

AFFILIATED INSTITUTIONS
ANNA UNIVERSITY, CHENNAI
REGULATIONS - 2009

M.TECH. PLASTIC TECHNOLOGY
II TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABI

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	PT9221	<u>Plastics Testing Technology</u>	4	0	0	4
2.	PT9222	<u>Plastics Composite Technology</u>	3	0	0	3
3.	PT9223	<u>Industrial Economics and Costing</u>	3	0	0	3
4.	E1**	<u>Elective – I</u>	3	0	0	3
5.	E2**	<u>Elective - II</u>	3	0	0	3
PRACTICAL						
6.	PT9226	<u>Plastics Testing Laboratory – I</u>	0	0	6	2
7.	PT9227	<u>Plastics Processing Laboratory – II</u>	0	0	12	4
8.	PT9228	Seminar II	0	0	2	1
TOTAL			16	0	20	23

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	E3**	Elective – III	3	0	0	3
2.	E4**	Elective – IV	3	0	0	3
PRACTICAL						
3.	PT9231	<u>Plastics Testing Laboratory – II</u>	0	0	12	4
4.	PT9232	<u>Project Work (Phase I)</u>	0	0	20	4
TOTAL			6	0	32	14

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	PT9241	Project Work (Phase II)	0	0	40	12
TOTAL			0	0	40	12

Total credit 26+23+14+12 = 75

LIST OF ELECTIVES

ELECTIVE I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	PT9251	<u>Plastics Characterization Techniques</u>	3	0	0	3
2.	PT9252	<u>Biodegradable Plastics</u>	3	0	0	3
3.	PT9253	<u>Advanced Plastics Processing Technology</u>	3	0	0	3
4.	PT9254	<u>Polymeric Nanocomposites</u>	3	0	0	3

ELECTIVE II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	PT9261	<u>Plastics Waste Management</u>	3	0	0	3
2.	PT9262	<u>Quality Management</u>	3	0	0	3
3.	PT9263	<u>CAD/CAM/CAE Application in Mould / Tool Design</u>	3	0	0	3
4.	PT9264	<u>Bio-Medical Plastics</u>	3	0	0	3

ELECTIVE III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	PT9271	<u>Polymer Blends & Alloys</u>	3	0	0	3
2.	PT9272	<u>Advanced Tool Design</u>	3	0	0	3
3.	PT9273	<u>Thermoplastic Elastomers</u>	3	0	0	3
4.	PT9274	<u>Coating Science & Technology</u>	3	0	0	3

ELECTIVE IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	PT9281	<u>Advanced Mould Manufacturing Technology</u>	3	0	0	3
2.	PT9282	<u>Secondary Processing Techniques</u>	3	0	0	3
3.	PT9283	<u>Plastics Packaging Technology</u>	3	0	0	3

UNIT I CONCEPTS OF TESTING & IDENTIFICATION OF PLASTICS 12

Basic concepts of testing - Specification and Standards - National and International Standards - Test specimen preparation - Pre-conditioning and test atmosphere.

Identification of plastics by simple tests - Visual examination - Density - Melting point - Solubility test - Flame test - Chemical tests.

UNIT II MECHANICAL PROPERTIES 12

Long-term Mechanical Properties – Creep – Stress relation.

Short-term Mechanical Properties: Tensile properties - Flexural properties - Compressive properties - Shear properties - Impact properties - Tear resistance - Hardness tests - Abrasion resistance - Friction test.

Specific gravity - Density by Density-gradient technique - Bulk density - Particle size by sieve analysis - Moisture analysis.

UNIT III THERMAL PROPERTIES 12

Melt flow index - Heat deflection temperature - Vicat softening temperature - Marten's Heat resistance test - Brittleness temperature - Specific heat - Glass transition temperature - Thermal conductivity - Co-efficient of thermal expansion - Shrinkage - Thermal stability - Flammability.

Characterization of plastics by IR, spectroscopy, light microscopy. Thermal and rheological characterization of plastics.

UNIT IV ELECTRICAL AND OPTICAL PROPERTIES 12

Dielectric strength - Dielectric constant and Dissipation factor - Insulation resistance - Volume and Surface resistivity - Arc resistance - Antistatic tests.

Refractive index - Luminous transmittance - Clarity and Haze - Photo-elastic properties - Colour measurements and Specular Gloss.

UNIT PERMANENCE PROPERTIES AND PRODUCT TESTING 12

Gas and Moisture Vapour Permeability - Water absorption - Chemical Resistance - Environmental Stress Cracking Resistance - Cracking - UV Resistance - Ozone Resistance - Weathering Resistance - Salt spray and Straining Resistance - Irradiation Effects - Microbiological attack.

Testing of Pipes and Fittings - Films & Sheets - Container - Foam - Laminates and FRP based products - Failure Analysis.

TOTAL: 60 PERIODS

REFERENCES

1. Vishu Shah, Hand Book of Plastics Testing Technology, John Wiley & Sons Inc., New York, 1998.
2. J. S. Anand, K. Ramamurthy, K. Palanivelu & C. Brahatheeswaran, How to Identify Plastics by Simple Methods, 1997.
3. R.P. Brown, Hand Book of Plastics Test Methods, George Godwin Ltd., London, 1981.
4. G. C. Ives, J. A. Mead, M. M. Riley, Hand Book of Plastics Test Methods, The Plastics Institute, London, 1971.
5. Frank T. Traceski, Specifications & Standards for Plastics & Composites, ASM International, Metals Park, OH, 1990.
6. J. Hasiam, H. A. Willis, Identification and Analysis of Plastics, London Iliffe Books Ltd., New Jersey, 1980.

PT9222

PLASTICS COMPOSITE TECHNOLOGY

L T P C
3 0 0 3

UNIT I

9

Introduction – Resins for composites – polyester resins – epoxy resin – phenolic resins – vinyl ester resins – alkyd resins.

UNIT II

9

Reinforcements for composites – Natural fibers – jute, sisal – synthetic fibers – glass fibers – types and different forms – carbon fibers – classification - graphite fibers – polyethylene fibers – silicon carbide and boron fibers.

UNIT III

9

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

UNIT IV

9

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 V

9

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 methods. Application of FRP products - in marine, chemical, railways, electrical and electronic industry, space structures – Robotics.

TOTAL : 45 PERIODS

REFERENCES

1. P.K. Mallic, Fiber Reinforced composites, Morcal Dekker Inc. 1988.
2. Sidney H. Goodman, Handbook of Thermoset Plastics, John Wiley & Sons, 1984.
3. T.G. Gutowski, Advanced Composites Manufacturing, John Wiley & Sons, 1997.
4. S.M. Lee, Reference Book for Composite Technology I, II & III, Technomic Publishing Co., 1989.

PT9223

INDUSTRIAL ECONOMICS AND COSTING

L T P C
3 0 0 3

UNIT I

FUNDAMENTAL PRINCIPLES OF COST ACCOUNTING

9

Financial and Cost Accounting – Costing – Elements of Cost – Cost centres – Methods & Types of Costing – Advantages of Cost Accounting – Preparation of cost sheet.

UNIT II

PURCHASE & STORES ORGANIZATION

9

Purchase of materials – Procedure for purchases – Levels of materials – Economic ordering quantity.

Store keeper and his functions – Bin card; Priced Stores Ledger – Perpetual Inventory System – ABC Method of stores control – Pricing of material issues (FIFO, LIFO, Average price, etc.).

UNIT III

LABOUR COSTING

9

Methods of recording attendance – Methods of remuneration – Time rate, Differential time rate, payment by results – Different Incentive schemes (Taylors differential, Merrick, Gantt Task Bonus, Emerson & Halsey plan).

UNIT IV BUDGETARY CONTROL & MARGINAL COSTING 9

Budget – Budgetary control – Types of Budgets – Advantages & Difference between Budgetary control and Standard costing – Zero base budgeting.
Marginal cost & costing – Cost volume profit Analysis – PIV Ratio – Margin of safety – Application of Marginal costing technique – Advantages – Break Even point & Analysis – Its advantages.

UNIT V TAX RULES & REGULATIONS 9

Brief about Income tax Rules, Customs, Excise Rules, Sales Tax & its application in industry.

TOTAL : 45 PERIODS

REFERENCES

1. B.M. Lall Nigam, I.C. Jain, Cost Accounting an Introduction – Prentice, Hall of India Pvt. Ltd., New Delhi, 2001.
2. S.P. Jain, K.L. Narang, Cost Accounting Principles and Practice, Kalyani Publishers, New Delhi, Ed. 12, 1993.
3. B.K. Bhar, Cost Accounting Methods and Problems – Academic Publisher, Calcutta, 1991.
4. T. Horngren, M.R. Foster, M.Datar, Cost Accounting A Managerial Emphasis – Prentice, Hall of India Pvt. Ltd., New Delhi, Ed.8, 1994.

PT9226

PLASTICS TESTING LABORATORY – I

**L T P C
0 0 6 2**

UNIT I CHEMICAL LAB

Identification of Plastics – Viscosity and Molecular Weight Determination – Determination of K-value for PVC.

UNIT II DEMONSTRATION

Melting point – Carbon black content – Filler content – Environmental stress cracking resistance – PH meter – Hooper Viscometer – Brookfield Viscometer.

UNIT III SPECIMEN PREPARATION LAB

Specimen preparation using injection moulding machine – Compression moulding machine – Two roll mill and Contour cutter.

UNIT IV DEMONSTRATION

Scrap grinder – Blender

UNIT V PHYSICO-MECHANICAL LAB

Tensile strength – Flexural strength – Compression strength – Tear strength – Impact strength – Hardness

UNIT VI DEMONSTRATION

Abrasion resistant tester – Folding endurance tester – Burst strength tester – Density gradient column – Creep tester – Moisture vapour transmission rate – Gas permeability – Sieve analysis.

TOTAL : 90 PERIODS

LABORATORY REQUIREMENTS

Chemical Laboratory

1.	Plastics Identification Kit	-	1 No.
2.	Viscometer	-	1 No.
3.	Melting point apparatus	-	1 No.
4.	Carbon black content tester	-	1 No.
5.	Environmental stress cracking resistance tester	-	1 No.
6.	Brookfield viscometer	-	1 No.
7.	P ^H meter	-	1 No.

Specimen Preparation Laboratory

8.	Injection moulding machine	-	1 No.
9.	Compression moulding machine	-	2 Nos.
10.	Two roll mill	-	1 No.
11.	Contour cutter	-	1 No.
12.	Scrap grinder	-	1 No.
13.	Blender	-	1 No.

Physico-mechanical Laboratory

14.	Universal testing machine	-	2 Nos.
15.	Tear strength tester	-	1 No.
16.	Impact strength tester	-	2 Nos.
17.	Shore A – Hardness tester	-	1 No.
18.	Shore D – Hardness tester	-	1 No.
19.	Rockwell Hardness tester	-	1 No.
20.	Abrasion resistance tester	-	1 No.
21.	Folding endurance tester	-	1 No.
22.	Burst strength tester	-	1 No.
23.	Creep tester	-	1 No.
24.	Humidity chamber	-	1 No.
25.	Gas permeability tester	-	1 No.
26.	Sieve analysis apparatus	-	1 No.

REFERENCES:

1. Vishu Shah, Hand Book of Plastics Testing Technology, John Wiley & Sons. Inc. New York, 1998.
2. R.P. Brown, Hand Book of Plastics Test Methods, George Godwin Ltd., London, 1981.
3. ASTM test standards for plastics Vol.8.01 to 8.04, 9.01 & 9.02, 2002.
4. ISO test standards, 1998.
5. J.S. Anand, K. Ramamurthy, K. Palanivelu & C. Brahatheeswaran, How to Identify Plastics by Simple Methods, 1997.

1. Micro processor controlled Injection moulding operation
2. Blow Moulding Automatic
3. Vacuum Forming
4. Rotational Moulding
5. Coating of Plastics
6. Welding & Sealing of Plastics
7. Screen Printing
8. Machine Maintenance
9. Mould Study
10. FRP – Hand lay up process
11. Co-extrusion

TOTAL : 180

LABORATORY REQUIREMENTS

- | | | | |
|---|---|--------|--|
| 1. Micro processor controlled inj. moulding machine | - | 3 Nos. | |
| 2. Blow moulding machine (Automatic) | - | 1 No. | |
| 3. Vacuum forming machine | - | 1 No. | |
| 4. Rotational moulding machine | - | 1 No. | |
| 5. Plastics coating machine | - | 1 No. | |
| 6. Ultrasonic welding machine | - | 1 No. | |
| 7. Plastic sealing machine | - | 1 No. | |
| 8. Printing machine (on plastics) | - | 1 No. | |
| 9. Machine maintenance kit | - | 1 No. | |
| 10. Moulds maintenance kit | - | 5 Nos. | |
| 11. Moulds for plastic products | - | 1 No. | |
| 12. FRP hand lay up kit | - | 1 No. | |
| 13. Plastic co-extrusion film plant | - | 1 No. | |

REFERENCES:

1. A.S. Athaly, Injection Moulding Practice, Multi-Tech. Publishing Co., New Delhi, 1997.
2. Irvin Rubin, Injection Moulding Theory and Practice, A. Wiley interscience Publication. 1972.
3. Lee, Blow Moulding Design Guide, Hansar Publishers, Munich, 1998.
4. Friedhelm Hensen, Plastics Extrusion Technology, Hansar Publishers, Vienna, 1988.

UNIT I THERMAL AND RHEOLOGICAL LAB

Melt flow index – Heat distortion temperature – Vicat softening point – Oxygen index.
 Demonstration: Brabender – Capillary Rheometer – Haake Viscometer – Thermal conductivity – Marten’s heat resistance – Low temperature brittleness – Stiffness by Torsion Pendulum.

UNIT II ELECTRICAL AND OPTICAL LAB

Volume and Surface resistivity – Breakdown Voltage – Comparative tracking index – Arc resistance – Haze – Gloss – Clarity.
 Demonstration: Refractive index – Microscopes – Colour Guard – Microtome cutter.

UNIT III CHARACTERIZATION LAB

Demonstration: Thermal analysis – Thermo gravimetric analysis (TGA) – Differential scanning calorimeter (DSC) – Weather-o-meter.

UNIT IV PRODUCT TESTING LAB

Pipe, film – Water storage tank

TOTAL: 180 PERIODS

LABORATORY REQUIREMENTS

THERMAL & RHEOLOGY LABORATORY

1.	Melt flow index tester	-	1 No.
2.	Heat deflection temperature tester	-	1 No.
3.	Vicat softening point tester	-	1 No.
4.	Oxygen index tester	-	1 No.
5.	Capillary rheometer	-	1 No.
6.	Haake Rheocord	-	1 No.
7.	Thermal conductivity tester	-	1 No.
8.	Martiens heat resistance tester	-	1 No.
9.	Low temperature brittleness tester	-	1 No.
10.	Flammability testing apparatus	-	1 No.

ELECTRICAL & OPTICAL LABORATORY

11.	Volume & Surface resistivity testing apparatus	-	1 No.
12.	Dielectric strength tester	-	1 No.
13.	Comparative tracking index tester	-	1 No.
14.	Arc resistance tester	-	1 No.
15.	Haze meter	-	1 No.
16.	Clarity meter	-	1 No.
17.	Gloss meter	-	1 No.
18.	Refractive index tester	-	1 No.
19.	Microscope	-	1 No.
20.	Colour measuring equipment	-	1 No.
21.	Microtome cutter	-	1 No.

CHARACTERISATION LABORATORY

22.	Differential Scanning Calorimeter	-	1 No.
23.	Thermo Gravimetric Analyser	-	1 No.
24.	Weather-o-meter	-	2 No.
25.	Gas chromatograph – FTIR	-	1 No.

PRODUCT TESTING LABORATORY

26.	Hydrostatic pressure tester	-	1 No.
27.	Hot water bath	-	1 No.
28.	Low temperature cabinet	-	1 No.
29.	Reversion test equipment	-	1 No.
30.	Hot air oven	-	1 No.
31.	Dart impact tester	-	1 No.

REFERENCES

1. Vishu Shah, Hand Book of Plastics Testing Technology, John Wiley & Sons. Inc. New York, 1998.
2. R.P. Brown, Hand Book of Plastics Test Methods, George Godwin Ltd., London, 1981.
3. ASTM test standards for plastics Vol.8.01 to 8.04, 9.01 & 9.02, 2002.
4. ISO test standards, 1998.

Thesis/Project work on any of the following specialised area to be carried out by each student.

- Polymer Blends & Alloys, Speciality & High Performance of Polymers
- Prototype Development of a machine/tool/testing equipment
- Experimental Investigation on a specific aspects of plastics processing/tooling.
- Development of new product designs and value analysis
- Design of moulds for plastic products with innovative concepts/techniques
- Studies related to process parameter optimisation in any processing technique for defect free production
- Application development for substitution of conventional materials by plastics
- Developmental work in Plastics Waste Management (PWM)/Recycling

UNIT I MOLECULAR WEIGHT DETERMINATION 9

Molecular weight averages - Molecular weight determination techniques like End-group analysis, Colligative Properties - Ebulliometry, Osmometry and Vapour phase Osmometry, Light scattering techniques, Solution viscometry, and Gel Permeation Chromatography.

UNIT II SPECTROSCOPIC CHARACTERIZATION 9

Introduction to Spectroscopic techniques - Ultraviolet - Visible Spectroscopy - Infra Red and Raman Spectroscopy - Nuclear Magnetic Resonance (NMR) Spectroscopy - Electron Spin Resonance Spectroscopy, X -Ray Diffraction.

UNIT III MICROSCOPIC AND CHROMATOGRAPHIC CHARACTERIZATION 9

Light Microscopy - Scanning electron microscopy - Transmission electron Microscopy and Scanning transmission electron microscopy. Analysis of residual monomer like VCM, Acetaldehyde, Acrylonitrile and Styrene content in Polymers by Gas Chromatography.

UNIT IV THERMAL CHARACTERIZATION 9

The basis of Thermal Analysis - Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) - Thermo-mechanical Analysis (TMA) - Thermo gravimetric Analysis (TGA) - Dynamic Mechanical Thermal Analysis (DMA) and Dielectrical Thermal Analysis.

UNIT V RHEOLOGICAL CHARACTERIZATION 9

Introduction and definitions related to fluid flow - Newtonian and non-Newtonian and visco elastic fluids. Rheological properties - viscosity, melt-flow, relationships describing temperature and shear rate dependence on the rheological behaviour of amorphous and crystalline plastics materials, Simple shear flow and its application for measurement of viscosity as well as normal stresses. Simple elongation flow and its significance. Dynamic flow behaviour, time dependent fluid responses. Viscosity measurements - capillary rheometer, viscometer, torque rheometers, cup flow and spiral flow tests for determination of flow behaviour.

TOTAL : 45 PERIODS

REFERENCES

1. Fred W. Billmeyer, J. R. Text book of Polymer Science, John Wiley & Sons, Singapore, 1994.
2. Seymour/Carraher's Polymer Chemistry An Introduction, Marcel Dekker, Inc., New York, 1996.
3. Campbell and J. R. White, Polymer Characterization Physical Techniques, Chapman and Hall, London, 1989.
4. J. Spels, Characterization of Solid Polymers, Chapman and Hall, London, 1994.
5. Charles L. Rohn, Analytical Polymer Rheology, Hanser Publishers, Munich, 1995.
6. Edith A. Turi, Thermal Characterization of Polymeric Materials, Academic Press, New York, 1981.

PT9252

BIODEGRADABLE PLASTICS

**L T P C
3 0 0 3**

UNIT I

9

Introduction – Chemistry and biochemistry of polymer degradation – Enzymes chemical degradation initiates biodegradation – Hydrolysis of synthetic biodegradable polymers.

UNIT II

9

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

UNIT III

9

Photo-biodegradable plastics – need for degradable polymers – technical requirements of degradable polymers – Agricultural plastics – Packaging plastics – Control of biodegradation by means of antioxidants.

UNIT IV

9

Test methods and standards for bio-degradable plastics – Criteria used in evaluation of biodegradable plastics – Description of current test methods – Scanning test for ready biodegradability – Test for inherent biodegradability – Test for simulation studies – Other methods for assessing polymer biodegradability.

UNIT V

9

Recycling technology for biodegradable plastics – Conventional recycling – Degradable complicate recycling – reprocessing polyethylene starch/film scrap – Economics in in-plant recycling.

TOTAL : 45 PERIODS

REFERENCES

1. G.J.L. Griffin, Chemistry and Technology of Biodegradable Polymers, Blackie Academic Professional, 1994.
2. Gerald Scott & Dan Gilad, Degradable Polymers-Principles & Applications, Chapman & Hall, 1995.
2. Handbook of Biodegradable polymers – Abraham J. Domb, Joseph Kost & David M. Wiseman.
3. Polymer Photodegradation – Mechanism and experimental methods – Jain F. Rabek.

UNIT I SPECIALIZED INJECTION MOULDING PROCESS - I 9

Introduction - Co-injection moulding, Two-colour injection moulding process - applications, Gas assisted Injection Moulding - Basic processes and procedures - Moulding aspects - shrinkage and summary. Reaction Injection Moulding (RIM) - Process - Mould - Process Controls – Merits.

UNIT II SPECIALISED INJECTION MOULDING PROCESS – II 9

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

UNIT III ADVANCED BLOW MOULDING - I 9

Introduction - Classification of advanced Blow moulding processes - Deep draw Double Wall Blow Moulding Technology - Split moulds- Versatility - Applications. Press Blow Moulding Technology Process - Applications, Three dimensional Blow Moulding Process - Applications.

UNIT IV ADVANCED BLOW MOULDING – II 9

Stretch blow moulding - Injection stretch blow moulding - Extrusion stretch blow moulding - Process - Merits & demerits - Applications. Multi-layer Blow Moulding - Process - Applications.

UNIT V ADVANCED EXTRUSION PROCESSES 9

Introduction - Profile Extrusion - Material - Process - Process optimisation - Cooling Profile applications. Process, down stream equipments - dies and application. Multi-layer films, co-extruded sheets, Pipes, Corrugated pipes.

TOTAL : 45 PERIODS**REFERENCES**

1. James F. Stenvenson, Innovation in Polymer Processing Moulding, Hanser Publishers, New York, 1996.
2. Donald V. Rosato, Injection Moulding Handbook, International Thomson Publishing Company, 1985.
3. Friedhelm Henson, Plastics Extrusion Technology, Hanser Publishers, New York, 1988.
4. Brunt Strong, Plastics: Materials and Processing, Prentice-Hall, New Jersey, 1996.

UNIT I PREPARATION OF SYNTHESIS 9

Polymer Nanocomposites, Nanocomposites Preparation and Synthesis, Polymer Matrices : Thermoplastics, Thermosets, Elastomers, Natural and Biodegradable Polymers

UNIT II RHEOLOGY OF NANOCOMPOSITES 9

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	9
Extrusion, Injection Moulding, Blow Moulding, Foaming, Rotational Moulding		
UNIT IV	STRUCTURE AND PROPERTIES CHARACTERIZATION	9
Scattering Techniques, Microscopic Techniques, Spectroscopic Techniques, Spectroscopic Techniques, Chromatography, Solid-state characterization: Mechanical Testing, Thermal Characterization		
UNIT V	APPLICATION OF POLYMER NANOCOMPOSITES	9
Thermoplastics, Thermosets, Biodegradable Polymers.		

TOTAL : 45 PERIODS

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
3. L.A. Utracki " Clay-Containing Polymeric Nanocomposites" Rapra Technology Limited, 2004

PT9261 **PLASTICS WASTE MANAGEMENT** **L T P C**
3 0 0 3

UNIT I **9**
Introduction – Sources of plastics waste – Separation technologies, viz. Sorting – Manual, automated, Density separation, Flotation, Solvent separation, Melt filtration, Separation of resin from fiber in waste FRP.

UNIT II **9**
Plastics waste management – 4 R & I approach viz. Source reduction, Reuse, Repair, Recycling, and Incineration with examples. Plastics recycling – Classification – Code of practice - Primary, secondary, tertiary and quaternary recycling with examples – Co-extrusion and Co-injection moulding – Waste plastics as fillers.

UNIT III **9**
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 lumbars, 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 **9**
Recycling of plastics by surface refurbishing – Application of a coating, polishing with examples – Plastics ageing – Environmental ageing – Thermal ageing – Chemical degradation – Wear and erosion. Biodegradable plastics – an over view.

UNIT V **9**
Environmental issues, policies and legislation in India, Review, Tutorial section. Plastics – Energy saving, Eco-friendly – Case studies. Life cycle analysis – a model.

TOTAL : 45 PERIODS

REFERENCES

1. R. Johanner Brandrup, Recycling and recovery of plastics, Hanser Publishers, New York, 1996.
2. Nabil Mustafa, Plastics Waste Management, Disposal Recycling and Reuse, Marcel Dekker, Inc. New York, 1993.
3. Ehrig, Plastics Recycling, Products and Processes, Hanser Publishers, New York, 1992.
4. Gerald D. Andrews & Pallatheri M. Subramanian, Emerging Technologies in Plastics Recycling, American Chemical Society, Washington, DC 1992.

PT9262

QUALITY MANAGEMENT

**L T P C
3 0 0 3**

UNIT I BASIC CONCEPTS OF QUALITY 9

Introduction to quality – Basic concepts – Definitions of Quality of Design and conformance – Quality assurance functions – Investigational methods – Quality circle. Organization for quality control, quality audit, costs of quality, ISO 9000 and their documentation.

UNIT II DATA COLLECTION AND PRESENTATION 9

SQC techniques and their applications – Organising for data collection – Summarisation of data – Presentation of data in the form of bar diagram, histogram, frequency distributions and pie diagram.

UNIT III MEASURES OF CENTRAL TENDENCY AND DISPERSION 9

Calculation of Mean, Median, Mode, Standard deviation and variance – Relationship of Mean, Median & Mode – Their calculation and interpretation.

UNIT IV PROBABILITY DISTRIBUTIONS 9

Concept of distributions – Normal, Binomial and Poisson distributions – Sampling distributions, t, f and λ distributions – Introduction to tests to simple hypothesis.

UNIT V INSPECTION, SAMPLING AND CORRELATION ANALYSIS 9

Variation – Process and product checks – Inspection – In process, patrol – Objections of inspection – 100% inspection concepts of acceptance sampling – Single, double and multiple sampling – OC curves and their characteristics. Concept of regression – Concept of correlation – Different types of correlation – Scatter diagrams – Correlation analysis.

TOTAL : 45 PERIODS

REFERENCES:

1. Suddhendu Biswas, Statistics of Quality Control, Wiley Eastern Ltd., 1998.
2. Juran & Geyna, Modern Methods for Quality control and improvement, John Wiley & sons, 1986.
3. Jerry Banks, Principles of Quality Control, John Wiley & Sons, 1989.
4. A.V. Feigenbaum, Total Quality Control, Mc Graw Hill Book Company, 1986.

UNIT I 9

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 9

Introduction to numerical control system – CNC machines - Types of control system for CNC machine – CNC processing – co-ordinate system – CNC axis and motion – CNC milling – CNC turning – CNC EDM – machining – CNC wire EDM concepts – concepts of CNC program – tool motion – canned cycles – CNC interface with CAD-CNC stimulation softwares.

UNIT III 9

Computer Integrated Manufacturing (CIM) - Computer Aided Design & Manufacturing (CAD/CAM) process – advanced CAD/CAM Technology – Flexible Manufacturing System (FMS).

UNIT IV 9

Rapid prototyping – Processes – Applications - Reverse Engineering – New generation cutting tools for Mould manufacturing.

UNIT V 9

Computer Aided Engineering (CAE) – Finite Element Analysis(FEA) – Flow analysis– Thermal analysis – Warpage Analysis – Cooling Analysis - Shrinkage Analysis - Pressure Analysis – C Mould – Mould Flow – Analysis – Introduction and Application.

TOTAL: 45 PERIODS

REFERENCES

1. Mikell P. Grooves and Emary W. Zimmers, Jr. 'CAD/CAM Computer Aided Design and Manufacturing', Prentice Hall, Inc. 1995.
2. Groover, M.P., 'Automation, Production system and CIM', Prentice – Hall of India, 1998.
3. Dr.Khalil Taraman, Robert E. King, Rachel Subrin, 'CAD/CAM Intergration and Innovation' – Computer and Development Department Marketing Services Division – Dearborn, Michigan, 1985.
4. Peter Kennedy, 'Flow analysis of injection moulds' – Hanser Publishers, Munich Vienna, New York, 1995.
5. U. Rembald, B.O. Nnaji, A. Storr, 'Computer Integrated Manufacturing and Engineering', Addison – Wesley Publishing Company, New York. 1993,

UNIT I 9

Recent Development in the Bio-Polymer Industry: Fibre –Reinforced composites starch based materials, Plant Produced Polymers, Microbially produced polymers, Biologically-Based resins, Adhesives, and coatings, continuing research and development on Bio-polymers

UNIT II	9
Synthetic and Natural biomaterials used in Biomedical applications	
i)	Polyolefin's, Polyamides, Acrylic Polymers, Fluorocarbons, Polyesters, Engineering Plastics.
ii)	Collagen, Polysaccharides, Proteins, etc.
UNIT III	9
Human applications of Plastics: Cardiovascular implants, Dental Implants, 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 IV	9
Blood Polymer interactions and blood compatibility, chemical and biochemical degradation of polymers, Tissue engineering and polymers.	
UNIT V	9
Testing and Evaluation: in-vitro/vivo; Standards in product development and regulations; Ethical and sociological issues.	

TOTAL : 45 PERIODS

REFERENCES

1. Buddy D. Ratner, Allan S. Hoffman, Fredrick, J. Schoen and Jack E. Lemons (Eds), Biomaterials, Science – An Introduction to Materials in Medicine, Academic Press, San Diego (1996).
2. Joon B. Park and Roderic S. Lakes, Biomaterials: An Introduction, 2nd edition, Plenum Press, New York (1992).

PT9271	POLYMER BLENDS & ALLOYS	L T P C
		3 0 0 3

UNIT I	9
Introduction to polymer blends & alloys – Definitions and nomenclature – reasons for making polymer blend – how to select blend components – preparation of alloys & blends – economy of blending.	
UNIT II	9
Introduction – compatibilization mechanisms – compatibilization methods – compatibilization by addition of copolymer reactive blending – future trends.	
UNIT III	9
Rheology of polymer blends - Introduction – Miscibility and flow behaviour of polymer blends – Immiscible blends – Flow behaviour of immiscible and miscible polymer blends. Complex flow – processing of polymer blends – flow through a contraction.	
UNIT IV	9
Techniques for studying blends and alloys – light microscopy – the microscope, micro structure – scanning electron microscopy – specimen preparation – application to polymer blends. Transmission electron microscopy - specimen preparation – application to polymer blends.	

UNIT V**9**

Thermal analysis - Differential thermal analysis, Differential scanning calorimeter – Glass transition temperature.

Other techniques: Light scattering – X-ray scattering – spectroscopy

TOTAL : 45 PERIODS**REFERENCES**

1. L.A. Utracki, Commercial Polymer Blends, Chapman & Hall, London, 1998.
2. R.P. Singh, C.K. Das, S.K. Mustafi, Polymer Blends and Alloys an Overview, Asian Books Pvt. Ltd., New Delhi, 2002.
3. R. Paul & Seymour Newman, Polymer Blends, Vol. 1 & 2, Academic Press, New York, 1978.

PT9272**ADVANCED TOOL DESIGN****L T P C
3 0 0 3****UNIT I****9**

Nozzle types – Hot runner unit moulds – Manifold Block Design – Inlet Aperture Design – The melt flow way – Expansion problem – Types of secondary nozzles – Valve systems – Heating systems – Hot runner unit grid – Insulated runner mould – Hot runner plate mould – Standard mould systems - Quick mould change system.

UNIT II**9**

Component design – Single interrupted thread design – collapsible core design – Automatic unscrewing moulds for internally threaded components – Axially fixed rotating core – withdrawing rotating core – Layout of impression – In line layout – pitch circle layout – power and transmission system – Archimedean screw design – Automatic unscrewing mould for externally threaded components – Mould construction for pitch circle and in line layout – Standard unscrewing type mould systems.

UNIT III**9**

Mould design – Structural foam moulding – Gas assisted injection moulding – Low pressure and vacuum moulding of polyurethane (RIM) casting – Resin transfer moulding insert and outset moulding – Mould Design checklist. – Case studies.

UNIT IV**9**

Design standard for inserts – Types of inserts – Selection of metal for inserts – Minimum wall thickness of material around inserts – Anchorage – Preparation of inserts before moulding – problem in moulding usual types of inserts – Comparison of inserts – Don'ts in insert design.

UNIT V**9**

Rapid prototyping & reverse engineering – 3 D laser deitizing – Influence of CAD/CAM/CAE in tool design – Finite element analysis (FEA) – Gate & runner design through mould flow analysis – Thermal analysis – Warpage & shrinkage analysis – Cooling analysis – Pressure analysis – Mould design checklist – Case studies.

TOTAL : 45 PERIODS

REFERENCES

1. James M. Margolis, Advanced Thermoset Composites, Van Nostrand Reinhold Company, New York, 1986.
2. John J. Morena, Advanced Composite Mould Making, Van Nostrand Reinhold Company, New York, 1988.
3. Bdye, Injection Mould Design, Affiliated East-West Press P.Ltd., New Delhi, 1989.
4. Gastrow, 108-Proven Design, Hanser Publishers Munich, New York, Barcelona, 1993.
5. Belosky, Plastic Product Design, Hanser, Germany, 1995.

PT9273

THERMOPLASTIC ELASTOMERS

L T P C

3 0 0 3

UNIT I

9

Introduction to Thermoplastic Elastomers (TPE) Polyolefin – based thermoplastic elastomers – Block copolymer, Random Block polymers, Graft copolymers, Polyolefin blend TPE's preparation, Properties, processing and applications.

UNIT II

9

Polyvinylchloride based Thermoplastic Elastomers – PVC/Nitrile Rubber blends, PVC/Polyurethane blends, PVC/Co-polyester elastomer blends.
Styrenic Thermoplastic Elastomers – Manufacture, Properties, Compounding, Processing and Applications.

UNIT III

9

Thermoplastic Polyurethane Elastomer – Raw materials, Synthesis, Properties, Processing, Blends and Applications.

UNIT IV

9

Polyamides based Thermoplastic Elastomers – Polyamide thermoplastic elastomers, Preparation properties, Structure – Property relationship, Processing and applications.
Thermoplastic Polyether ester Elastomers – Synthesis, polymer structure and Morphology, Properties, Blends and applications.

UNIT V

9

Dynamically vulcanized Thermo Plastic Elastomer Blends – Introduction - Preparation of Elastomer – Plastic blends by dynamic vulcanization, properties and applications.
Ionomeric Thermoplastic Elastomers: Synthesis, Properties, ionic interactions in polymer blends and applications of ionomeric elastomers.

TOTAL : 45 PERIODS

REFERENCES

1. G.Holden, N.R. Legge, R. Quirk, H.E. Schrolder, Thermoplastic Elastomers – 2nd Edition, Hanser Publishers, Munich, 1996.
2. Anil K. Bhowmick, Howard L. Stephens, Hand Book of Elastomers New Developments and Technology, Marcel Dekker, Inc., New York, 1988.
3. S.K. De, Anil K. Bhowmick, Thermoplastic Elastomers from Rubber – Plastic Blends, Ellis Horwood, New York, 1990.
4. Benjamin M. Walker, Hand Book of Thermoplastic Elastomers, Van Mostrand Reinhold Company, New York, 1979.

UNIT I**9**

Basic paint technology; Polymeric binders, Pigments and extenders additives.

UNIT II**9**

Essential concepts of paint formulation and paint properties : paint preparation (pigment dispersion), surface preparation and paint application, paint properties and their evaluation mechanism of film formation, factors affecting coating properties, methods used for film preparation and their properties; barrier properties and corrosion, mechanical properties, aging properties, rheological properties, adhesion properties and other related properties.

UNIT III**9**

Mathematics of paint formulation, formulations of coatings as finishes (automotive appliances, coil, can, marine, aircraft etc) and for various substrates (Steel, timber, masonry, plastics etc.)

UNIT IV**9**

State of the art technologies, specialty coatings (radiation durable, nonpolluting, powder, high solids etc.)

UNIT V**9**

Water – borne coatings : Water – A Fundamental Constituent of water-borne coatings, Types of Aqueous coatings systems, Binders in water-borne coatings, Additives in water-borne coatings, Pigments and fillers, The action of Amines and Auxiliary solvents in Aqueous, The manufacture of water-borne coatings

TOTAL : 45 PERIODS**REFERENCES**

1. Outline of Paint Technology, W.M. Morgans (3rd Edition – Recently CBS Publishers.
2. Paints, Coatings and Solvents, Dieter Stage (Ed.) – 2nd Edition – Wernor Freitag Ltd (Eds)
3. Principle & Paint Formulation, R. Woodbridge (Ed) – 1991
4. Doren “Water-borne” Hanser 1994

UNIT I**PROGRAMMING AND OPERATION OF CNC MACHINES****9**

Introduction – Co-ordinate system – Dimensioning – Axes and motion nomenclature – Part programme structure – Tool compensation – MDI – Sub-routines – Canned cycle – Machining cycles – Programming examples for Machining centre – Turning centre – Introduction to Computer and CAD/CAM

UNIT II**IMPORTANCE OF EDM IN MOULD MAKING****9**

Brief about EDM – Electrode materials – Applications – CNC EDM – CNC wire EDM – Its development in Mould and Die industry

UNIT III**PRODUCTIVITY SOLUTIONS FOR THE MANUFACTURING OF MOULDS & DIES****9**

CNC Tooling – Different tool materials – Applications – Different tool coatings – Endmills

UNIT IV**9**

Machinery & Joining Of Plastics: Introduction – Importance of machining – methods viz. cutting, drilling, blending, filling, etc. Joining – principles – cohesion principle, adhesion principle – solvent cementing, Dop cementing, welding of plastics – viz. high frequency welding thermal sealing, spin welding, vibration welding, hot plate welding, ultrasonic welding, Adhesive bonding – examples: Mechanical fasteners.

Other Secondary Processes: Printing, painting, Hot stamping, In mould decoration, Electro plating and vacuum metallising.

UNIT V**9**

Casting Processes: Dipcasting, slush casting, continuous casting, cell casting, processes and applications.

Rotational Moulding: Introduction – principle – process – machinery used – materials – moulds, process parameters – merits & demerits of roto moulding.

Coating Processes: Roller coating, powder coating, fluidised bed coating, electrostatic spray coating, processes and applications.

TOTAL : 45 PERIODS**REFERENCES**

1. Donal V. Rosato & Dominick V. Rosato, Plastics Processing Data Book, Van Nostrand Reinhold, New York, 1990.
2. A. Brent Strong, Plastics: Materials and Processing Practice – Hall, New Jersey, 1996.
3. M.N. Watson, Joining Plastics in Production, The Welding Institute, Cambridge, 1988.

PT9283**PLASTICS PACKAGING TECHNOLOGY****L T P C
3 0 0 3****UNIT I INTRODUCTION****9**

Introduction to Packaging – Functions of packaging – Major packaging materials viz. Polyolefins, Polystyrene, Polyvinylchloride, Polyesters, Polyamides (Nylons), Polycarbonate and Newer materials such as High Nitrile polymers, Polyethylene Naphthalate (PEN), Polyetherimide (PEI) and LCP – Properties and Applications in Packagings.

UNIT II CONVERSION TECHNOLOGY-I**9**

Extrusion – Blown film, cast film, sheet, multi-layer film and sheet, lamination, stretch and shrink wrap and heat sealing – Injection moulding for manufacturing of packaging products – Influence of process variables and its effects. Blow moulding – Extrusion blow moulding, Die shaping, Programmed parison, Injection blow moulding and Stretch blow moulding

UNIT III CONVERSION TECHNOLOGY-II**9**

Thermoforming – Vacuum forming, Drape forming, Snap-back vacuum forming, Plug-assisted vacuum forming, Pressure forming, Matched mould forming, Scrap less thermoforming, Skin pack and blister packs, Thermoform/fill/seal systems (TFFS). Advantages and disadvantages of thermoforming.
Printing – Surface treatment, Printing on films and containers viz. Flexographic printing,

Rotogravier printing, Pad printing, Hot stamping, Reverse printing.

UNIT IV PERFORMANCE EVALUATION OF PACKAGING PRODUCTS 9

Mechanical properties – Tensile properties, Impact properties, Tear strength, Burst strength, Stiffness, Crease or flex resistance, Co-efficient of friction, Blocking, Orientation and shrinkage.

Optical Properties – Clarity, Haze and gloss

Barrier Properties – Oxygen transmission, Water vapour transmission rate – Migration.

UNIT V ENVIRONMENTAL CONSIDERATION 9

Plastic waste – Classification, Segregation, Sorting and Waste Management viz. source reduction, reuse/repair, recycling related to packaging films and constrainers.

Pollutants an outline – Chloro Fluoro Carbon (CFC), Dioxin

Life cycle assessment: A case study

TOTAL : 45 PERIODS

REFERENCES

1. Gordon L. Robertson, Food Packaging Principles and Practice, Marcel Dekker, Inc., New York 1993.
2. Louis T. Manzione, Plastic Packaging of Microelectronic Devices, Van Nostrand Reinhold, New York, 1990.