UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025

REGULATIONS - 2009

CURRICULUM I TO IV SEMESTERS (FULL TIME)

M.TECH. POLYMER SCIENCE AND ENGINEERING

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	PL 9111	Polymer Chemistry	3	0	0	3
2.	PL 9112	Science of Polymeric materials	3	0	0	3
3.	PL 9113	Polymer Process Engineering	3	0	0	3
4.	E1	Elective I	3	0	0	3
5.	E2	Elective II	3	0	0	3
PRACTICAL						
6.	PL 9116	Polymer Science Laboratory	0	0	4	2
		TOTAL CREDITS	**15**	**0**	**4**	**17**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	PL 9121	Characterization and Testing of Polymers	3	0	0	3
2.	PL 9122	Polymer Technology	3	0	0	3
3.	PL 9123	Instrumentation in Polymer Industries	3	0	0	3
4.	E3	Elective III	3	0	0	3
5.	E4	Elective IV	3	0	0	3
PRACTICAL						
6.	PL 9126	Polymer Processing and Testing Laboratory	0	0	6	3
7.	PL 9127	Seminar	0	0	2	1
		TOTAL CREDITS	**15**	**0**	**8**	**19**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	E5	Elective V	3	0	0	3
2.	E6	Elective VI	3	0	0	3
3.	E7	Elective VII	3	0	0	3
PRACTICAL						
4.	PL 9131	Industrial Training (4 weeks)	0	0	0	2
5.	PL 9132	Project work (Phase I)	0	0	12	6
		TOTAL CREDITS	**9**	**0**	**12**	**17**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	PL 9141	Project Work (Phase II)	0	0	24	12
		TOTAL CREDITS	**0**	**0**	**24**	**12**

TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF DEGREE 65

ELECTIVES FOR M.TECH. (POLYMER SCIENCE AND ENGINEERING)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	PL 9151	Adhesive science and technology	3	0	0	3
2.	PL 9152	Composites	3	0	0	3
3.	PL 9153	Conducting polymers	3	0	0	3
4.	PL 9154	Engineering plastics	3	0	0	3
5.	PL 9155	Plastic waste management	3	0	0	3
6.	PL 9156	Rubber technology	3	0	0	3
7.	PL 9157	Synthetic resins	3	0	0	3
8.	PL 9158	Industrial management	3	0	0	3
9.	PL 9159	Total quality management	3	0	0	3
10.	PL 9160	Biopolymers and biodegradable polymers	3	0	0	3
11.	PL 9161	Heat, mass and momentum transport processes	3	0	0	3
12.	PL 9162	Reaction engineering	3	0	0	3
13.	PL 9163	Process instrumentation	3	0	0	3
14.	PL 9164	Computer aided design	3	0	0	3
15.	PL 9165	Synthetic fibers	3	0	0	3

PL9111 POLYMER CHEMISTRY

3 0 0 3

Unit I Fundamentals of polymers 12

Basic concepts of polymer science – classification of polymers – Polymer microstructure-chemical structure and geometrical structure - ladder, star and honey- comb polymers – interpenetrating networks –tacticity – crystalline and amorphous polymers- thermal transitions–glass transition temperature(Tg) - heat distortion temperature.

Unit II Bio and inorganic polymers 9

Naturally occurring polymers – starch, cellulose, polypeptides – modified cellulose polymers – rayon, cellophane, cellulose acetate, butyrate and nitrate – ethyl cellulose – carboxy methyl cellulose- organometallic polymers - co-ordination polymers - polyamides- Inorganic polymers - phosphorous and nitrogen containing polymers – silicones.

Unit III Chain polymerisation 8

Kinetics and mechanism of free radical, cationic, anionic and coordination polymerisation – stereo regular polymerization - chain transfer reaction and constant –Trommsdorff's effect - living polymers – Alfin catalysts – iniferters.

Unit IV Step growth polymerisation and copolymerization 8

Kinetics of condensation polymerisation – copolymerisation – copolymer equation – composition of copolymers by NMR, IR and UV spectra and chemical methods – monomer reactivity ratios and their significance - metathetical, electrochemical and ring opening polymerisations.

Unit V Molecular weight, solubility and fractionation of polymers 8

Molecular weight of polymers – number, weight and viscosity average molecular weights – polydispersity - molecular weight distribution – determination of molecular weight by GPC and viscometry – polymer dissolution - thermodynamics of polymer dissolution - solubility parameter – fractionation of polymers - reactions of polymers - introduction of new functional groups - cross linking, cyclisation and degradation reactions.

Total Periods 45

References

1. F.N. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.
2. V.R. Gowarikar, N.V.Viswanathan and Jayadev Sreedhav, Polymer Science, Wiley Eastern Limited, Madras 2006.
3. R.J. Young, Introduction to Polymers, Chapman and Hall Ltd., London, 1999.
4. Gorge Odean – Principles of Polymerisation, 4th editon, Mc.Graw Hill Book Company, New York.2004.
5. M.S.Bhatnagar, " A Text Book of Polymers (chemistry and Technology of polymers), Vol I, II & III, 1st Edn., S.Chand and Company, Newdelhi, 2007.

PL9112 SCIENCE OF POLYMERIC MATERIALS

3 0 0 3

Unit I **8**

Polymer structure – chain structure – micro structure – crystal structure crystallinity –determination of crystallinity, size and orientation of crystallites using x-rays- conformation and configuration- analysis of random flight chain model – application to rubber elasticity - engineering rubbers.

Unit II **13**

Mechanical properties – deformation of plastic materials- classification of plastic materials based on their stress – strain relationship – effect of temperature on deformation-time dependence and viscoelasticity in solid plastics –models of viscoelasticity – Boltzmann's superposition principle- dynamic mechanical properties – yielding of plastics- aspects of the yield process under tensile stress – crazing and shear yielding – yielding in semicrystalline polymers –mechanical failure in plastics.

Unit II **6**

Thermal properties –enthalpy –melting and crystallisation – importance of Tg - factors affecting Tg – determination of Tg – thermal conductivity – thermal expansion and contraction - factors affecting thermal expansion .

Unit IV **8**

Electrical properties –electrical properties at low stress and high stress- breakdown mechanisms – behaviour of dielectric under a.c. field – electrically conductive plastics – electrical applications of plastics.

Unit V **10**

Melt flow properties - fundamental concepts of rheology – geometry of flow – rheological and viscous behaviour in simple shear - viscous properties of plastic melts in simple shear – measurement of shear properties – cone and plate – concentric cylinder – capillary extrusion viscometer – types of capillary viscometer – factors affecting shear flow – elongational flow – factors affecting elongational flow - melt elasticity.

Total Periods 45

References

1. Birley, Haworth, Batchelor, Physics of Plastics – Processing Properties and Materials Engineering, Hamer Publication, 1992.
2. N.C. McCrum et.al, Principles of Polymer Engineering, Oxford University Press, London 1988.
3. J.J. Aklonis and J.Mcknight, Introduction to Polymer Viscoelasticity, John Wiley and sons, New York, 1983.
4. Bever, Encyclopedia of Materials Science and Engg., Pergaman press, London, 1980.

PL9113 POLYMER PROCESS ENGINEERING

3 0 0 3

Unit I Mixing devices **8**

Mechanical and kinetics of mixing – different types of mixing devices – two role mixing – internal mixing and screw mixing – twin screw compounding machines – high temperature and pressure mixing devices – powder coating – metallizing – antistatic agents

Unit II Injection moulding process **9**

Components in the injection moulding machines - Injection moulding process analysis – principles of compression and transfer moulding –vacuum moulding – Disc moulding – Moulds - Multi daylight moulds - Mould clamping devices – reaction injection moulding

Unit III Extrusion processes **9**

Mechanism of flow –Drag flow , Pressure flow, Leak flow - analysis of polymer extrusion process - Basic flow patterns in extrusion die – die exit instabilities – die swell – processing methods based on extruder (Granule production, profile production, film blowing, blow moulding, extrusion stretch blow moulding) – extrusion coating process

Unit IV Special moulding techniques **9**

Calendering rolls arrangement and control – methods of sheet forming – matched mould forming –air blowing –vacuum forming techniques – thermo forming – techniques of blow moulding –rotation moulding –plastic finishing techniques.

Unit V Basic concepts in die design **10**

Types of moulds – clamping force – ejection devices – mould cooling –screw standards – feeding devices –CAD / CAM applications.

Total Periods 45

References

1. Crawford R.J. Plastics Engineering , Pergamon Press, London, 1987.
2. Richard G.Griskey, Polymer Process Engineering, Chapman and Hall, 1995.
3. Peter Powell, A. Jan Ingen Houz, Engineering with Polymers, Stanley Thomas Publishers Ltd., 2nd Edn. 1992.
4. George Mathews, Polymer Mixing Technology, Applied Science Publishers,1982.
5. Friedhelm Hansen, Plastics Extrusion Technololgy, Hanser Publishers, Munich, 1988.

PL9116 POLYMER SCIENCE LABORATORY

0 0 4 2

Unit I **16**

Polymer synthesis – bulk, solution, emulsion, suspension and slurry polymerisations and high temperature condensation polymerisation, interfacial polycondensation, th and redox initiated polymerisations.

Unit II **10**

Kinetics of polymerisation – dilatometry, gravimetry.

Unit III **14**

Determination of reactivity ratio of MMA – styrene copolymer – characterisation by TGA, TMA, NMR and IR. Crystallinity of polymers – X-ray diffraction study.

Unit IV Determination Molecular weight **10**

Molecular weight determination – viscometry, end group analysis, GPC, light scattering, osmometry.

Unit V Fractionation of polymers **10**

Fractionation of polymers – Fractional precipitation method – polydispersity

Total Periods 60

References

1. Edward A. Colloind, J.Bares and F.W. Billmeyer Jr., Experiments in Polymer Science, Wiley Interscience, New York 1973.
2. Wayne R.Sorenson and T.W.Campbell, Preparative Methods of Polymer Chemistry 3nd edition, Wiley – Interscience, New York, 2001.
3. E.M.McCaffery, Laboratory Preparation for Macromolecular Chemistry, McGraw Hill, Kogakush 1970.

PL9121 CHARACTERISATION AND TESTING OF POLYMERS

3 0 0 3

Unit I Characterisation tests **11**

TGA, DTA, DSC, TMA, XRD, IR, NMR, GC, GPC melt index and viscosity.

Unit II Thermal and electrical properties **9**

Heat deflection temperature, vicat softening temperature, thermal conductivity thermal expansion, brittleness temperature – dielectric strength dielectric constant, dissipation factor, resistance.

Unit III Mechanical properties and flammability **9**

Tensile tests, compressive properties, impact properties, deformation, brittleness abrasion resistance hardness tests – incandescence resistance, ignition properties, oxygen index, surface burning characteristics.

Unit IV Optical properties and analytical tests **9**

Refractive index, luminous transmittance, haze, density, water absorption, moisture analysis, sieve analysis, crush and burst strength.

Unit V Testing of foam plastics and testing organizations. **7**

Foam properties, rigid and flexible foam - testing methods - ASTM, ANSI, NBS, NEMA, NFPA, UL, SPI and SPE.

Total Periods 45

References

1. Vishnu Shah, Hand book of Plastics testing technology, John-Willey &Sons, New York, 1984.
2. L.D.S.Yadav, Organic Spectroscopy, Anamaya Publishers, 2005.
3. H.Kaur, Instrumental methods of chemical analysis, K.K.Mittal Publishers, 2003
4. Iver, Mead and Riley, Hand book of Plastic test methods, Illith Publishers, New York, 1982.
5. A.Ya. Malkin, A.A. Aska Dsky, V.V. Koverica Experimental methods of polymers, Mir Publishers, Mascow, 1998.
6. Schmitz, J.V., Testing of polymers, Interscience, New York, 1965
7. W.Kemp, Organic Spectroscopy, 3rd Edn, ELDS, McMillian, London, 1991.

PL9122 POLYMER TECHNOLOGY

3 0 0 3

Unit I **9**

Raw materials – petroleum, natural gas, biogas and coal sources of monomers – manufacture of acetylene, ethylene, propylene, vinyl chloride, toluene, phenol and styrene.

Unit II **9**

Polymerisation reaction engineering – homogeneous and heterogeneous polymerisation – classification – bulk, dispersion, solution, suspension and emulsion polymerisations – reactors for polymerisation.

Unit III **9**

Specific technology of polymerisation – polystyrene, HDPE, LLDPE, nylons, butyl rubber, polypropylene, PVC and PET – copolymerisation techniques – SBR and ABS.

Unit IV **9**

Polymer processing – processing of thermoplastics and thermosetting plastics – compounding – fillers, plasticizers, coupling agents –antidegradants, cross-linking agents, stabilisers, lubricants, colourants, and antioxidants – machines

Unit V **9**

Processing technology of elastomers – processing of natural and synthetic rubbers – vulcanisation, mastication and cyclisation- moulding – calendaring and extrusion techniques – reaction injection moulding – sintering - solution casting – SMC and DMC – fibre spinning and drawing.

Total Periods 45

References

1. A.Brydson, Plastic materials, 4th edition, Butterworth – Heinamann Ltd., London, 2002
2. John Murphy, Additives for Plastics Handbook, 2nd edition, Elsevier Advanced Technology, 2003.
3. J.A. Biesenberger and H.Sebastian, Principles of Polymerisation Enginering, Wiley- Interscience Publication, NewYork, 1988.
4. D.H. Morton and Jones, Polymer Processing, Chapman and Hall, London, 1989.
5. Stephen L.Rosen, Fundamental Principles of Polymeric Materials, 2nd edition, John Wiley and Sons Inc., New York, 1993.

PL9123 INSTRUMENTATION IN POLYMER INDUSTRIES

3 0 0 3

Unit I	**6**
Process variables such as temperature, pressure, flow etc. and their measurements. Examples in polymer processing in moulding, extrusion.	
Unit II	**10**
Measurement and control – Simple systems-first and higher order systems-Design specifications on system time response – feed back control diagram – proportional, integral, derivative and PID controls	
Unit III	**10**
Mathematical analysis of processes and feed back control systems –poles, zeros and system stability-Stability Analysis- Routh's Test-Root locus-frequency response using Bode plot.	
Unit IV	**9**
Computer control and application – mathematical concepts of discrete variables analysis and multivariable processes and other control methods as feedforward control, ratio control and internal model control etc.	
Unit V	**10**
Instrumentation in blow moulding, extrusion and injection moulding and control systems.	
Total Periods	**45**

References

1. D.M.Considine, Process Instruments and Controls Hand Book, McGraw Hill Book Co.,1964.
2. D.R.Coughanour, Process Systems Analysis and Control, McGraw Hill Book Co.,1991.
3. H.R.Simonds, Encyclopedia of Plastic Equipment, Reinhold Publishing Co., 1964.
4. D.V.Rosato, Blow Moulding Hand book, Hanser Publications, 1989.
5. Allan L. Griff, Plastic Extrusion Technology, Reinhold Plastics Applications Series, 1962.
6. A.Whelan, Developments in Injection Moulding, Applied Science Publications,1989.
7. Sidney Levy, Plastic Extrusion Technology Hand Book, Industrial Press Inc.,NewYork,1989.

PL9126 POLYMER PROCESSING AND TESTING LABORATORY

0 0 4 2

Unit I
Processing of polymers – principles of compounding and processing for the manufacture of plastics and rubber products- injection, blow and compression moulding, extrusion, calendaring and casting processes.

Unit II
Testing of plastics and dry rubber products – mechanical properties – tensile, Flexural, compressive, impact, hardness, abrasion and fatigue resistance tests.

Unit III
Thermal properties – thermal conductivity, thermal expansion and brittleness temperature, heat deflection temperature.

Unit IV
Electrical properties – dielectric strength, dielectric constant and dissipation factor. Electrical resistance tests - arc resistance.

Unit V
Optical properties – refractive index, transmittance and haze, gloss.

Unit VI
Material characterisation tests – thermoplastics – MFI, capillary rheometer test – thermosets – apparent (bulk) density, bulk factor, pourability, viscosity (Brookefield), gel time and peak exothermic temperature.

Unit VII
Flammability tests – oxygen index test, ignition temperature determination.

Unit VIII
Analytical tests – specific gravity, density, water absorption, moisture analysis.

Unit IX
Identification and analysis of plastic and dry rubber materials – chemical and thermal analysis for identification of polymers.

Total periods-60

References

1. W.E. Brown (Ed), Testing of Polymers, Vol. 4, Wiley –Interscience, New York, 1969.
2. J.N. Schmitz (Ed) Testing of Polymers, Vol. 1 –3 , Wiley – Interscience New York, 1965, 1966, 1968.
3. G.C.Ives, J.A. Mead and M.M. Riley, Handbook of Plastics Test Methods, Illith Publishers, London, 1982,
4. J.Haslam, H.A.Willis and D. Squirrell, Identification and Analysis of Plastics. 2nd Edn., Iliffe Book, Butterworth, London, 1972.

PL9151 ADHESIVE SCIENCE AND TECHNOLOGY

3 0 0 3

Unit I Adhesion mechanism **9**

Definition and mechanisms of adhesion- mechanical interlocking – interdiffusion theories –adsorption and surface reaction. Surface topography, wetting and setting, thermodynamic work of adhesion – influence of constitution on adhesion – interfacial bonding – coupling agents.

Unit II Characterization of adhesives **9**

Principle of fracture mechanics, peel, Lap sheen and Butt tensile tests. Pull out of an extendable fibre, various testing of adhesives, energy dissipation – plasticity – strength of elastomers.

Unit III Industrial adhesives **9**

Inorganic adhesives – animal glues – caesin – starch – cellulosics. Principle of compounding – role of resin – fillers – antioxidants – accelerator systems.

Unit IV Adhesive types **9**

Adhesive from natural, butyl, nitrile, styrene – butadiene – carboxylic polymers and neoprene rubbers, polysulphide, phenolic resin, epoxy, polyurethane, polyvinyl acetate, polyvinyl alcohol, polyvinyl acetal, acrylic, high temperature silicone adhesives. Water based – pressure sensitive – hot melt adhesives – anaerobic adhesives

Unit V Applications of adhesives **9**

Adhesives for building construction, medical use, automobile industry bonded and coated abrasives – fabrics, cyanoacrylate based adhesives, bonding technology for textile, metal, plastics, wood, paper and glass.

Total periods **45**

References

1. V.Cagle Charles, Handbook of adhesive bonding, McGraw Hill Book Company, New York, 1978.

2. R.L.Patrick, Treatise on adhesion and adhesives, Vol.5, Marcel Dekker Inc., New York, 1981.

3. W.A.Lees, Adhesives in engineering design, Springer Verlag, Berlin, 1984.

4. D.M. Brewis and D.Briggs (Ed.), Industrial adhesion problems, Wiley-Interscience Publication, New York, 1985.

PL9152 COMPOSITES

3 0 0 3

Unit I Characteristics & Classification 8

Introduction –Characteristics, advantages, and need of composites – classification – particulate, fibrous and laminated composites, hybrid composites, CCCs, nanocomposites. Woven, knitted and braided materials, flexible composites. Advanced composites.

Unit II Fibers 10

Fibers-Glass –Types-E, S, C and D glasses. Rovings, yarns, CSM, surface mats, performs, woven and non woven fabrics-Production, Properties and applications. Carbon –Precursors- PAN and Pitch based; types –HT, HM and intermediate modulus, production, properties and applications. Aramid –Types-Kevlar, Technora HM-50-Production properties and applications. Natural fibers. Surface treatments. Woven, knitted and braided materials – Three dimensional fabrics (woven and braided) – fabric reinforced composites - flexible composites – Applications.

Unit III Resins 9

Resins **-**Thermosets: Unsaturated polyester, epoxy, vinyl ester, silicone resins– production, properties and applications. Thermoplastics: Examples, Comparison with thermosets. Prepregging techniques. Properties and applications.

Unit IV Processing Methods 9

Different types of molds**-** DMC, SMC and prepregs. Hand & Spray lay up- RTM, Bag, autoclave, centrifugal and compression molding processes, Filament winding and sandwich construction.

Unit V Testing Methods 9

Testing of composites – fiber volume fraction, tensile, shear, compressive, flexural and thermoelastic responses of lamina and laminates - IOSEPESCU shear test - notched strength – fracture toughness-non destructive testing.

Total periods 45

References

1. Mel. M. Schwartz, Composite Materials, Vol 1 & 2, Prentice - Hall PTR, New Jersey, 1997.
2. Bor Z.Jang, Advanced Polymer composites, ASM International, USA, 1994.
3. L.A. Carlsson and R.B. Pipes, Experimental Characterization of advanced composite materials, Second Edition, CRC Press, New Jersey, 1996.
4. George Lubin, Stanley T. Peters , Handbook of Composites, Springer, 1998.
5. Richard M. Christensen, Mechanics of composite materials, Dover Publications, 2005.
6. A.A. Vaidya and S.S.Trivedi,Textile auxillaries and finishing chemicals, ATIRA, Ahemadabad, 1981.

7. Sanjay K.Mazumdar, Composites Manufacturing: Materials, Product, and Process Engineering, CRC Press, 2001.

PL9153 CONDUCTING POLYMERS

3 0 0 3

Unit I Electrochemistry of conducting Polymers 8

Electrochemistry of electronically conducting polymers-source of electronic conduction in polymers – solitons , polarons and bipolarons – emiconductors and conducting polymers.

Unit II General synthesis of conducting polymers 9

Synthesis of conducting polymers – chemical, electrochemical and enzymatic methods –doping –general considerations – measurement of conductivity – van der Pauw technique – factors affecting conductivity.

Unit III Characterization of conducting polymers 8

Characterization of conducting polymers – electroanalytical techniques – cyclic voltammetry, chronoamperometry and chronocoulometry, spectral methods - use of UV-vis ,Raman, XRD and NMR.

Unit IV Synthesis, processability and applications 10

Synthesis, processability and applications of acetylene, aniline, pyrrole, thiophene and para – phenylene based conducting polymers.

Unit V Applications of conducting polymers 10

Conducting polymers in microelectronics – corrosion and ESD protection, EMI shielding and lithography. LED-rechargeable batteries – artificial muscles - electrochromic devices–sensor devices–conductive composites.

Total periods 45

References

1. T.A. Skotheim, R.L. Elsenbaumer and J.R. Reynolds, Hand book of Conducting Polymers – 2nd Edn, Revised and enlarged, Marcel Dekker Inc., New York, 1998.
2. J.M. Margolis (Ed.), Conducting Polymers and Plastics, Chapman and Hall, London, 1989.
3. R.B. Seymour, ed., Conductive Polymers", Plenum Press, New York, 1981.

4. Z.Tadmore Principles of Polymer Processing, Wiley – Interscience, New York, 1979.

5. B. Wessling, Electronic Properties of Conjugated Polymers, Vol.3, Springer, Berlin, 1989.

6. H.G. Kiess (Ed.), Conjugated Conducting Polymers, Springer, Berlin, 1992.

D.S.Soane and Z. Martynenko (Eds.), Polymers in Microelectronics, Elsevier,Amsterdam, 1989.

PL9154 ENGINEERING PLASTICS

3 0 0 3

Unit I Polymers for electrical and electronics applications 10

Engineering plastics – polymers in electrical and electronics industry – electro conducting polymers – polymer batteries – electrets - polymers with piezoelectric, pyroelectric and ferroelectric properties-photo conducting polymers.

Unit II Polymers for high temperature applications 10

Polymers for high temperature resistance– fluoro polymers – aromatic polymers– heterocyclic polymers – polymers as building materials – ultrahigh fibres – aramids – technora – carbon fibres.

Unit III Polymer blends, alloys and liquid crystals 10

Polymer blends and alloys – reinforced plastics – ionic polymers –interpenetrating networks – sequential – simultaneous – full and semi IPN – thermoplastic IPN – liquid crystalline polymers (LCP) – lyotropic and thermotropic liquid crystals – main chain and side chain liquid crystalline polymers–processing of LCP's- applications –ablative plastics.

Unit IV Polymers in lithography and water treatment 10

Polymers in lithography – photoresist – positive resists – negative resists – solution inhibition resists – image reversal process – Ion exchange resins – polymer membrane –polymer complexes for water treatment.

Unit V Polymers for biomedical applications 5

Polymer for biomedical applications – polymers in dentistry – tissue adhesives – dialysis membrane – blood oxygenators – bone cement – prostheses – biodegradable sutures – control drug delivery systems.

Total periods 45

References

1. H.F. Mark (Ed), Encyclopedia of Polymer Science and Engineering, Wiley – Interscience, New York, 1991
2. L.L. Chapoy (Ed), Recent Advances in Liquid Crystalline Polymers, Chapman and Hall, London, 1985.
3. R.W. Dyson, Speciality Polymers, Chapman and Hall, New York, 1987.
4. C.P.Wong, Polymers for Electronic and Photonic Applications, Academic Press, New York, 1992.

PL9155 PLASTIC WASTE MANAGEMENT

3 0 0 3

Unit I Polymer wastes **9**

Sources of plastic waste – definitions - generation of industrial plastic waste - plastic in solid waste; Separation of components in municipal refuse - separation process specific to plastics.

Unit II Primary and secondary recycling **9**

Primary recycling – degradation of plastics – industrial practice; Secondary recycling – approaches to secondary recycling – mechanical reworking of plastic waste – chemical modification of mixed plastic waste – coextrusion and coinjection moulding – waste plastics as fillers.

Unit III Tertiary and Quaternary recycling **9**

Tertiary recycling – chemicals from plastics waste – pyrolysis chemical decomposition of plastic waste; Quaternary recycling energy from plastics waste – incinerator – energy recovery from municipal refuse – effect of plastics on the incineration process – plastics as land refill.

Unit IV Recycling of plastics **9**

Recycling of plastics – surface refurbishing; Plastic aging – environmental aging – thermal aging – weathering – chemical degradation – ionising radiation – wear and erosion; Biodegradation – biodegradable plastics – photodegradable plastics.

Unit V Recycling processes **9**

Specific recycling processes – PET reprocessing – polyolefines – polystyrene – PVC – acrylics; Thermosets – PURS – phenolics – polyesters – epoxy resins – melamine and urea resins – recycling technologies.

Total periods **45**

References:

1. Nabil Mustafa, Plastics Waste Management: Disposal, Recyling and Reuse, Marcel Dekker Inc., New York, 1993.
2. R. J. Ehrig, Plastic recycling: Products and Processes, Hanser Publishers, New York, 1992.
3. Jacob Leidner, Plastic waste: Recovery of Economic Value, Marcel Dekker Inc., New York, 1982.
4. John Scheirs, Plastic Recycling, John Wiley and Sons, New York, 1998.
5. Ann Christine, Albertsson and Samuel J. Huang, Degradable Polymers: Recycling of Plastics, Marcel Dekker Inc., New York, 1995.

PL9156 RUBBER TECHNOLOGY

3 0 0 3

Unit I Fundamentals of Rubber **8**

Criteria for a polymer to behave as a rubber – structure vs Tg, chemical, mechanical and electrical properties – polymerisation types and techniques involved in production of general purpose rubbers – ozone attack on rubbers– protection against oxidation - antioxidants – network bound antioxidants, vulcanisation – effect of crosslink density on properties – role of accelerators, activators – non–sulphur vulcanisation systems.

Unit II Specialty Rubbers **8**

Heat resistant rubbers –polyisobutylene, butyl and EPDM rubbers – solvent/oil resistant rubbers –nitrile, neoprene and chloroprene rubbers, EMA,ACM, EVA – hypalon and chlorinated PE – high performance, specialty and modified rubbers – fluorine containing and silicone rubbers, polyurethanes , polyethers, polysulphide, polyalkenomers and thermoplastic elestomers – reclaim, liquid and powdered rubbers, ebonites.

Unit III Processing of Rubber **8**

Rubber processing – mixing operations – composition, concentration, stabilisation, coagulation, open mill mixing, internal and continuous mixers – forming operations – calendering – extrusion –spreading and moulding operations.

Unit IV Manufacture of Tyres and Tubes **7**

Rubber product manufacture – tyres – functions, requirements – basic design reinforcing systems –construction – manufacture – testing – tube manufacture– compounding for tyre and tube.

Unit V Belting, hoses and Footwear **14**

Belting and hoses – conveyor, transmission (V and flat) belting. troughing moulded, braided and hand–built hoses – compounding - footwear and ports goods – hot air vulcanized – compression moulded – direct moulded process for shoe bottoming – injection moulded sole and heel units – safety and antistatic foot wear – micro and macrocellular rubbers – expanding rubber by nitrogen gassing and chemical blowing agents– tennicoit rings

45

Total periods

References

1. M.Morton, Rubber Technology, Van Nostrand Reinhold, 1987.
2. A. Whelan and K.S.Lee, Developments in Rubber Technology, Vol. 1 – 4, Applied Science Publishers, London 1981.
3. A.K. Bhowmick and H.L.Stephens, Hand Book of Elastomers, Marcel Dekker, New York, 1988.
4. J. A. Brydson, Rubbery Material and their Compound', Kluwer Academic Publishers Group, 2001.
5. C. M. Blow and C.Hepburn, "Rubber Technology and Manufacture", 2rd Edn.,Butterworths, London, 1982.
6. A. Whelan, Injection Moulding Machine, Elsevier Publications, London, 1989.

PL9157 SYNTHETIC RESINS

3 0 0 3

Unit I Classification of Polymers **10**

Introduction – Classification of natural, modified and synthetic polymers – effect of structure on properties of polymers — Salient features of plastics-water soluble polymers– classification- functions and properties – starch- dextrinization – modified starches – cellulose and its derivatives- commercial Applications.

Unit II Water soluble Polymers **10**

Synthetic water soluble polymers, preparation, properties and applications of polyvinyl alcohol – polyvinyl pyrrolidone – polyacrylic acid and its homologs – polyacrylamide – polyethylene oxide – polyethyleneimine. Application of water soluble polymers in pharmaceuticals – cosmetics – textiles – paper – detergents and soaps – paint – flocculation – beverages – polyelectrolytes.

Unit III Thermoplastic resins **10**

Thermoplastic resins – polyolefins – vinyl polymers – poly vinyl chloride-polystyrene – PMMA – SAN – PAN - Teflon – polyamides – polycarbonates and their applications.

Unit IV Thermosetting resins **10**

Thermosetting resins – phenolic resins – aminoplast – UF- MF - polyesters – alkyd resins – epoxies – bisphenol A and cycloaliphatic based epoxy resins - polyurethanes and polyureas – silicone resins.

Unit V Rubbers, fibers and Plastics **5**

Elastomers – natural rubber – vulcanization - synthetic rubbers - butyl- SBR neoprene. Application of synthetic resins as fiber – commodity plastics – sheets and film – foam – packaging – biodegradable and engineering applications.

Total periods **45**

References

1. J.A. Brydson, Plastic Materials, Newness - Butterworths, Seventh Edn, London, 1999.

2. R.L.Davidson and S. Marshall, Water Soluble Resins, Van-Nostrand Reinhold, New York, 1988.

3. R.B. Seymour and C.E.Carraher, Jr., Polymer Chemistry – An Introduction, Marcel Dekker Inc., New york, 2005.

4. Maurice Morton, Rubber Technology, Van Nostrand Reinhold, New York, 2002.

PL9158 INDUSTRIAL MANAGEMENT

3 0 0 3

Unit I Man power planning **12**

Need – objectives – planning for future – manpower planning process- projecting manpower supply and demand at organisational level – developing manpower strategy - recruitment selection and induction – process of recruitment – selection tests – placement induction – orientation – training and development – training – management development – retraining – evaluation of training programmes.

Unit II Motivation and productivity **12**

Issues in managing people – Maslow's need hierarchy – social needs and productivity –hygienes and motivators – motivational climate – demotivation – cases – performance appraisal – job performance and performance measurement – validity and reliability – methods – problems in Indian context – career planning – responsibility – process of career planning and development – advantages and limitations.

Unit III Union management perspective **7**

Approaches to industrial relations – public policies – major events in international issues – perspectives for India – trade with development and functions – growth of trade unions – development – functions – structure – leadership and management in the trade union.

Unit IV Dynamics of conflict and collaboration **7**

Process of conflict – types of conflict – interpersonal conflict – managing inter group relations and conflict – industrial conflict resolution – consultation- collective bargaining – types of bargaining – new collective bargaining –negotiation skills – trends in collective bargaining.

Unit V Workers participation and management **7**

Concept, strategies and practices –models in workers participation management – design and dynamics of articipative forms – case studies– case study analysis – synthesis

Total periods 45

References

1. C.B. Memoria, Personnel Management, Himalaya Publishing Co., Bombay, 1985.

2. Robbins, The Management of Human Resource, Prentics, Hall, New Jersey, 1982

3. C.B. Memoria and S.Memoria, Dynamics of Industrial Relations in India, Himalaya Publishing co., Bombay, 1985

4. H.C. Lucas Jr., Information System Concepts for Management, McGraw Hill, Kogakusha, 1978.

PL9159 TOTAL QUALITY MANAGEMENT

3 0 0 3

Unit I Introduction to theory of quality control 9

Introduction to quality control theory - elements of quality, fundamentals of statistics and probability in quality control –measures of central tendency on-normal distribution – significance tests – difference between means. inomial, Poisson distributions – thorndike chart – hypergeometric distribution.

Unit II 9

Control of process quality – principles of control – quality capability analysis – quality capability study – average range method for determining process capability – control of variable quality – characteristics – theory of control charts –control limits- types of control charts – control chart for variables –X and R control charts – control charts for attributes – P. Chart, C. Charts.

Unit III 9

Quality assurance and acceptance – acceptance sampling-operating characteristics curve – development of single sampling plan, concept of AQL, LTPD producers and consumers risk – average outgoing quality (AOQ) curve. Other acceptance sampling plans – sampling tables.

Unit IV 9

Quality engineering – planning for quality and reliability – quality standards – specification of inspection methods, setting of standard quality levels – introduction to ISO-9000 –design of quality experiments using statistics –analysis of variance.

Unit V 9

Reliability and maintainability – definition of reliability, factors affecting reliability – MTTF –MTBF – evaluation of reliability, quality management – organising for quality – economy of quality- techniques of ABC analysis- quality management education – zero defects concept – quality circles concept- applying total quality management in enterprises.

Total periods 45

References

1. A.J. Ducan, Quality Control and Industrial Ttatistics, Homewood, Illinois, 1959.

2. A.V.Feigen Baum, Total Quality Control, McGraw Hill Co. New York, 1961

3. B.L. Hansen, Quality Control: Theory and Applications, PHI, New Jersey, 1966.

4. M.Lal, Total Quality Management –A Pratical Approach, Wiley Eastern, New York, 1990.

PL9160 BIOPOLYMERS AND BIODEGRADABLE POLYMERS

3 0 0 3

Unit I Synthetic Biodegradable polymers 11

Biodegradable polymers - poly $\in$-caprolactone- modified poly $\in$- caprolactone copolymer with ester, amide and urethane linkages, polyglycolate, polymandelic acid. Copolymer of 1,4- butanediol with adipic acid and sebacic acid, polyalkylene tartrate cellulose block copolymers -biodegradable polyamides –copolymers of α-amino acid (glycine, serine), $\in$ - aminocaproic acid. Benzyl substituted urethane – polyester urea – polyamide urethane - synthesis and properties. γ -polyglutamic acid, bacterial polyesters. Applications – agriculture, medicine, packaging.

Unit II Principles of biodegradation 9

Biodegradation -introduction – modes of biological degradation –enzymatic degradation of biopolymers (poly saccharides, proteins, nucleic acids) and synthetic polymers - microbial degradation of synthetic polymers.

Unit III Disposal of municipal waste 8

Disposal of solid municipal waste by biodegradation – composting (bioreactors) deposition in landfills – microbial decomposition processes in anaerobic rubbish dumps. Ideal bioreactors – stirred tank reactor – Batch and continuous operations – Fed - Batch operation - plug flow reactor.

Unit IV Biopolymers 8

Biopolymers - introduction – functions – cotton, wool, paper, rubber, collagen hyaluroran- melanin for UV protection –Applications.

Unit V Structure of biopolymers 8

Proteins, nuclic acids and polysaccharides – the macromolecular structure and biological functions of polymers- primary, secondary, tertiary and quarternary structure of polymers – structure maintenance and transmission of the biological information-structure and enzymatic activity – mechano structural function of biopolymers- viruses and phages – living macromolecules.

Total periods 45

References

1. J.Guillet, Ed., Polymers and Ecological problems, Plenum Press New York, 1973.

2. W.Schnabel Polymer Degradation – Principles and Practical Applications, Hanser International, 1981.

3. L.L.Hench, E.C. Ethridge Ed., Biomaterials – An Interfacial Approach, Biophysics and Biotechnology Series, Vol 4, Academic Press New York, 1982.

4. Jens Nielsen and John Villadsen, Bio-reaction Engineering Principles, Plenum Press. New York, 1994.

5. Charles G. Gebelein, Ed., Biotechnological Polymers – Medical, pharmaceutical and industrial applications,Technomic Publishing Co., Switzerland,1993.

PL9161 HEAT, MASS AND MOMENTUM TRANSPORT PROCESSES

3 0 0 3

Unit I Momentum transport Process **10**

Momentum transport –fluid behaviour – overall mass, energy and momentum balances – differential mass, energy and momentum balance-polymeric liquids

Unit II **Solution to equations of motion** **9**

Solution to equations of motion - flow measurement - boundary layer flow – turbulent flow – dimensional analysis applied to momentum transport – design equation for incompressible fluid- flow through packed column–fluidisation.

Unit III Heat transfer by conduction process **8**

Heat transfer – steady state conduction – unsteady state conduction – numerical and graphical methods in analysis of heat conduction.

Unit IV Convective heat transfer process **8**

Convective heat transfer – heat transfer in laminar and turbulent flow- boiling and condensation – design equations for convective heat transfer – heat exchangers.

Unit V Mass transfer **10**

Mass transfer – molecular diffusion – binary systems – convective mass transfer coefficients – mass transfer in laminar and turbulent flow –design equations for convective mass transfer – analysis between momentum, heat and mass transfer.

Total periods 45

References

1 Bird, Stewart and Light foot, Transport Phenomena, John Willey & Sons, 1980.

2. C.J.Geankoplis, Transport Processes and Unit Operation, Prentice Hall, 1982.

3. W.J. Beck, Transport Phenomena, John Wiley & Sons, New York, 1984.

4 J.R.Welty, C.E. Wicks and R.E.Wilson, Fundamentals of Momentum, Heat and Mass transfer, John – Wiley & Sons, New York, 1976.

5. C.J. Geankoplis, Transport Processes – Momentum, Heat and Mass, Allyn and Bacon Inc., London, 1980.

PL9162 REACTION ENGINEERING

3 0 0 3

Unit I Reaction kinetics and evaluation of reaction rate 12

Reaction kinetics – rate equation – elementary, non-elementary reactions – mechanism – temperature dependence of reaction rates – analysis of experimental reactor data – evaluation of reaction rate – integral and differential analysis for constant and variable volume system

Unit II Rectors 12

Ideal reactors – homogeneous reaction systems – batch, stirred tank and tubular flow reactor – design for multiple reactions – choice, yield, conversion, selectivity, reactivity – consecutive, parallel and mixed reactions.

Unit III Heat effects in reactors 12

Heat effects in reactors – isothermal and non-isothermal homogeneous systems adiabatic reactors – rates of heat exchange for different reactors –design for constant rate heat input and constant heat transfer coefficient operation – batch and continuous reactors

Unit IV Reactor stability 4

Reactor stability – criteria for stability of reactors, limit cycles and oscillating reactions

Unit V Chemical equilibria and equilibrium constant 5

Reaction equilibria – equilibrium in chemically reactive system – evaluation of equilibrium constant – effects of temperature on equilibrium – equilibrium composition evaluation.

Total periods 45

References

1. O.Levenspiel, Chemical Reaction Engineering Kinetics, John-Wiley, 2nd edition, London, 1972

2. J.M.Smith,Chemical Engineering Kinetics, McGraw Hill Book Co.,3nd edition, New Delhi, 1981

3. E.Bruce Nauman, Chemical Reactor Design, John Wiley & Sons, New York, 1987.

4. H. Scott Fogler**, "** Elements of Chemical Reaction Engineering", (4th Edn) Prentice Hall, 2005.

PL9163 PROCESS INSTRUMENTATION

3 0 0 3

Unit I Temperature measurement **9**

Differential expansion and fluid expansion types - resistance thermometers- thermoelectric pyrometers - radiation pyrometers - optical pyrometers- pyrometric cones- ultrasonic thin wire thermometer- location of temperature

measuring devices in equipments.

Unit II Pressure, level and flow measurement **9**

Liquid types and spring balanced type pressure measuring devices- manometer and sealed belt types of pressure measuring equipments- pressure transmitters - various types of level measuring equipments - volumetric, variable head meters for flow measurement- variable area meters - velocity and current meters- ultrasonic flow meters - mass meters.

Unit III Physical property measurement **9**

Density and specific gravity - viscosity and consistency - refractive index analysers - boiling point and flash point analysers - thermal conductivity measurement - moisture measurement.

Unit IV Process chemical analyzer **9**

Chromatographic analysers, infrared analysers, ultraviolet and visible radiation analysers, mass spectrometers, electroanalytical instruments.

Unit V Indicating and recording instruments **9**

Measurement to indicator transducers, analog and digital indicating and recording instruments, variables of importance to various industries and their measurement

Total periods **45**

References

1. Eckman, D.P. – Industrial Instrumentation, Wiley Eastern Ltd., 1990.
2. Rebert , H. Perry –Chemical Engineering Hand Book, 8th Edn.,McGraw Hill Co.,Inc. New York, 2007.
3. A.E. Fribance – Industrial Instrumentation Fundamentals, McGraw Hill Co. New York, 1983.

PL9164 COMPUTER AIDED DESIGN

3 0 0 3

Unit I Computer graphics fundamentals 10

Graphic primitives – transformations – graphic standards – representation of curves – surface and solid modeling.

Unit II Interactive computer programming 10

Requirements of interactive programming – types of interactive programming- objective oriented programming – development of interactive programmes in languages like Auto LISP etc. – applications.

Unit III Computer animation 10

Conventional animation – computer animation – animation requirements – animation types – animation techniques – design application.

Unit IV Mechanical assembly 5

Assembly modeling – mating conditions – representation schemes – assembling sequences – assembly analysis.

Unit V Prototypying, process planning and CAD CAM integration 10

Basics of prototypying - principles and planning –basics of process planning and CAD CAM integration.

Total periods

45

References

1. Donald Hearn and M. Pauline Baker, Computer Graphics, Prentice Hall, Inc.1997.

2. Ibrahim Zeid, CAD / CAM – Theory and Practice, McGraw Hill, International Edition, 1998.

3. Mikell, P. Grooves and Emory W.Zimmers Jr., CAD / CAM Computer – Aided Design and Manufacturing, Prentice Hall Inc., 1995.

PL9165 SYNTHETIC FIBRES

3 0 0 3

Unit I Introduction to textile process 5

Classification of fibres, yarn manufacture, fabric manufacture, wet processing of textile, testing of textile materials.

Unit II Manufacture of fibre forming polymers **15**

Polymer production - fibre forming polymers – properties, characterization - production of polyethylene terephthalate (PET), polyester, nylon, polyacrylonitrile and polypropylene.

Unit III Manufacture of filament fibre **15**

Filament fibre manufacture - melt, wet and dry spinning of polymers- spin finishes – functions, constitution and application - post spinning operations – drawing and winding.

Unit IV Manufacture of Staple fibre **5**

Staple fibre manufacture - production of staple fibres – drawing of tow, heat setting, crimping and cutting - tow to top converters – advantages, principles and working of machines.

Unit V Texturization **5**

Texturization - introduction, methods, false twist texturing, air jet texturing, comparison.

Total periods 45

Reference

1. A.A.Vaidya, Production of Synthetic Fibres, Prentice Hall of India Pvt. Ltd., New Delhi 1988.
2. V.B.Gupta and K.K.Kothari (Ed), Man-made Fibres Production, Processing Structure, Properties and Applications, Vol. I and II, Dept. of Textile Technology, IIT, New Delhi 1988.
3. H.F. Mark,S.M.Atlas and E.Cernia (Ed), Man-made Fibres -Science and Technology, Vol . I to III, Interscience publishers, New York, 1987.
4. V.Usenko, Processing of Man-made Fibres, MIR publishers, Moscow, 1985.
5. Menachem Lewin and Eli M.pearce, (Ed), Hand bok of Fibre Science and Technology, Vol IV Fibre chemistry, Marcel Dekker Inc., New York, 1985.
6. T.Nakajima, Advanced Fibre Spinning Technology, Wood head, S.B. Leed, 1994.
7. S.B. Warner, Fibre science, Prentice Hall, 1995.