Proposed Syllabus Structure for the B.Tech Course, Polymer Engineering and Technology Department

Semester I

No.	Subjects	Hours/week (L + T)	Marks	Credits
1	Inorganic Chemistry	2+1	50	3
2	Organic Chemistry-I	3+1	100	4
3	Applied Mathematics-I	2+2	100	4
4	Applied Physics-I	3+1	100	4
	TOTAL	15	350	15
5	Engineering Graphics-I	8	100	4
6	Physics Laboratory	4	50	2
7	Inorganic Chemistry Laboratory	4	50	2
8	Organic Chemistry Laboratory	4	50	2
	Total Practicals	20	250	10
		35	600	25

Semester II

No.	Subjects	Hours/week (L + T)	Marks	Credits
1	Organic Chemistry-II	3+1	100	4
2	Analytical Chemistry	2+1	50	3
3	Material & Energy Balance Calculations	2+2	100	4
4	Applied Mathematics-II	2+2	100	4
5	Applied Physics-II	2+1	50	3
	TOTAL	18	400	18
6	Engineering Applications of Computers	4	50	2
7	Organic Chemistry Laboratory	4	50	2
8	Analytical Chemistry Laboratory	4	50	2
9	Communication Skills	4	50	2
	Total practicals	16	200	8
		34	600	26

- **#where there are one special subject or practical in specials bracket it should be considered common for both Polymer & Paints students**
- *** where there are two special subject or practical in specials bracket first one is for Polymers & second one is for Paints students**

Semester III

No.	Code	Subjects	Hours/week (L +T)	Marks	Credits
1	GET1104	**Engineering Mechanics and Strength of Materials**	3+1	50	3
2	GET1105	**Electrical and Electronics Engineering***	2+1	50	3
3	CHT1341	**Physical Chemistry**	3+1	100	4
4	PST 1101	**Spl 1:** Polymer Science & Technology I	3+1	100	4
5	PST 1102	**Spl 2:** Polymer Science & Technology II	2+1	50	3
6	PST 1301	**Spl 3: Materials Technology**	2 +1	50	3
		TOTAL	21	400	19
7	GEP1106	**Electrical and Electronics Engineering Laboratory**	4	50	2
8	CHP1342	**Physical Chemistry Laboratory**	4	50	2
9	PSP1101	**Pr1:** *Analysis & Characterization of raw materials & polymers-I*	4	50	2
		Total Practicals	12	150	6
			33	550	26

Semester IV

No.	Code	Subjects	Hours/week (L +T)	Marks	Credits
1	CET1105	**Transport Phenomena**	3+1	100	4
2	PST 1103	**Spl 4** Polymer Science & Technology III	3+1	100	4
3	PST 1302	**Spl 5** Thermoplastics Polymer Technology I	2+1	50	3
4	PYT1202	**Spl 6** Technology of Thermoset Polymers- I	2+1	50	3
5	PST 1303	**Spl 7** Colour Physics & colour Harmony	3+1	100	4
		TOTAL	18	400	18
6	PSP 1102	**Pr 2:** *Analysis & Characterization of raw materials & polymers-II*	4	50	2
7	PSP 1201	**Pr 3:** Synthesis & Characterization of resins & polymers-I	4	50	2
8	PYP1203	**Pr 4:** Colour Physics	4	50	2
		Total Practicals	12	150	6
			30	550	24

Semester V

No.	Code	Subjects	Hours/week (L + T)	Marks	Credits
1	CET1406	**Chemical Engineering Operations**	2+1	50	3
2	CET1212	**Chemical Reaction Engineering**	2+1	50	3
3	PST 1112	**Spl 8:** Thermoplastics Polymer Technology II	2+1	50	3
4	PST 1113	**Spl 9:** Thermoplastics Polymer Technology III	2+1	50	3
5.	PST 1114	**Spl 10:** Technology of Thermoset Polymers- II	2+1	50	3
6	PST 1115	**Spl 11:** Technology of Thermoset Polymers- III	2+1	50	3
		TOTAL	18	300	18
7	PSP 1116	**Pr 5** *Analysis , Characterization of raw materials* & Synthesis of resins & polymers	4	50	2
8	PSP 1117	**Pr 6** Synthesis & Characterization of resins & polymers-II	8	100	4
9	PSP 1118	**Pr 7** Synthesis & Characterization of resins & polymers-III	4	50	2
		Total Practicals	16	200	8
			34	500	26

Semester VI

No.		Subjects	Hours/week (L + T)	Marks	Credits
1	CET1713	**Instrumentation & Process Control**	2+1	50	3
2	PST 1119	**Spl 12: Pigments &** Additives for Polymers	2+1	50	3
3	PST 1201	**Spl 13** Compounding & processing of polymers-I	3+1	100	4
4	PST 1113	**Spl 14** Design & Fabrication of Molds I	2+1	50	3
5	PST 1115	**Spl 15** Design & Fabrication of Molds –II	2+1	50	3
6	PST 1204	**Elective-I:** Structure property relationship	2+1	50	3
		TOTAL	19	350	19
7	CEP1714	**Chemical Engineering Laboratory**	4	50	2
8	PSP 1205	**Pr 8:** Mold Designing	8	100	4
9	PSP 1206	**Pr 9** Processing of Polymers-I	4	50	2
		Total	16	200	8
			35	550	27

In-Plant Training: 50 marks/2 credits

Semester VII

No.	Code	Subjects	Hours/week (L + T)	Marks	Credits
1	CET1514	**Project Economics**	2+1	50	3
2	HUT1103	**Industrial Psychology and Human Resource Management**	2+1	50	3
3	PST 1208	**Spl 16:** Nanomaterials and Their Applications	2+1	50	3
4	PST 1207	**Spl 17:** Technology of Elastomers	2+1	50	3
5	PST 1209	**Spl 18:** Evaluation & testing of Polymers	2+1	50	3
6	PST 1210	**Elective II:** Packaging & Decoration of plastics	2+1	50	3
		TOTAL	18	300	18
7	PSP 1211	**Pr 10** Analysis & Characterization of Polymers	8	100	4
8	PSP 1212	**Seminar**	4	50	2
9	PSP 1213	**Pr 11 Processing of Polymers-I I**	4	50	2
		Total Practicals	16	200	8
			34	500	26

Semester VIII

No.		Subjects	Hours/week (L + T)	Marks	Credits
1		**Industrial Management**	2+1	50	3
2		**Value Education**	2+1	50	3
3		**Design and Analysis of Experiments**	2+1	50	3
4	PST 1213	**Spl 19 Colorants and *Additives For Polymers***	2+1	50	3
5	PST 1214	**Spl 20: *Compounding and Polymer Processing- II***	2 +1	50	3
6	PST 1215	**Elective III- Speciality polymers**	2+1	50	3
		TOTAL	18	300	18
7	PSP 1216	**Pr12:** Processing of Polymers-III	4	50	4
8	PSP 1217	**Experimental Project**	12	150	6
		Total	16	200	10
			34	500	28

Total credits of all semesters = 25 (Sem I) + 26 (Sem II) + 25 (Sem III) + 24 (Sem IV) + 26 (Sem V) + 27 (Sem VI) + 2 (IPT) + 27 (Sem VII) + 28 (Sem VIII) = 209

Total Marks: 600 (Sem I) + 600 (Sem II) + 550 (Sem III) + 550 (Sem IV) + 500 (Sem V) + 550 (Sem VI) + 50 (IPT) + 500 (Sem VII) + 550 (Sem VIII) = 4450

- **#where there are one special subject or practical in specials bracket it should be considered common for both Polymer & Paints students**
- *** where there are two special subject or practical in specials bracket first one is for Polymers & second one is for Paints students**

Subject heads	AICTE Norms	Proposed syllabus in %			
		Marks	% Marks	Credits	% Credit
General	**5- 10 %**	**250**	**5.68**	**14**	**6.73**
Basic Sciences	**15 – 25 %**	**1150**	**26.14**	**50**	**24.04**
General Engineering +Chemical Engineering	**15 – 25 %**	**650**	**14.77**	**31**	**14.90**
Professional courses	**55 – 65%**	**2350**	**53.41**	**113**	**54.33**
GRAND TOTAL	**--**	**4400**	**100**	**208**	**100**

Electives to be offered by Polymer Engineering and Technology Department and their prerequisite

S. No.	Elective	Prerequisite
1	Polymer Science & Technology II(SemIII) Polymer Science & Technology III (SemIV)	**No prerequisite**
2	**Elective-I:** Structure property relationship	**No prerequisite**
3	**Elective II:** Packaging & Decoration of plastics (Sem. VII)	**No prerequisite**
4	**Elective III- Speciality polymers** (Sem VIII)	**Polymer / Paints / Textiles Background**

SEMESTER I No Special Subjects

SEMESTER II No Special Subjects

SEMESTER III

THEORY

PST 1101 Special 1: ***Polymer Science & Technology I*** (4 h/ week)
(Polymer/ Surface coating) Marks 100

PST 1101	**Polymer Science and Technology-I**
	Course Outcomes
CO1:	Student should be able to understand the basic concept of monomer, polymer and repeating units and their properties
CO2:	Student should be able to understand the basic concepts of degree of polymerisation
CO3:	Student should be able to understand in detail about the chemistry of polymers and the possible chemical modification
CO4:	Ability to understand the extraction process
CO5:	Student should be able to understand the physical and chemical characterization of raw materials
CO6:	Ability to understand the modifications of various monomers

Historical developments in polymeric materials, Basic concepts & definitions : monomer & functionality, oligomer, polymer , repeating unites, degree of polymerization, molecular weight & molecular weight distribution. (5)

Natural Polymers: Chemical & Physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins etc. (9)

Raw material for synthetic polymers: Manufacturing of various fractions of crude petroleum important for polymer industry for (a) Raw Materials such as ethylene, propylene, butadiene, vinyl chloride, vinylidene dichloride, styrene, acrylic monomers like acrylic acid, acrylonitrile, methacrylic acid, methacrylates, acrylamide etc, (b) solvents such as alcohols, toluene, xylene, acetone, ketones, terpenes, chloromethanes etc. Evaluation of raw materials and reactants for synthesis & manufacturing of polymers. (c) Polyacids such as phthalic acid, terephthalic acid,

isomers and anhydrides etc. (d) phenols, polyols and their modifications, (e) Isocyanates, (f) Amino Compounds, (g) Other petroleum based material (31)

(15)

Textbooks/Sourcebooks:

1. Raw Materials for Industrial Polymers by H Ulrich, Hanser Publication1989.
2. Principles of Polymer Science, by Bahadur and Sastry, Narosa Publishing House 2002.
3. Polymer Science by Gowarikar, Johan wiley and Sons 1986.
4. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
5. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
6. Petrochemicals The Rise of an Industry by Peter H. Spitz, Johan Wiley and sons 1988.
7. Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.

PST1102:Special 2 ***Polymer Science & Technology II*** (2 hrs/ week)
(Polymer/ Surface coating) Marks 5

PST 1101	**Polymer Science and Technology-II**
	Course Outcomes
CO1:	Student should be able to understand the basic concepts of monomer, polymer, degree of polymerization, and repeating units and their properties
CO2:	
CO3:	Student should be able to understand in detail about the chemistry and rheology of polymers.
CO4:	Ability to understand the polymer rheology
CO5:	Student should be able to understand the physical and chemical characterization of raw materials
CO6:	Ability to understand the applications of various polymers.

Classification of polymers thermoplastic/ thermoset, addition/ condensation, natural /synthetic, crystalline/amorphous, step growth /chain growth, ,commodity…specialty, homochain/ heterochain, confirmation: homo & copolymers (detailed graft ,block alt, ladder etc. & nomenclature), configuration cis/trans; tacticity, branched/ crosslinked, Classification of polymers based on end use etc. (7)

Molecular weight and its distribution determination (Mn to Mz & MWD), carothers equation, states of polymers, transition temperatures such as Tg, Tc, Tm, solubility parameter, solution properties, temperature, good/ bad solvent, (12)

Addition, condensation polymerization mechanism (7)

Surface tension/ energy & contact angle measurements of different polymeric systems & their wetability with other substances. (4)

Textbooks/Sourcebooks:

1. Principles of Polymer Science, Bahadur and Sastry, Narosa Publishing House 2002.
2. Polymer Science , Gowarikar, Johan wiley and Sons 1986.
3. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
4. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
5. Polymer Chemistry , Malcolm P. Stevens, Oxford University Press, Inc, 1990.
6. Text book of polymer Science, Billmeyer, John Wiley ans Sons 1984.
7. Principles of Polymer Systems, Rodriguez, Hemisphere Publishing Corpn, 1982.
8. Introduction to Polymer Science and Technology, H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977
9. Polymer Science and Technology of Plastics and Rubbers, P. Ghosh,
10. Tata McGraw-Hill Publishing Company 1990.
11. Textbook of Polymer Science, P. Nayak and S. Lenka, Kalyani Publishers, 1986.
12. Fundamentals of Polymer Science an introductory text, P. Painter and M. Colman, Technomic publishing Co Inc,1994.
13. Textbook of Polymer Science and Engg Anilkumar and Gupta, tata McGraw-Hill Publishing Co, Ltd., 1978.
14. Polymer Science and Technology by J. R. Fried, Prentice-Hall, Inc 1995.
15. Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.
16. Fundamentals of Polymer Processing, S. Middleman, Houghton Mifflin Compony, 1997.

PST1301: Special 3: Materials Technology: (2 hrs/ week)
(Polymer/ Surface coating) Marks 50

Crystal structure, crystal defects, atomic packing factor, study of different metals iron/steel, Al, brass, copper, nickel, chrom, titanium etc. Their different grades/ compositions of alloys. Annealing, nitriding, carburizing & other treatments etc. corrosion of metals, electrochemistry, corrosion & its prevention. Use of different grades of steel for manufacture of reactors, molds, dies & plastic processing equipments.

Textbooks/Sourcebooks:

Mechanical metullargy Dieter

Practicles:

PSP1101:Pr1: ***Analysis & Characterization of raw materials & polymers-IV*** Marks 50
(Polymer/ Surface coating) **2X4**

Course Outcome:

1) Able to be characterized the various samples such as raw materials as well as resins, emulsions etc.
2) Able to do the chemical characterization for given samples by acid value, saponification value etc.
3) Able to characterized the pigments which is one of the core of any paint formulation so significance of its properties will help to design the paint formulation
4) The knowledge and hand on experiment about basic testing such as density, solids etc. is get hence student are able to formulate the paint as well as characterized the raw materials and paint partially
5) With the experiments of acid value etc. student can comment about the structure of the raw material.

1) To Check the colour of oil & resins.
2) To Check the colour of oils & resins on heating.
3) To check the viscosity of oils & resins solution using Ford Cup or Brookfield viscometer.
4) To check the melting range of given resin by capillary tube method.
5) To find the acid value of given sample.
6) To find Aniline point of given solvent.
7) To find the distillation large of given solvent.
8) To find the evaporation rate of given solvent.
9) To find flash point of given solvent.
10) To find moisture content of solvent (qualitative analysis)
11) To find specific gravity of solvent by pycnometer.
12) To find the moisture content of pigment.
13) To find the water soluble matter of pigment.
14) To check the Acidly & Alkalinity of pigment.
15) To check bleeding of pigment.
16) To find oil absorption value of pigment.
17) To find minimum surfactant demand by Daniel flow-point method

SEMESTER IV

THEORY

PST1103: Special 4: ***Polymer Science & Technology III (Polymer)*** (4 hrs/ week)
(Polymer/ Surface coating) Marks 100

PST 1204	**Polymer Science and Technology III**
	Course Outcomes
CO1 :	Ability to understand the general techniques of polymerizations, uses and applications.
CO2:	Ability to understand the kinetics and properties of various polymerization techniques
CO3:	Ability to understand the thermodynamics and factors affecting dissolution
CO4:	Ability to understand the monomer reactivity ratio and properties of polymers.
CO5 :	Ability to understand application of polymerization techniques

Techniques of polymerization: bulk, solution, suspension, emulsion, plasma etc. Different initiating systems such as free radicle polymerization, redox, cationic & anionic polymerization (different terms such as living polymers, inifers, telechelics). Their kinitics & control over structure of polymer. (18)
Condensation polymerization, different catalysts used case studies of condensation polymerization, carothers equation, Comparison of these systems with advantages & disadvantages. (10)
Copolymerization, reactivity ratios & kinitics of copolymerization (copolymer composition equation). (10)

Rheological concepts of polymer solutions and melts, degradation plasticization Mixing operations: Typical agitation system, dissolution (10)

Different advanced catalyst systems: Ziegglar natta catalyst & metallocene catylysts & their role in polyolefins, ATRP etc.

(12)

Textbooks/Sourcebooks:

1. Principles of Polymer Science, Bahadur and Sastry, Narosa Publishing House 2002.
2. Polymer Science , Gowarikar, Johan wiley and Sons 1986.

3. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
4. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
5. Polymer Chemistry , Malcolm P. Stevens, Oxford University Press, Inc, 1990.
6. Text book of polymer Science, Billmeyer, John Wiley ans Sons 1984.
7. Principles of Polymer Systems, Rodriguez, Hemisphere Publishing Corpn, 1982.
8. Introduction to Polymer Science and Technology, H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977
9. Polymer Science and Technology of Plastics and Rubbers, P. Ghosh,
10. Tata McGraw-Hill Publishing Company 1990.
11. Textbook of Polymer Science, P. Nayak and S. Lenka, Kalyani Publishers, 1986.
12. Fundamentals of Polymer Science an introductory text, P. Painter and M. Colman, Technomic publishing Co Inc,1994.
13. Textbook of Polymer Science and Engg Anilkumar and Gupta, tata McGraw-Hill Publishing Co, Ltd., 1978.
14. Polymer Science and Technology by J. R. Fried, Prentice-Hall, Inc 1995.
15. Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.
16. Fundamentals of Polymer Processing, S. Middleman, Houghton Mifflin Compony, 1997.

PST1302: Special *5: Thermoplastic Polymer Technology I* (2 hrs/week)
(Polymer/ Surface coating) Marks 50

Course outcomes

Upon completion of this course the student is expected to:

CO1.Ability to apply Polymer engineering, Polymer science knowledge for the manufacturing of thermoplastic Polymers like Polyolefin's Polyesters K1 K2 A1

CO2.Ability to understand properties of polymers, their structure properties and relation as well as to analyze and interpret data K4 K1 K2 A1

CO3.Ability to identify, formulate and know practical applications of thermoplastics K4 K1 K2 A1

CO4. Ability to use, know polymer processing techniques, skills and modern engineering tools necessary for polymer fabrication so as to be easily adaptable to polymer industry A1 K1 K2

CO5.Ability to have understanding of impact of thermoplastic polymers their grades types on environment, engineering community and society at large K1 K2

Polyethylenes; modified polyethylenes, Polypropylene and copolymer of PP, modified Polyolefins like crosslinked & filled polyolefins, Polyisobutylene & polyolefin plastomers etc. (15)

Engineering Polymers Polyesters such as PET, PBT, PTT, Polycarbonates, Polyacetal etc. (15)

Polyethylenes; modified polyethylenes, Polypropylene and copolymer of PP, modified Polyolefins like crosslinked & filled polyolefins, Polyisobutylene & polyolefin plastomers etc. (15)
Engineering Polymers Polyesters such as PET, PBT, PTT, Polycarbonates, Polyacetal etc. (15)

PST1303: Special 6: ***Technology of Thermoset Resins-I*** (2 hrs/ week)
(Polymer/ Surface coating) Marks 50

PST 1114	**Technology of Thermoset Resins-I**
	Course Outcomes
CO1:	Ability to understand basic concepts of resins
CO2:	student should able to understand curing systems of Various resins
CO3:	student should able to understand structure properties and relationships of resins
CO4:	Ability to understands about raw materials used in industry
CO5	Ability to understand modification chemistry of Resin

Polyester Resins- unsaturated polyesters resins: Raw material: poly-basic acids, polyfunctional glycols. Curing of resins through unsaturation of the resin/polymer backbone. Curing systems, catalysts and accelerators. Polyester based composites & their recipes, Water reducible polyesters, high solid polyesters/ polyesters for powder coatings Moulding compositions, DMC,SMC,fibre and film forming compositions. (12)

Phenolics: Basic components of the polymer. Different kinds of phenols and their derivatives, different kinds of aldehydes used. Novolacs and Resol: effect of the ratio of phenol to aldehyde on the nature and the property of the polymer.Theory of resinification and effect of pH on the reaction mechanism and the reaction product. Curing of phenolics
Modification of phenolics such as novolac-epoxy oil soluble and oil reactive. Phenolic moulding compounds, ingredients, compounding and applications. (9)

Amino resins: Basic raw materials used like urea/melamine/ aniline/ formaldehyde. Synthesis of UF and MF resins.Theory of resinification and effect of pH on the reaction mechanism and the reaction product. Properties and application of the UF, MF and AF resins Modification of resins with alcohols and phenols Moulding materials, compounding, processing and applications. (9)

Text/ Source Books

1. Text book of Polymer Science by Billmeyer, John Wiley ans Sons 1984.
2. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
3. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
4. Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.
5. Introduction to Polymer Science and Technology by H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977
6. Handbook of Polyethylene, A. J. Peacock, Marcel Dakker Inc,2000
7. PVC Technology, A. S. Athalye and Prakash Trivedi, Multi-Tech Publishing Co, 1994.

8. Engineering Thermoplastics Polycarbonates Polyacetals Cellulose Esters, L. Bottenbruch, Hanser Publishers, 1996.
9. Composite Polymeric Material, R. P. Sheldon, Applied Science Publishers, 1982.
10. Composites: Design Guide, Industrial Press Inc, 1987.
11. Composite Material Handbook, M. M. Schwartz, McGraw-Hill company, 1984.
12. Biopolymers, Wiley, VCH Verlag, 2003
13. Handbook of Thermoplastics, O. Olabisi, Marcel Dekker, 1997.
14. Plastics Materials J. A. Brydson, Butterworth Scintific, 1990.
15. Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.
16. Polymer and Resins; Their Chemistry and Chemical Engg, Brage Golding, D.Van Nostrand Company Inc, 1959.
17. Structures of Cellulose, Atlla, American Chemical society, 2003.
18. Styrene Based Plastics and their Modifications, Svec, Ellis Harwood, 1991.
19. Polymer Technology by Miles and Briston
20. Surface Coating, OCCA Publication.
21. Organic Coating Technology by H. F. Payne.
22. Organic Coating: Science and Technology by Z. Wicks.]

PYT1202: Special 7: ***Colour Physics and Colour Harmony*** (2 hrs/week)
(Polymer/ Surface coating) Marks 50

Introduction-geometric and chromatic attributes; Radiation and illumination; SPD, CT and CCT; Sources and illuminants; Need for artificial sources – various ways of producing light and different artificial sources; Lamp efficacy and colour rendering properties of sources. (6)

Interaction of radiation with matter – gloss and diffused reflectance, absorption of light in sample; Various transitions in molecule, Beer – Lambert law and its verification, deviation from Beer – Lambert law, Additivity of absorbance, mixture analysis, absorbance and scattering in the sample – Kubelka – Munk theory. (8)

Perception of colour in eye \ brain, various colour theories (3)

Additive – substractive mixing, colour specification systems – Munsell colour order system, CIE system, colour spaces, colour difference formulae. (6)

Single constant Kubelka – Munk theory of colourant formulation and recepie prediction; Modern computerised methods of colour matching; Finding the dyeing recipes, shade sorting, etc. using the CCM software (3)
Decorative effect using pattern and design theory; Application of CAD for textiles. (4)

Text/Reference Books :

1. Color : A Multidisciplinary Approach, Zollinger Heinrich Zurich, Verlag Helvetica Chemica Acta, 1999
2. The color Science of Dyes and Pigments, R. McLaren Bristol, Adam Hilger Ltd., 1983
3. Industrial Color Technology, Johnson R.M., Sartzman M., American Chemical Society Washington D.C., 1971

4. Computer Color Analysis : Textile Apllications, Sule A.D., New Age International Ltd., New Delhi, 1997

PRACTICLES

PSP1102: Pr 2: ***Analysis & Characterization of raw materials & polymers-II*** (2 hrs/ week)
(Polymer/ Surface coating) Marks 50

Course Outcome:

6) Able to characterized the various samples such as raw materials as well as resins, emulsions etc.
7) Able to do the chemical characterization for given samples by acid value, saponification value etc.
8) Able to characterized the pigments which is one of the core of any paint formulation so significance of its properties will help to design the paint formulation
9) The knowledge and hand on experiment about basic testing such as density, solids etc. is get hence student are able to formulate the paint as well as characterized the raw materials and paint partially
10) With the experiments of acid value etc. student can comment about the structure of the raw material.

1. To find polymer content and NVM of emulsion polymer
2. Analysis of carbon black, saw dust etc.
3. To find bulk density of fillers like Tio2, Carbon black etc
4. Identification of pigment by spot test
5. To determine Acid value,amine value, iodine value

PSP1201:Pr 3: Synthesis & Characterization of resins & polymers-I (2 hrs/ week)
(Polymer/ Surface coating) Marks 50

1) To synthesis polymer using Bulk, solution, suspension & emulsion polymerization method.
2) To study auto acceleration by solution polymerization method.
3) Synthesis of copolymers by emulsion Bulk, solution & suspension and emulsion, Polymerization.

PYP1203:Pr4: ***Color Physics (Polymers) (Term Work)*** (4hrs/week)
(Polymer/ Surface coating) Marks 50

1. Determination of unknown concentration of a dye in solution by Dubosque colorimeter.
2. Verification of B-L law (dependence of absorbance on concentration) by spectrophotometer.
3. Mixture analysis using spectrophotometer.
4. Determination of gloss of various samples using gloss meter
5. Determination of color of various textile samples in terms of Lovibond primaries and chromaticity co-ordinates using Lovibond tintometer

6. Specification of color of a textile sample in terms of 'Lab' at using color computer.
7. Finding color differences (ΔE) between set of samples vis a vis dye solution concentration.
8. Finding color differences (ΔE) between set of samples vis a vis time of exposure.
9. Determination of colors of samples in terms of Munsell color system using Munsell Color Tree.
10. Recipe prediction and matching of colored samples using CCM.

Suitable number of experiments from the above list will be performed

SEMESTER V

THEORY

PST1112:Spl 8: ***Thermoplastic Polymer Technology (Polymer)*** **II** (2 hrs/week)
(Polymer/ Surface coating) Marks 50

Styrenic polymers - Polystyrene, HIPS, SAN, ABS, important copolymers of styrene maleic anhydride and styrene acrylics copolymers, toughening mechanism of impact modified plastics . (12)

Polymamides- Nylon 6, Nylon 6,6, Nylon 11, aromatic polyamide such as Kevlar (10)

Acrylic polymers & copolymers, Polyacrylamide, PMMA, ASA, Polyacrylonitrile etc. (7)

PST1113:*Spl 9: Thermoplastic Polymer Technology (Polymer)* **III** (2 hrs/week)
(Polymer/ Surface coating) Marks 50

Course objectives

1.To study industrial manufacturing process advantages disadvantages, process parameters of the thermoplastics like PVC Cellulosics Speciality polymers etc
2.To give understanding of properties like physical mechanical thermal rheological etc and structure properties and relationship
3.To make aware of practical applications of thermoplastics.
4.To study basic processing methods coating applications related to of the thermoplastics
5.To make aware of basics and developments in biopolymers dendrimers LCP etc.

Course outcomes

Upon completion of this course the student is expected to:

CO1.Ability to apply Polymer engineering, Polymer science knowledge for the manufacturing of thermoplastic Polymers like PVC Cellulosics Speciality Polymers etc K1 K2 A1

CO2.Ability to understand properties of polymers, their structure properties and relation as well as to analyze and interpret data K4 K1 K2 A1

CO3.Ability to identify, formulate and know practical applications of thermoplastics K4 K1 K2 A1

CO4.Ability to use, know polymer processing techniques, skills and modern engineering tools necessary for polymer fabrication, so as to be easily adaptable to polymer industry and coating industry 5 A1 K1 K2

CO5. Understanding basics and developments in biopolymers dendrimers LCP and their impact on environment, engineering community and society at large K1 K2 S2

Polyvinyl chloride & its copolymers, Poly vinyl acetate, Polyvinyl alcohol etc. (8)

Modified cellulosics: Cellulose esters and ethers such as Ethyl cellulose, CMC, HPMC, cellulose acetals atc., Liquid crystalline polymers; speciality plastics- PES, PAES, PEEK, PEAK etc. (15)

Developments in new polymers such as dendrimers, biopoplymers & biodegradable polymers, thermoplastic PU etc. (7)

PST1114:*Spl 10: Technology of Thermoset Resins-II (Polymer)* (2 hrs/ week)
(Polymer/ Surface coating) Marks 50

PST 1114	**Technology of Thermoset Resins-II** **Course Outcomes**
CO1:	Ability to understand basic concepts of resins
CO2:	student should able to understand curing systems of Various resins
CO3:	student should able to understand structure properties and relationships of resins
CO4:	Ability to understands about raw materials used in industry
CO5	Ability to understand modification chemistry of Resin

Epoxy resins: Basic raw materials like epichlorohydrin and di hydroxy phenol. Different di hydroxy phenolic compounds which can be used. Classification of epoxy resins. Synthesis of epoxy resins. Ratios of reaction components and their effect on the properties of reaction product and molecular weight in particular. Curing of the resin: curing agents like amines, acids, anhydrides, etc. Epoxy compositions and their ingredients, like diluents, flexibilizers, etc. Epoxy adhesives along with their recipes. Novolac epoxy, epoxy acrylates, Modified epoxides & epoxy resins for advanced applications. (12)

Polyurethanes- Thermoset: Basic components: diisocyanates and diols, different diisocyanates and diols usedReactions of isocyanates with various other functional groups Synthesis of polymers Polyurethane foams, polyester and polyether foams. Processes like one-shot process,

Polyether pre-polymers, Quasi-pre-polymer polyether foams, etc. Difference between thermoset & thermoplastic PU. Flexible foams Polyurethanes in Coatings Polyisocyanates IPN using polyurethanes-acrylic blends (10)

Silicones Thermoplastic and Thermoset: Preparation of intermediates, Grignard's method, direct method, olefin addition method, sodium condensation method, rearrangement of organo chlorosilanes. Nature and effect of Si-H, Si-O, Si-Si, and Si-C bond. Effect of different functional groups on properties, Silicone fluids, resins, elastomers, RTV silicones. Their compounding, processing and applications. Silicone modified resins. (8)

PST1115:*Spl 11: Technology of Thermoset Resins-III (Polymer)* (2 hrs/ week)
(Polymer/ Surface coating) Marks 50

PST 1115	**Technology of Thermoset Resins-III**
	Course Outcomes
CO1	Ability to understand basic concepts of polymers and applications
CO2	Student should able to understand basic chemistry of Various resins i.e alkyd resins
CO3	Student should able to understand structure properties and relationships of resins
CO4	Ability to understands about thermoset polymers

Thermosetting acrylics: Synthesis of acrylic polymers and co-polymers, different techniques. Structure property relationship application of thermosetting acrylics, like anaerobic adhesives, laminating resins, etc. (6)

Alkyd resins: Basic components like polyfunctional alcohols, poly-basic acids, vegetable oils/fatty acids. Different types of drying oils: drying, semi-drying and non-drying with examples. Influence of all these components in the synthesis and properties of the final alkyds obtained modification of alkyds: modification with rosin, maleic anhydride, acrylics, vinyls, imides etc. (15)

Miscellaneous thermosetting polymers:
Polyimides, plasma-polymers & other thermoset polymers (9)

Text/ Source Books

1) Text book of Polymer Science by Billmeyer, John Wiley ans Sons 1984.
2) Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
3) Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
4) Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.
5) Introduction to Polymer Science and Technology by H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977
6) Handbook of Polyethylene, A. J. Peacock, Marcel Dakker Inc,2000
7) PVC Technology, A. S. Athalye and Prakash Trivedi, Multi-Tech Publishing Co, 1994.
8) Engineering Thermoplastics Polycarbonates Polyacetals Cellulose Esters, L. Bottenbruch, Hanser Publishers, 1996.

9) Composite Polymeric Material, R. P. Sheldon, Applied Science Publishers, 1982.
10) Composites: Design Guide, Industrial Press Inc, 1987.
11) Composite Material Handbook, M. M. Schwartz, McGraw-Hill company, 1984.
12) Biopolymers, Wiley, VCH Verlag, 2003
13) Handbook of Thermoplastics, O. Olabisi, Marcel Dekker, 1997.
14) Plastics Materials J. A. Brydson, Butterworth Scintific, 1990.
15) Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.
16) Polymer and Resins; Their Chemistry and Chemical Engg, Brage Golding, D.Van Nostrand Company Inc, 1959.
17) Structures of Cellulose, Atlla, American Chemical society, 2003.
18) Styrene Based Plastics and their Modifications, Svec, Ellis Harwood, 1991.
19) Polymer Technology by Miles and Briston
20) Surface Coating, OCCA Publication.
21) Organic Coating Technology by H. F. Payne.
22) Organic Coating: Science and Technology by Z. Wicks.]

PRACTICLES

PSP1116: Pr 5 : *Analysis , Characterization of raw materials* & Synthesis of resins & Polymers (2x2 hrs/ week)
(Polymer/ Surface coating) Marks 50

Course Outcome:

11) Able to characterized the various samples such as raw materials as well as resins, emulsions etc.
12) Able to do the chemical characterization for given samples by acid value, saponification value etc.
13) Able to characterized the pigments which is one of the core of any paint formulation so significance of its properties will help to design the paint formulation
14) The knowledge and hand on experiment about basic testing such as density, solids etc. is get hence student are able to formulate the paint as well as characterized the raw materials and paint partially
15) With the experiments of acid value etc. student can comment about the structure of the raw material.

1.) Analysis of formalin, phenol, substituted phenol, epichlorohydrine, plasticizer..
2) Determination of Hydroxy value, K-Value , carboxyl value, epoxy value, ester value, sap value etc. RI of solvent and plasticizer, color and viscosity by Gardeners tube etc.

PSP1117: Pr 6 : Synthesis & Characterization of resins & polymers-II (4 x 4hrs/ week)
(Polymer/ Surface coating) Marks 100

Course outcomes
Upon completion of this course the student is expected to:

CO1.Ability to apply Polymer engineering, Polymer science and formulate the laboratory scale experiment for polymer synthesis. K2 K3 A1

CO2.Ability design and conduct experiments. K2 K5 S2

CO3.Ability to analyze and interpret data, process parameters characterize polymers within realistic constraints of the experiment K2 K4 K6

CO4.Ability to use, know polymer processing techniques, skills and modern engineering tools necessary for paper laminate novolac molding powders polymer fabrication, so as to be easily adaptable to polymer industry and coating industry A1 K1 K2

CO5. An ability to communicate effectively and understanding of professional and ethical responsibility team work A3

CO6.Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social K2 A3

1.) Synthesis of novolac, Resol, epoxy, amino, unsaturated polyester resin and their analysis
2). Manufacturing of molding powder of phenolic resin & Amino resin
3.) Making paper laminate of resol resin. To find free phenol & free formaline content of phenolic resin etc.

PSP1118:Pr 7 :Synthesis & Characterization of resins & polymers-III (2x2 hrs/ week)
(Polymer/ Surface coating) Marks 50

Course outcomes

Upon completion of this course the student is expected to:

CO1.Ability to apply Polymer engineering, Polymer science and formulate the laboratory scale experiment for polymer synthesis. K2 K3 A1

CO2.Ability design and conduct experiments. K2 K5 S2

CO3.Ability to analyze and interpret data, process parameters and to characterize polymer within realistic constraints of the experiment K2 K4 K6

CO4.Ability to use, know polymer processing techniques, skills and modern engineering tools necessary formaking paper plastisol organosol etc so as to be easily adaptable to polymer industry and coating industry A1 K1 K2

CO5. An ability to communicate effectively and understanding of professional and ethical responsibility team work A3

CO6.Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social K2 A3

1.) Aqueous polymerization of acrylamide.

2.) Synthesis of modified amino, epoxy, modified phenolic resin. etc
3.) Core and shell polymer
4.) Manufacturing of Plastisol ,organosol, Polyaniline synthesis. Etc.

SEMESTER VI

THEORY

PST1119:Spl 12: 1 ***Pigments & additives for Polymers*** (4 hrs/ week)
(Polymer/ Surface coating) Marks 10

Course Outcomes:
CO 1: Ability to identify and choose various pigments and additives for a particular application
CO 2: Understanding of basic ideas, properties, dosage, techniques of dispersion for wide variety of pigments (organic and inorganic)
CO 3: Ability to understand the mechanism of color formation and effect of various factors on shade and hue of pigment.
CO 4: Should be able to perform manufacturing and synthesis of various pigments
CO 5: Ability to decide the dosage and selection criteria for various types of additives.

Properties required in a pigment and extender (4)

Pigment dispersion basics (2)

Inorganic pigments such as titanium dioxide, zinc oxide, carbon black, chromate pigments, molybdate orange, chrome green, ultramarine blue, iron blue, cadmium red, pearlescent and other effect pigments (15)

corrosion inhibiting pigments, such as zinc phosphate, zinc and barium chromate pigments, ceramic pigments, metal flake pigments, extenders (9)

Theory of color formation in organic compounds, effect of auxiliary groups on the shade and hue of the pigment (Bathochromic and hyper chromic shift) (3)
Manufacture of Carbon black different grades such as furnace & channel black
Additives such as dispersion aids, UV stabilizers, antioxidants & antiozonents, processing/flow modifiers, different fillers such as calcium carbonate, mica, talc & others etc. (12)

PST1201:Spl 13: ***Compounding and Polymer Processing- I (Polymer)*** (4 hrs/ week)
Marks 100

Course Outcome:
1) Able to Process the polymers by various techniques
2) Able to Formulate the master batches and Process it
3) Can Formulate the batch for any processing with proper quantity of each and every ingredient such as fillers and additives etc.

4) The temperature during processing, screw dimensions, the rate of addition as well as concentration of addition of filler etc. the knowledge of such small details of processing is learned which helps them to design as well as process the polymer in future.
5) The knowledge about the trouble shooting during the processing is given hence student can handle any emergency.

Basic Concept of Compounding and Processing; Concept of Master batches (2)

Classification and type of Additive for Plastics: Antioxidants, Light stabilizers, UV stabilizers, Lubricants and relative auxiliaries, Processing aids , Impact modifiers, Flame retardance, antistatic agents.PVC stabilizers and Plasticizers (3)

Colouration of Plastics: Chemistry , synthesis, properties and applications of –Inorganic Pigments such asTitanium dioxide, Zinc oxide, Lithophone, Carbon blacks, Metal oxide pigments, Chromium and Cadmium pigments, Ultra marine blue etc. (12)

Commonly used **Organic pigments such as** Antraquinone, Benzimidazolone dioxazines, Diazo lakes, lake reds, Lithol rubones, Monoazo lakes, Napthol AS lakes, Napthol AS, Perylenes, Phthalocyanines, Quinacridones, Dyes for transparent plastics. Dispersion of Pigments as well as agglomeration aspect should also be covered. In addition shrinkage and warpage will also be discussed. (15)

Processing Techniques: Basic of varies processing techniques such as
a) One-dimensional process is like Coating and Adhesives.
b) Extruders: single screw and twin screw extruders, Film blowing, coextrusion of multilayred films, Fiber spinning, Pipe extrusion, Extrusion of profiles, coextrusion of pipes, Extrusion of cable material, extrusion of sheet, Calendaring, Thermoforming.
c) Molding: Injection molding Blow molding, Compression molding, Injection stretch blow molding, Resin transfer molding, Gas and water assisted injection molding and other three dimensional molding. (18)

Text books/ References

1) High performance pigments — Huge M. Smith
2) Pigment Handbook Part 1, 2,3 — Patton
3) Application properties of Pigments — A. Karnik

Special 14:
GET1113: ***Design and Fabrication of Moulds*** **I** ***(Polymers)*****.** (2 hrs/ week)
Marks 50

Compression moulds : Positive, semi-positive and flash mould with horizontal and vertical flash, arrangement of loading shoes, simple two plate and three-plate moulds, split moulds.(15)
Injection moulds : Two plate and three plates types, injection, venting, runner and gates, calculation of number of cavities, hot runner mould.
Computer softwares used in designing of molds & mold flow analysis (15)

GET1115: Special 15: *Design and Fabrication of Moulds II (Polymers).*
(2hrs/ week)

Marks 50

Transfer moulds : Principles of integral pot, auxiliary ram and separated pot mould, calculation of number of cavities. (5)

Extrusion dies : extrusion of simple shapes tubing, cable covering and sheeting dies. (10)

Mould fabrication : steels for moulding tools and their treatment include processes used for mould fabrication, finishing processes. (5)

Heating systems for plates and moulds, measurement and control of temperature of moulds and dies, simple blow mould. (5)

Introduction to computer aided design and software design aspects for moulds and dies. (5)

Reference Books :

1. Plastic mould engineering handbook by Du Boi's and I. Pribble.
2. Plastic moulds and Dies Laszlo Sors.
3. Injection moulds by Pye.
4. Compression and transfer moulding of plastics by J. Butler.
5. Extrusion dies design by M. V. Joshi.
6. Plastic engineering data book by Glanvill.

Elective I

PST1204:Structure property Relationship (2hrs/ week)
(Polymers/ Surface coatings) Marks 50

PST 1204	**Structure property Relationship (Polymers/ Surface coatings)**
	Course Outcomes
CO1:	Ability to understand the general structural features of polymers
CO2:	Ability to understand the Configuration and conformation and structure properties of polymers and Molecular mass heterogeneity and structure properties
CO3:	Ability to understand the thermodynamics and factors affecting dissolution
CO4:	Ability to understand the polymer chain flexibility and thermal properties of polymers.

CO5:	Ability to understand the intermolecular orders and the crystallinity properties
CO6:	Ability to understand the degradation/stabilization of polymers and to analyses the respective case studies

General structural features of polymers: Effects of atoms types of bonds, bond dissociation energy and functional groups on properties of polymers (3)

Configuration and conformation and structure properties of polymers (2)

Molecular mass heterogeneity and structure properties (1)

Polymers solutions: thermodynamics of dissolution, factors effecting dissolution and swelling of polymers, phase equilibrium of polymer-solvent systems, polymer solution, Florry-Huggins theory (6)

Polymer chain flexibility: concept of flexibility, various factors deciding flexibility of polymers with case studies, properties of polymers affected by flexibility (6)

Intermolecular orders: Amorphous, crystalline and oriented forms of polymers, crystallinity in polymers, factors affecting crystallinity, properties affected by crystallinity of polymers (6)

Thermal properties of polymers: fire retardant polymers, factors affecting glass transition (Tg) temperature, heat stability etc. with case studies (4)
Degradation and stabilization: various stresses acting on polymers and their influence, method of improving the stability of polymers with case study (6)

Text/Source Books

1. Polymer Structure, Properties and application, R.D. Deanin, American Chemical Society, 1974.
2. Relating Materials, Properties to Structure; Handbook and Software for Polymer calcilations and Materials Properties, D. J. david and Ashok Mishra, Technical Publishing Componey, Inc, 1999.
3. Properties of Polymer; Correlations with Chemical Structurees and their numerical Estimation and Predication from Additive Group Contribution van Krevelen, Elsevier Publication Company, 1990.
4. Relating Materials Properties to structure, D. J. David, Technical Publishing Company Inc, 1999.
5. Polymer Chemistry, C. E. Carrshar, Marcel Dakker Inc, 2003.
6. Physical chemistry of Polymers, A. Tager, Mir Publishers, 1978.
7. Polymer Association Structures M. A. EL-Nokally, American Chemical Society, 1989.
8. Polymer Solutions; Introduction to Physical Properties, Teraoka, Iwao, John Wiley and Sons. Inc, 2002.
9. Polymer Chemistry; An Introduction, M. P. Stevens, Oxford University Press, 1990.

PRACTICLES

PSP1205: Pr 8: ***Design Of Moulds/ Drawing (Polymers)(Term Work)*** (2 x 4hours/week)
Marks 100

(1) Compressor Mould Design.
(2) Transfer Mould Design.
(3) Injection Mould Design.
(4) Extrusion Die Design.
(5) Blow Mould Design.
Pro E/ / Mold flow etc.

PSP1206: Pr 9 Processing of Polymers-I (Polymers) (2hrs/ week)
Marks 50

Course outcomes

Upon completion of this course the student is expected to:

CO1.Ability to apply Polymer engineering, Polymer science and formulate the laboratory scale experiment for composite synthesis. K2 K3 A1

CO2.Ability design and conduct experiments based on compounding processing of polymers and composites K2 K5 S2 A4 A1

CO3.Ability to analyze and interpret data, process parameters within realistic constraints of the experiment K2 K4 K6

CO4.Know polymer processing like injection molding blown film batch mixer machines etc and modern engineering tools so as to be easily adaptable to polymer industry. A1 K1 K2

CO5. An ability to communicate effectively and understanding of professional and ethical responsibility team work A3

1) Compounding of PVC
2) Manufacturing of FRP composites like epoxy ,polyester polymer.
3) To Study efficiency of heat stabilizer.
4) To study injection moulding & batch mixer, extrusion process
5) To study blown film extrusion plant.
6) Compounding of PVC
7) Manufacturing of FRP composites like epoxy ,polyester polymer.
8) To Study efficiency of heat stabilizer.
9) To study injection moulding & batch mixer, extrusion process
10) To study blown film extrusion plant.

SEMESTER VII

THEORY

PST1208: Spl 16: Nanomaterials and their Applications (2 hrs / week)
Marks 50

Course Outcomes:

1) Able to understand the significance of nanosize.
2) Able to synthesized various nanomaterials and nanocomposites
3) Able to take care of safety measurements and to deal with any emergency when working with nanoparticles
4) Able to judge the property variation with differentiation of particle size of any filler, pigment etc. in polymer composite, coating etc.
5) Gets aware about new and emerging technology in Polymer and Coating industry such as carbon nanotubes and anticorrosive coating with the use of same.

Definition,Classification of nanomaterial and its unique properties. (2)
Synthesis properties and applications of Carbon nanotubes,fulleneres, inorganic nanomaterials like titanium dioxide, zinc oxide etc, nanoparticles of gold, silver cellulosics etc. (14)
Dendrimers, Nanoclays and its differnt treatment, Polymer nanocomposites and its processing properties,applications and charecterization,nanocoatings,safty regulatins of nanomaterials(14)

Text/Source Books

1. Nanomaterials, Nanotechnologies and Design ,D Schodek Willian Andrew Publishing,NY ,2008
2. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
3. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
4. Nanomaterial :An introduction to synthesis ,properties and applications,D.Vollath,Viely-Vch 2008
5. Polymer composite Handbook, CRC Press
6. Polymer Nanocomposites,Joseph Koo, Mcgralhill ,2008

PST1207: Spl 17: Technology of Elastomers (2 hrs / week)
Marks 50

PST 1213	**Technology of Elastomers**
	Course Outcomes
CO1 :	Ability to understand the elastomer and various types of it.
CO2:	Ability to understand in detail about the elastomers and there physical, chemical properties, uses, applications and lubricants and various rheology modifiers
CO3:	Ability to understand the Impact modifiers, classification of Fillers
CO4:	Ability to understand the Reinforcements and their treatments & use in plastics

CO5:	Student should be able to understand in detail about the Flame retardants, antistats, nucleating agents, blowing agents
CO6:	Student should be able to Cross linking agents, antislip, antiblock, mold release and miscellaneous additives

Definition of elastomers and requirements of polymer to be elastomer: effect of molecular weight, tie points and glass transition temperature (Tg) characteristics. Different types of monomers used in synthesis of elastomers, classifications of elatomers, different processeses used during life cycle of rubber manufacture, storage, compounding, forming and vulcanization of rubbers, different ingredients used in it and functions of various compounding ingredient, various equipments used for compounding and their comparison (14)

Definitions of different terms like scorch, cure/ over cure & study of curing. Different types of vulcanization systems used for compounding and fillers used in elastomers, measurement of mooney viscosity and state of cure for rubber compound. RTV (7)

Synthesis of various rubbers natural rubber/ synthetic polyisoprene styrene butadiene rubber, SBS block copolymer, nitrile rubber, EPR and EPDM rubber, polybutadiene rubber, butyl and neoprene/ chloroprene rubber, silicone rubber, etc. and their properties and applicationsUse of carbon black in rubbers, Manufacture of tyres, (9)

Text/Source Books

1. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
2. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
3. Rubber as an Engineering Materila, K. Nagdi, Hanser Publishers, 1993.
4. Handbook of Rubber Technology, S. Blow, Galgotia Publications Pvt. Ltd., 1998.
5. Rubber Technology, Morell S. H. applied Science Publication, 1981.
6. Plastics and Rubber, E. W. Duck, Butterworth, 1971.

PST1209: Spl 18 : ***Evaluation and Testing of Polymers*** **(**2hrs/ week)
Marks 50

Course Outcomes:

1) Able to understand the significance and can suggest the technques which are used for anaylsis of Polymers such as NMR
2) Students gets knowledge about various properties of polymers such as mechanical, electrical etc. hence they can suggest the various polymer depending upon specific application
3) The sigficance of rheology is well understood by student and correlation of rheology and tempreture is understood hence student can apply this knowledge while processing of polymers
4) Student gets therotically knowledgable about FTIR, NMR etc hence in case of any hand on experiment with such equipment they can apply this knowledge.
5) Student gets idea theortically about how to identify any unknown sample.

Glass transition temperature, melting temperature, heat distortion temperature, etc. Sample preparation, standardization, conditioning of sample, processability test, dynamic mechanical analysis, melt flow rate, Vicat softening temperature. Study of a dilatometer. Study of thermo-chemical analysis and differential scanning calorimeter,
molecular weights and its determination. (8)

Fourier transform infrared spectrometry, Ultraviolet - visible spectrometry, Nuclear magnetic resonance spectrometry, Mass spectrometry, X-ray diffraction spectrometry, Gas chromatography. Scanning electron microscopy, travelling electron microscope Molecular weight determination Viscosity of polymer solutions and polymers: Their significance, application to polymers using different viscometers. Rheology of Paint system (12)

Surface volume resistivity, Breakdown voltage, Arc resistance, Tan Delta, Tensile strength, flexural strength, impact resistance, percentage elongation, tear test, fatigue and wear, hardness, compressive strength time dependant properties like creep, stress, relaxation,etc.Refractive index, gloss, color matching, haze, limiting oxygen index, smoke density Tests for adhesives Identification of polymers using chemical methods (10)

Text/Source Books

1. Handbook of Plastics Analysis, H. Lobo and J. V. Bonilla, Marcel Dekker, 2003.
2. Handbook of polymer Testing Roger Brown, Marcel Dekker Inc, 1999.
3. Instrumental Methods by Dyer.
4. Developments in Polymer Characterization 1-5 by J. V. Dawkins

Elective II

PST1210: Packaging and Decoration of Plastics (2 hrs / week)
Marks 50

Introduction of plastic packaging**,** Plastics- performance all wrapped up, ASTM terminology, , Indian scenario, Selection criteria for flexible packing materials, Manufacturing Multilayer films, laminates, Lamination Techniques troubleshooting Printing on films/ laminates, print evaluation, troubleshooting in print lamination, extrusion coating and lamination. Designing a packaging line, important accessories for packaging machine, sealing methods.. Product performance requirements for laminates. Flexible pouches. Aluminum foil based laminates. co-extruded films / sheets. Barrier packaging (12)

Characteristics of packaging films such as – Permeability, Heat seal, Printing, Drop impact etc. (5)
Decoration of plastics by printing, colouring, embossing, Metallizing films and paper etc. printing and painting on plastics etc. (13)

1. Metallizing of Plastics, H. Narcus, Reinhold Publishing Corp, 1960.
2. Decorating Plastics, J M Margolis, Hanser Publishers, 1986.
3. Handbook of Plastics Joining: a Practical Guide, Plastics Design Library, 1997.
4. Plastics Finishing and Decoration, D. Sastas, Van Nostrand Reinhold Co, 1986.
5. Crosslinking and Network Formation in Polymers, f. R. Jones

6. Plastics Films, J. H. Briston, The Plastics Institute, 1974.
7. Plastics process Engineering, Thorne, Marcel Dekker, 1979.
8. Thermoforming J. L. Thorne, hanser Publishers, 1988.

PRACTICLES

PSP 1211: Pr 10 Analysis and Characterization of Polymers **(**4hrs/ week)
Marks 100

Course Outcomes:

1) Able to identify unknown polymer sample in any given form.
2) Student gets knowledge of thermal characterization, solubility technique, correlation of solubility and structure of polymers, flammable or inflammable nature of various polymers.
3) In case of unknown sample by applying the above knowledge they can identified the sample.
4) The knowledge about the temperature effect on polymers, its solubility helps the student to segregate the polymers for various application depending upon its properties.
5) The knowledge of commodity polymers, engineering plastic and special purpose polymers is gets clear with such identification.

Analysis and identification of resins, plastics rubber sample like:
PE, PP, EPR, Rosin, Epoxy, Alkyd, PET, ABS, SAN. PS, PVC, MF, UF, PC, PMMA, polyisoprene, SBR, Nylons, etc.

PSP1213:Pr 11 Processing of Polymers-II **(**2hrs/ week)
Marks 50

Course outcomes
Upon completion of this course the student is expected to:

CO1. Ability to use select analytical and physical testing equipment and modern engineering tools necessary for characterization of polymers A1 K1 K5 K6

CO2.Ability to use, know polymer processing and compounding techniques, skills and modern engineering tools so as to be easily adaptable to polymer industry A1 K1 K2 A4 A2

CO3.Ability to analyze and interpret data, process parameters within realistic constraints of the experiment K2 K4 K6

CO4. An ability to communicate effectively and understanding of professional and ethical responsibility team work A3

CO5.Know welding techniques casting thermoforming and modern engineering tools so as to be easily adaptable to polymer industry. A1 K1 K2

1. To find output of twin screw Extruder.
2. To study plastic welding, bonding process.
3. To study casting process of epoxy, acrylate resin etc.
4. To study thermoforming, corona discharge treatment method.
5. To find MFI of given sample
6. Compression and injection molding of polymers.

PSP1212:3 ***Seminar (Term Work)*** **(**2hrs/ week)
Marks 50

Students will be required to prepare critical reviews of selected topics in Chemical Technology and Allied subjects and submit in the form of standard typed report. The students will also be required to make an oral presentation of the review.

SEMESTER VIII

THEORY

PST1213: Spl. 19: Colorants and ***Additives For Polymers (Polymer)***

(2hrs/ week)
Marks 50

PST 1213	**Spl. 19: Colorants and Additives For Polymers (Polymer)**
	Course Outcomes
CO1 :	Ability to understand the Concepts of degradation of plastics and the use of different stabilizers to prevent the degradation.
CO 2 :	Ability to understand in detail about the plasticizers, lubricants and various rheology modifiers
CO3:	Ability to understand the Impact modifiers, classification of Fillers
CO4:	Ability to understand the Reinforcements and their treatments & use in plastics
CO5:	Student should be able to understand in detail about the Flame retardants, antistats, nucleating agents, blowing agents
CO6:	Student should be able to Cross linking agents, antislip, antiblock, mold release and miscellaneous additives

Concepts of degradation of plastics due to UV, heat , ageing etc.; Use of additives to prevent this; stabilizers for PVC/ heat stabilizers, Chemical nature, composition and testing of various additives such as UV stabilizer etc. Plasticizers, Lubricants, Processing aids & various

rheology modifiers, Impact modifiers, classification of Fillers and Reinforcements such as organic/inorganic, particulate/fibrous, macro/micro/nano etc. Their treatments & use in different plastics their properties & use in plastics, Flame retardants, antistats, nucleating agents, blowing agents, Cross linking agents, antislip, antiblock, mold release and miscellaneous additives

Organic and Inorganic Pigments, dyes,heat reflective pigments, heat absorbing pigment, pearl pigments, speciality pigments ,azo pigments pyrrolopyrrol pigments, rhodamine CICP, quinophthalone pigments, thio indigo polycyclic pigments, peryline and perynone pigments, indoline pigments, metallic pigments, para red etc..

Text/Source Books

1. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
2. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
3. Handbook of polymer Testing Roger Brown, Marcel Dekker Inc, 1999.
4. Plastics Additive Handbook, Gachter and Mullar, Hanser Publishers, 1987.
5. Fillers and Filled Polymers, J. F. Gerard, Wiley-VCH verlag GmbH, 2001.
6. Handbook of Fillers, G. Wypych, Chem Tech Publishing 2000.
7. Handbook of Fillers and Reinforcements for Plastics, H. S. Katz and J. V. Milewski, Van Nostrand Reinhold Co, 1978.
8. Crosslinking and Network Formation in Polymers, f. R. Jones
9. Photochemical Conversion and Stabilization of Polymers, V .Shlyapitokh, Hanser Publication, 1984.
10. Handbook of Plastics Analysis, H. Lobo and J. V. Bonilla, Marcel Dekker, 2003.

PST 1214:Spl 20 ***Compounding And Polymer Processing- II (Polymer)*** **(**2hrs/ week)
Marks 50

Course outcomes

Upon completion of this course the student is expected to:

CO1.Ability to apply Polymer engineering, Polymer science knowledge for the manufacturing reinforcement like glass fibers carbon fibers K1 K2 A1

CO2.Ability to understand properties of polymer Composites, Mechanics their structure properties and relation as well as to analyze and interpret data K4 K1 K2 A1

CO3.Ability to identify, formulate and know practical applications of Polymer Composites K4 K1 K2 A1

CO4.Ability to know decoration and coating of plastic substrates , so as to be easily adaptable to polymer industry and coating industry A1 K1 K2

CO5. Understanding basics and principals in bonding and welding ,degradation of plastics and their impact on environment, engineering community and society at large K1 K2 S2

Fillers and reinforcement: Varies materials such as Calcium carbonate, Dolomite, Silica Glass, Mica, Talc, Carbon, Clay etc. and reinforcement such as Inorganic and Organic fiber such as glass fiber, boron fiber, carbon fiber, aramide fibers, natural fibers etc. Functional fillers. (6)

Polymer composites such as DMC, SMC, FRP etc. using fillers reinforcement and other polymeric fillers, Composites Mechanics (7)

Reaction Injection Molding, Pultrusion, Pull winding, Handlay up technique etc (7)

Post extrusion techniques such as - electroplating, Stamping, Welding and bonding
Degradation and stabilization of plastics. (10)

Text/Source Books

1. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
2. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
3. Transport Phenomena, Bird and Steuuart, John Wiely and Sons, Inc1960.
4. Unit Operation of Chemical Engineering, McCabe and Smith, McGraw-Hill Book Company, 1985.
5. Plastics Engineering by R. J. Crawford ,Pergamon Press 1989.
6. Understanding Injection Molding Technology by Herbert Rees, Hanser Publishers, 1994.
7. Understanding Extrusion by Chris rauwendaal, Hanser Publishers, 1998
8. Rotational Molding by Glenn L. Beall, Hanser Publishers, 1998
9. Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.
10. Introduction to Polymer Science and Technology by H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977
11. Understanding Compounding, R. H. Wildi and Maier, Hanser Publisher Inc, 1998.
12. Fundamentals of Polymer Processing, S. Middleman, Houghton Mifflin Compony, 1997.
13. Injection Moulding of Plastics a User Guide by Klockner Windosor India Ltd. 1994.
14. Fillers and Filled Polymers, J. F. Gerard, Wiley-VCH verlag GmbH, 2001.
15. Handbook of Fillers, G. Wypych, Chem Tech Publishing 2000.
16. Handbook of Fillers and Reinforcements for Plastics, H. S. Katz and J. V. Milewski, Van Nostrand Zeinhold Co, 1978.
17. Composite Polymeric Material, R. P. Sheldon, Applied Science Publishers, 1982.
18. Composites: Design Guide, Industrial Press Inc, 1987.
19. Composite Material Handbook, M. M. Schwartz, McGraw-Hill company, 1984.
20. Polymer Processing Fundamentals, Osswald, A. Tim, Hanser Publishers, 1998.
21. Fundamentals of Reaction Injection Moulding, C. W. Macosko, Hanser Publishers, 1989.

Elective III

PST 1215: Specialty polymers (Polymers) **(**2hrs/ week)
Marks 50

Specialty plastics- PES, PAES, PEEK, PEAK etc ,Processing, properties and its application Introduction to Polymer blends & alloys & polymer composites and nanocomposites, SANP Hydrogels ,Hyperbranched polymers Shape memory Polymers Specialty polymers such as LCPs & conducting polymers, inorganic polymers, IPNs, smart polymers, polymers for fuel cells etc.

Text/ Source Books

1. Text book of Polymer Science by Billmeyer, John Wiley ans Sons 1984.
2. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
3. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
4. Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.
5. Introduction to Polymer Science and Technology by H. S. Kaufman and J. J. Falcetta, Wiley – Interscience Publication, 1977
6. Handbook of Polyethylene, A. J. Peacock, Marcel Dakker Inc,2000
7. PVC Technology, A. S. Athalye and Prakash Trivedi, Multi-Tech Publishing Co, 1994.
8. Engineering Thermoplastics Polycarbonates Polyacetals Cellulose Esters, L. Bottenbruch, Hanser Publishers, 1996.
9. Composite Polymeric Material, R. P. Sheldon, Applied Science Publishers, 1982.
10. Composites: Design Guide, Industrial Press Inc, 1987.
11. Composite Material Handbook, M. M. Schwartz, McGraw-Hill company, 1984.
12. Biopolymers, Wiley, VCH Verlag, 2003
13. Handbook of Thermoplastics, O. Olabisi, Marcel Dekker, 1997.
14. Plastics Materials J. A. Brydson, Butterworth Scintific, 1990.
15. Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.

PRACTICALS

PSP 1216:Pr 12: Processing of Polymers III (Polymers) **(**4hrs/week)
Marks 50

Course outcomes
Upon completion of this course the student is expected to:

CO1. Ability to use select analytical and physical testing equipment and modern engineering tools necessary for characterization of polymers A1 K1 K5 K6 A1 A2

CO2.Ability to analyze and interpret data, process parameters and characterize additives and polymers within realistic constraints of the experiment K2 K4 K6

CO3. An ability to communicate effectively and understanding of professional and ethical responsibility team work A3

1) To find Tg, Tc, and Tm of given resin by DSC.
2) To find molecular weight & PDI of given resin urging GPC.
3) To find moisture content of given sample. (quantitative analysis)
4) To Study DMTA, wealthiest test, salt spay.optical microscope. Surface tensometer, XRD. Colour Values by spectro photometer.
5) Mechanical Testing of polymer sample like tensile, izod/charpy impact, % elongatioin etc.
6) To find Vicat softening point of given polymer sample.
9) To find electrical proportion like BDV, Arc resistance given sample

PSP 1217: 2 *Project Work (Term Work)* 12hrs/week
Marks:150

Every student will be required to submit a project report in a typed standard format on a topic set by one or more faculty members. The object of the project work is to test the ability of the student to tackle an investigational problem in his field of specialization. Every student will be orally examined in the subject incorporated in his project report.