting – 3D surface & Solid Modelling – Concepts of engineering data base – Various techniques used to analyse the material properties.

Unit-II

Unit-III

Unit-IV

REFERENCES:
MTPE-022 POLYMERIC NANO COMPOSITES (3 -0-0)

UNIT I
PREPARATION OF SYNTHESIS Polymer Nanocomposites, Nanocomposites Preparation and Synthesis, Polymer, Matrics : Thermoplastics, Thermosets, Elastomers, Natural and Biodegradable Polymers

UNIT II
RHEOLOGY OF NANOCOMPOSITES Rheology of Multiphase Systems, Rheology of Polymer / clay Nano composites, Recent studies on Rheology, Measure Techniques, Steady shear Rheology, Dynamic Rheology, Non Linear Viscoelastic properties, Extensional Rheology, Rheological modeling of Nanocomposites.

UNIT III
PROCESSING OF NANOCOMPOSITES Extrusion, Injection Moulding, Blow Moulding, Foaming, Rotational Moulding

UNIT IV
STRUCTURE AND PROPERTIES CHARACTERIZATION Scattering Techniques, Microscopic Techniques, Spectroscopic Techniques, Spectroscopic Techniques, Chromatography, Solid-state characterization: Mechanical Testing, Thermal Characterization

UNIT V
APPLICATION OF POLYMER NANOCOMPOSITES Thermoplastics, Thermosets, Biodegradable Polymers.

REFERENCES:
1. Luigi Nicolis & Gianfranco Carotenuto “Metal -Polymers Nanocompsites” A John Wiley & Sons, Inc Publication 2005
2. Y.C. Ke & P. Stroeve “ Polymer-Layered Silicate and Silica Nanocomposites- Elsevier, 2005

MTPE–023 Failure Analysis (3-0-0)

Unit I
Introduction and overview, Concepts of fracture mechanics and strength of materials, Elements of solid mechanics,

Unit II

Unit III
Plastic crack-tip fields, Mode-I fields and fracture criterion, K approach fracture criteria, Engineering approach to plastic fracture, J-integral approaches and numerical concepts, CTOD approach, Tearing modulus, Time dependent fracture, non-linear aspects of fatigue crack growth.
Unit IV
Theoretical models, Fatigue cracks, standard tests and testing procedures. Brittle fracture, Notch toughness, defects and service behaviour, Application of fracture mechanics concepts and limitations,

Unit V

Books:
3. Advanced Fracture Mechanics Kanninen, Melvin F Popelar, Carl H Oxford University Press

LAB 1

MTPL 151 PLASTICS PRODUCT DESIGN & TOOL DESIGN LAB (0-0-3)

1 Part Drawing from product
2 Product Design Practice
3 Two Plate Mould Design (Injection)
4 Three Plate Mould Design (Injection)
5 Split Mould Design (Injection)
6 Compression Mould Design
7 Transfer Mould Design
8 Mould Design for Industrial Components
9 Blow Mould Design
10 Extrusion Die Design

LAB 2

MTPL 152 PLASTICS CHARACTERISATION & TESTING LAB (0-0-3)

Minimum any 8 –

Testing practical to be conducted as per BIS, ASTM, ISO standards wherever applicable


RHEOLOGICAL LAB Melt Flow Index - Viscosity and Molecular weight determination-Determination of K-Value for PVC

CHEMICAL LAB Identification of plastics- Viscosity and Molecular weight determination-Determination of K-Value for PVC DEMONSTRATION: Melting point –carbon black content – filler content- Environmental stress cracking resistant- PH meter- Hooper viscometer – Brookfield viscometer.
**THERMAL AND** Heat distortion temperature – Vicat Softening point – Oxygen Index


**ELECTRICAL AND OPTICAL LAB**
Volume and surface resistivity – Breakdown Voltage – Comparative Tracking Index – Air resistance – haze- gloss – clarity.

**DEMONSTRATION** : Refractive Index- Microscopes – Colour Grade – Microtome cutter.

**PHYSIO-MECHANICAL LAB:**
Tensile strength, Flexural strength, Compression strength, Tear strength – impact strength – hardness.


**SPECIMEN PREPARATION LAB:**
Specimen preparation using injection moulding machine- compression moulding machine - two roll mill and contour cutter.

**DEMONSTRATION** : Scrap Grinder – Blended , Product Testing.
SYLLABUS
M.Tech. Semester II

DEPARTMENT SUBJECT

MTPT-201 RHEOLOGY & CHARACTERISATION OF PLASTIC MATERIALS

(3-0-0)

Unit – I
Introduction and definitions related to fluid flow, Newtonian and non-Newtonian and viscoelastic fluids, Rheological properties – Viscosity, melt-flow, relationships describing temperature and shear rate dependence on the rheological behaviour of amorphous and crystalline plastics materials,

Unit _ II
SiMTPLe shear flow and its application for measurement of viscosity as well as normal stresses, SiMTPLe elongational flow and its significance. Dynamic flow behaviour, time dependent fluid responses. Viscosity measurements capillary rheometers, viscometer, types of viscometers, torque rheometers, cup flow and spiral flow tests for determination of flow behaviour. Rheology of modified polymer systems.

Unit - III
Analytical methods of characterization of polymers for molecular weight such as Gel Permeation Chromatography (GPC), Dilute Solution Viscosity, Solution Light Scattering, etc.,

Unit - IV
Structural characterization techniques such as scanning electron microscopy (SEM), light microscopy, X-Ray deflection, density gradient column, Mechanical and thermal characterization, principles of Differential Scanning Calorimetry (DSC), Thermo Gravimetric Analysis (TGA), Fourier Transform Infra Red Analysis (FTIR), Dynamic Mechanical Analyser (DMA) etc.

Books-
2. Plastics engineering hand Ed 5 Society of the Plastics industry
3. CroMTPTOn “Analysis of Plastics”
4. Haslam “identification and analysis of plastics”
5. Vishu shah “Plastics testing technology hand book”
MTPT- 202 TESTING & QUALITY CONTROL OF PLASTICS : (3-0--0)

Unit – I
Identification of common plastics materials by SiMTPLe test e.g. Visual inspection, density, effects of heat, combustion and solvents, analysis with common solvents.

Unit II

Unit III
Application of national and international standards (BIS-ASTM-ISO) for testing and their significance. Processing and flow properties – Melt flow index, relationship of melt flow index, on processing behaviour and properties.

Unit IV
Influence of processing conditions on the properties of polymers.
Product testing – pipe and fittings- film and sheets – container testing and FRP based products.
Factors affecting the quality of materials and products. Uncertainty measurement. Analysis of failure and its measurements.

Books
1 Plastics Testing Technology hand book - by Vishu Shah
2 SiMTPLe methods for identification - by R.P. Braun
3 Analysis of Plastics - by T.R. CroMTPton
6 Hand book of plastics test methods - by R.P. Brown
7 Identification and analysis of Plastics -by J. Haslam & others
DEPARTMENTAL ELECTIVE - III

MTPE-031 PLASTICS PRODUCT & TOOL DESIGN (3-0-0)

Unit - I
Product Design:
Inserts – materials- Selection of metal for inserts – minimum wall thickness of material around inserts – Anchorage – relieving moulding stresses around inserts.

Unit - II
Tool design:
Layout of cavities: Star arrangements, Symmetrical arrangements – in-line arrangement.
Ejection: Types of Ejection, Position & critical area of ejection, Calculation of ejection force required, Types of sprue puller.
Mould temperature Control: Principle of heat pipe, heat rod, capillary tube and its applications – Mould cooling- types of integer type cavity and core plates cooling, Types of bolster cooling, insert cooling, rate of heat to be removed, ejection temperature, cooling efficiency calculation, cooling time calculation.

Unit - III
Types of injection moulds:
Shrinkage effects – Processing behaviour of plastics- Flow characteristics – Injection Pressure – Injection speed- hold on time- Gate freezing - Ejection temperature – Anticipated shrinkage.

Unit - IV
Type of extrusion dies: Film, Sheet, pipe, wire/ cable dies.

Books-
1 Injection Mould Design for Thermoplastics - By R.G. W. Pye
2 Practical Injection Moulding of Plastics - By Walter Mink
3 Injection Mould Design fundamentals - By Glanvill & Denton
4 Injection Mould- 102 Proven Design - By H. Gastrow
5 Injection Moulds & Moulding - By J.B. DYM
6 Blow Molding of Plastics - By E.G. Fischer
7 Plastics Extrusion Theory & Technology - By Gerhard Schenkel
8 Extrusion Dies - By Michaeli Walter
9 Extrusion of Plastics - By E.G. Fischer
Unit – I
Advanced injection moulding techniques
Microprocessor controlled Injection moulding – Multi colour Injection moulding Sandwich moulding – Gas assisted injection moulding – RIM (Reaction injection moulding) Basic processes and procedures – Moulding aspects – shrinkage and summary – Quality control in Injection moulding, statistical process control techniques.
All Electric Injection Moulding Machines, dose loop microcellular foam injection moulding, water resist injection moulding, multi component injection moulding, robotic for automation.

Unit – II
Multi-layer Moulding, Counter flow moulding, Liquid Injection Moulding processes. Structural foam moulding – Low pressure and high pressure processes – Merits & demerits.

Unit – III

Unit – IV
Advanced Blow Moulding – 11

REFERENCES:
4. Brunt Strong, Plastics: Materials and Processing, Prentice-Hall, New Jersey,
MTPE–033 BIO-MEDICAL PLASTICS (3-0-0)

UNIT I
Synthetic and Natural biomaterials used in Biomedical applications
i) Polyolefin’s, Polyamides, Acrylic Polymers, Fluorocarbons, Polyesters, Engg. Plastics.
ii) Collagen, Polysaccharides, Proteins etc.

UNIT II
Human applications of Plastics : Cardiovascular iMTPLants, Dental iMTPLants, Role of plastics in Ophthalmology, Hydro gels, Drug Delivery Systems, Sutures, Burn Dressings and Artificial Skin. Hernia Mesh, adhesives and Sealants, Artificial organs and devices, Blood bags, Condoms etc.

UNIT III
Blood – polymer interactions and blood compatibility, Chemical and biochemical degradation of polymers, Tissue engineering and polymers.

UNIT IV
Testing and evaluation: in-vitro-/vivo; Standards in product development and regulations; Ethical and sociological issues.

Books
DEPARTMENTAL ELECTIVE - IV

MTPE-041 ADDITIVES, BLENDS & ALLOYS of POLYMERS (3-0-0)

Unit I

Unit II

UNIT- III

UNIT- IV

TEXT- BOOK:
1. Applications of Plastics - by J.S. Anand
2. Additives & Compounding - by R. Gachter & H. Muller
3. Plastics Additives - by Ernest W. Flick

REFERENCES:
MTPE-042  COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER  (3-0-0)

Unit I
Introduction, Conservation equation, Mass Momentum and Energy equations, Convective form of the equation and general description.
Clarification into various types of equation, Parabolic, Elliptic, Boundary and initial conditions, Overview of numerical methods.

Unit II
Finite difference methods; Different means for formulating finite difference equations, Taylor series expansion, Integration over element, Local function method;

Unit III
Finite volume methods; Central, upwind and hybrid formulations and comparison for convection-diffusion problem, Treatment of boundary conditions; Boundary layer treatment; Variable property, Interface and free surface treatment, Accuracy of F.D. method.

Unit IV
Solution of finite difference equations; Iterative methods; Matrix inversion methods, ADI method, Operator splitting, Fast Fourier Transform applications.

Unit V
Phase change problems, Rayleigh-Ritz, Galerkin and Least square methods; Interpolation functions, One and two dimensional elements, Applications.
Phase change problems; Different approaches for moving boundary; Variable time step method, Enthalpy method.

Books:
1. Computational Methods for Fluid Dynamics Ferziger Joel H Springer-Verlog
4. Middleman Stanley John Wiley
Unit I
Steel for moulds - Selection, Properties of steels, Common steels used, Strength of materials, calculation of wall thickness for cavity - insert size- heat treatment- life of mould cavity.

Non- Ferrous metals for moulds: Zinc base alloys and aluminium alloys., Beryllium Copper, Polyesters, Epoxies, Silicones

Unit II

Unit III.

Unit IV
Mould surface treatments, surface texturing, mould polishing. Inspection and quality control of moulds and products.

REFERENCES:
DEPARTMENTAL ELECTIVE - V

MTPE 051 ORGANISATION MANAGEMENT (3-0-0)

Unit 1:
Principles of Business Organisation, Industrial Ownership, organisation and Role of Supervision, Plant Location and Plant Layout.

Unit 2:

Unit 3:

Unit 4:
Basic Accounting Records, Preparation of Final Accounts: Profit & loss Account, Balance Sheet, Break Even Point Analysis, Principles of costing, Methods of Costing. Depreciation, Capitals, Concept of MIS.
Books:
1. Organisation Management- By M. D. Bhushan
2. Organisation Management- By M. C. Shukla
3. Industrial Engineering & Management- By Dr. O.P.Khanna
4. Cost and Management Accountancy for students- By J. Batty.
5. Weldon’s Costing- By Weldons

MTPE 052 POLYMER COMPOSITES TECHNOLOGY (3-0-0)

UNIT I

UNIT II
Additives for composites , catalysts, room temperature and elevated temperature, accelerators, coupling agents, fillers, flame retardants, toughening agents, UV, stabilizers.

UNIT III
Processing of composites – Important processes like hand lay-up, spray-up, resin transfer moulding, vacuum bag, pressure bag moulding, centrifugal casting, pultrusion, filament winding, moulding compounds – SMC, DMC, BMC, TMC.

UNIT IV
Testing Quality control & end use of plastics – Testing for mechanical, electrical, thermal, optical and chemical properties, Determination of shelf life and gel time – Non-destructive testing

TEXT BOOKS :

5. 1PP Composites - By Chapman Hall & J. Karge Kocsis
6. 2 PP Co-polymer & Blends - By Chapman Hall & J. Karger Kocsis
7. Text book of Polymer Science - By Fred W. Billmeyer
8. Principles of Polymer Systems - By F. Rodriguez
9. Principles of Polymer Chemistry - By A. Ravve
10. Introduction to polymer Science - By Hans Georgelias
11. Polymer Science & technology - By Joel R. Fried

MTPE 053 PLASTICS WASTE MANAGEMENT & RECYCLING (3-0-0)

Unit – I

Unit – II

Unit – III
Mechanical recycling of commonly used plastics, such as PP, PE, PET, etc. mixed waste recycling – co-extruded films waste, commingled waste Extrusion flow moulding for production of plastics lumbers, chemical recycling/feedstock recycling processes for recovery of oil, monomer and energy – thermolytic processes. Solvolysis – process outline for PMMA, PET, etc. Fluidised bed incinerator with energy recovery.

Unit – IV

REFERENCES:
LAB 3

MTPL 251 PROCESSING OF PLASTICS LAB (0-0-3)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Practical on</th>
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<tbody>
<tr>
<td>1</td>
<td>Injection Moulding (Hand Operated)</td>
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<tr>
<td>2</td>
<td>Injection Moulding (Semi-automatic)</td>
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<tr>
<td>3</td>
<td>Injection Moulding (automatic)</td>
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<td>4</td>
<td>Micro Processor Control injection Moulding Operation</td>
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<tr>
<td>5</td>
<td>Extrusion Process</td>
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<tr>
<td>6</td>
<td>Compression Moulding (Hand Operated)</td>
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<tr>
<td>7</td>
<td>Compression Moulding (Semi-operated)</td>
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<tr>
<td>8</td>
<td>Blow Moulding (Hand Operated)</td>
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<tr>
<td>9</td>
<td>Blow Moulding (Automatic)</td>
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<tr>
<td>10</td>
<td>Vacuum Forming</td>
</tr>
<tr>
<td>11</td>
<td>Rotational Moulding</td>
</tr>
<tr>
<td>12</td>
<td>Scrap Grinding</td>
</tr>
<tr>
<td>13</td>
<td>Coating of Plastics</td>
</tr>
<tr>
<td>14</td>
<td>Welding &amp; Sealing of Plastics</td>
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<tr>
<td>15</td>
<td>FRP-Hand Lay up Process</td>
</tr>
</tbody>
</table>

MTPL: 252 SEMINAR-I 0:0:2

The student(s) will be required to prepare and deliver a Seminar, on the assigned topic with the help of Power Point Presentation as well as submit a type written report.
SYLLABUS
M.Tech. Semester III

MTPL: 351 SEMINAR-II 0:0:6

The student(s) will be required to prepare and deliver a detailed Seminar, on the assigned Topic(s) with the help of Power Point Presentation as well as submit a type written report. The seminar shall also include a detailed question answer session.

MTPL -352: DISSERTATION 0:0:30

The student(s) will be required to search literature pertaining to the Project/Dissertation undertaken related to Processing / blending/ characterisation of Polymer/Plastics materials/composite/ Nanocomposite/ Products/new product development etc, comprehend it and prepare a report for assessment and viva-voce.

SYLLABUS
M.Tech. Semester IV

MTPL-451: DISSERTATION (FINAL) 0:0:36

The student(s) will be required to perform the experimental work in the lab pertaining to the Project/ Dissertation undertaken as in MTPT-352, under the guidance of the Supervisor. The candidate is required to present his/her work from time to time before the departmental Post Graduate Committee for internal assessment. After completion of work the students are required to comprehend it and prepare a detailed Project report for external assessment. The candidate will also be required to prepare and deliver a detailed presentation pertaining to the work done during the project/ dissertation.