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

### Semester I

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- # 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
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In-Plant Training: 50 marks/2 credits
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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
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Electives to be offered by Polymer Engineering and Technology Department and their prerequisite

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</tbody>
</table>
SEMESTER I  
No Special Subjects

SEMESTER II  
No Special Subjects

SEMESTER III

THEORY

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

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

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) Polycids 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

Textbooks/Sourcebooks:

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

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

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.
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,

Addition, condensation polymerization mechanism

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

Textbooks/Sourcebooks:
2. Polymer Science, Gowarikar, Johan wiley and Sons 1986.
9. Polymer Science and Technology of Plastics and Rubbers, P. Ghosh,

PST1301: Special 3: Materials Technology:
(Polymer/ Surface coating) 
(2 hrs/ week) 
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
(Polymer/ Surface coating) 
(Marks 50) 
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) (Polymer/ Surface coating) (4 hrs/ week) Marks 100

<table>
<thead>
<tr>
<th>PST 1204</th>
<th>Polymer Science and Technology III</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1 :</td>
<td>Ability to understand the general techniques of polymerizations, uses and applications.</td>
</tr>
<tr>
<td>CO2:</td>
<td>Ability to understand the kinetics and properties of various polymerization techniques</td>
</tr>
<tr>
<td>CO3:</td>
<td>Ability to understand the thermodynamics and factors affecting dissolution</td>
</tr>
<tr>
<td>CO4:</td>
<td>Ability to understand the monomer reactivity ratio and properties of polymers.</td>
</tr>
<tr>
<td>CO5 :</td>
<td>Ability to understand application of polymerization techniques</td>
</tr>
</tbody>
</table>

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 kinetics & 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 & kinetics 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 & metalloocene catylysts & their role in polyolefins, ATRP etc. (12)

Textbooks/Sourcebooks:
2. Polymer Science, Gowarikar, Johan wiley and Sons 1986.
9. Polymer Science and Technology of Plasctics and Rubbers, P. Ghosh,

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

<table>
<thead>
<tr>
<th>PST 1114</th>
<th>Technology of Thermoset Resins-I</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1:</td>
<td>Ability to understand basic concepts of resins</td>
</tr>
<tr>
<td>CO2:</td>
<td>student should able to understand curing systems of Various resins</td>
</tr>
<tr>
<td>CO3:</td>
<td>student should able to understand structure properties and relationships of resins</td>
</tr>
<tr>
<td>CO4:</td>
<td>Ability to understands about raw materials used in industry</td>
</tr>
<tr>
<td>CO5:</td>
<td>Ability to understand modification chemistry of Resin</td>
</tr>
</tbody>
</table>

Polyester Resins- unsaturated polyester 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**

19. Polymer Technology by Miles and Briston
20. Surface Coating, OCCA Publication.
22. Organic Coating: Science and Technology by Z. Wicks.]

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

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 – subtractive 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 :
PRACTICALS

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: Pr 4: 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
7. Finding color differences ($\Delta E$) between set of samples vis a vis dye solution concentration.
8. Finding color differences ($\Delta E$) 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**  
(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 .  
Polymamides- Nylon 6, Nylon 6,6, Nylon 11, aromatic polyamide such as Kevlar

Acrylic polymers & copolymers, Polyacrylamide, PMMA, ASA, Polyacrylonitrile etc.

**PST1113: Spl 9: Thermoplastic Polymer Technology (Polymer) III**  
(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

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

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

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

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

Developments in new polymers such as dendrimers, biopolymers & biodegradable polymers, thermoplastic PU etc.

PST1114: Spl 10: Technology of Thermoset Resins-II (Polymer) (Polymer/ Surface coating)

<table>
<thead>
<tr>
<th>PST 1114</th>
<th>Technology of Thermoset Resins-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1:</td>
<td>Ability to understand basic concepts of resins</td>
</tr>
<tr>
<td>CO2:</td>
<td>student should able to understand curing systems of Various resins</td>
</tr>
<tr>
<td>CO3:</td>
<td>student should able to understand structure properties and relationships of resins</td>
</tr>
<tr>
<td>CO4:</td>
<td>Ability to understands about raw materials used in industry</td>
</tr>
<tr>
<td>CO5:</td>
<td>Ability to understand modification chemistry of Resin</td>
</tr>
</tbody>
</table>

Epoxy resins: Basic raw materials like epichlorohydrin and di hydroxy phenol. Different dihydroxy 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.

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


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

<table>
<thead>
<tr>
<th>PST 1115</th>
<th>Technology of Thermoset Resins-III</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Ability to understand basic concepts of polymers and applications</td>
</tr>
<tr>
<td>CO2</td>
<td>Student should able to understand basic chemistry of Various resins i.e alkyd resins</td>
</tr>
<tr>
<td>CO3</td>
<td>Student should able to understand structure properties and relationships of resins</td>
</tr>
<tr>
<td>CO4</td>
<td>Ability to understands about thermoset polymers</td>
</tr>
</tbody>
</table>

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

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.

Miscellaneous thermosetting polymers:
Polyimides, plasma-polymers & other thermoset polymers

Text/ Source Books
2) Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
19) Polymer Technology by Miles and Briston
20) Surface Coating, OCCA Publication.
22) Organic Coating: Science and Technology by Z. Wicks.

**PRACTICLES**

**PSP1116: Pr 5 : Analysis , Characterization of raw materials & Synthesis of resins & Polymers**

*(Polymer/ Surface coating)*

(2x2 hrs/ week)

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**

*(Polymer/ Surface coating)*

(4 x 4hrs/ week)

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 to design and conduct experiments. K2 K5 S2

CO3. Ability to analyze and interpret data, process parameters and 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 (Polymer/ Surface coating) (2x2 hrs/ 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 polymer synthesis. K2 K3 A1

CO2. Ability to 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 for making 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 (3)
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

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

Colouration of Plastics: Chemistry, synthesis, properties and applications of – Inorganic Pigments such as Titanium dioxide, Zinc oxide, Lithophane, Carbon blacks, Metal oxide pigments, Chromium and Cadmium pigments, Ultra marine blue etc.

Commonly used Organic pigments such as Antraquinone, Benzimidazolone dioxazines, Diazo lakes, lake reds, Lithol rubones, Monoazo lakes, Naphthol AS lakes, Naphthol 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.

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 multilayered films, Fiber spinning, Pipe extrusion, Extrusion of profiles, coextrusion of pipes, Extrusion of cable material, extrusion of sheet, Calendering, 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.

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.
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.
5. Extrusion dies design by M. V. Joshi.

Elective I

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

<table>
<thead>
<tr>
<th>Course Outcomes</th>
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</thead>
<tbody>
<tr>
<td>CO1: Ability to understand the general structural features of polymers</td>
</tr>
<tr>
<td>CO2: Ability to understand the Configuration and conformation and structure properties of polymers and Molecular mass heterogeneity and structure properties</td>
</tr>
<tr>
<td>CO3: Ability to understand the thermodynamics and factors affecting dissolution</td>
</tr>
<tr>
<td>CO4: Ability to understand the polymer chain flexibility and thermal properties of polymers.</td>
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<tr>
<td>CO5:</td>
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<tr>
<td>CO6:</td>
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</tbody>
</table>

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

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 Process 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, fullerenes, inorganic nanomaterials like titanium dioxide, zinc oxide etc, nanoparticles of gold, silver cellulosics etc. (14)
Dendrimers, Nanoclays and its different treatment, Polymer nanocomposites and its processing properties, applications and characterization, nanocoatings, safety regulations of nanomaterials (14)

Text/Source Books
5. Polymer composite Handbook, CRC Press
6. Polymer Nanocomposites, Joseph Koo, Mcgralhill, 2008

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

<table>
<thead>
<tr>
<th>PST 1213</th>
<th>Technology of Elastomers</th>
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<tbody>
<tr>
<td><strong>Course Outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>CO1: Ability to understand the elastomer and various types of it.</td>
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<tr>
<td>CO2: Ability to understand in detail about the elastomers and their physical, chemical properties, uses, applications and lubricants and various rheology modifiers</td>
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</tr>
<tr>
<td>CO3: Ability to understand the Impact modifiers, classification of Fillers</td>
<td></td>
</tr>
<tr>
<td>CO4: Ability to understand the Reinforcements and their treatments &amp; use in plastics</td>
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</tbody>
</table>
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 elastomers, different processes 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.

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.

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 applications. Use of carbon black in rubbers, Manufacture of tyres.

Text/Source Books

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

Course Outcomes:
1) Able to understand the significance and can suggest the techniques which are used for analysis 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 temperature 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 theoretically 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.

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

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

**Text/Source Books**

3. Instrumental Methods by Dyer.
4. Developments in Polymer Characterization 1-5 by J. V. Dawkins

**Elective II**

**PST1210: Packaging and Decoration of Plastics**

Marks 50


Characteristics of packaging films such as – Permeability, Heat seal, Printing, Drop impact etc.

Decoration of plastics by printing, colouring, embossing, Metallizing films and paper etc. printing and painting on plastics etc.

5. Crosslinking and Network Formation in Polymers, f. R. Jones

**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.

**PSP 1213: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  

**PSP1212:3 Seminar (Term Work)**  
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)**  

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>CO1 :</td>
<td>Ability to understand the Concepts of degradation of plastics and the use of different stabilizers to prevent the degradation.</td>
</tr>
<tr>
<td>CO2 :</td>
<td>Ability to understand in detail about the plasticizers, lubricants and various rheology modifiers</td>
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<td>CO3:</td>
<td>Ability to understand the Impact modifiers, classification of Fillers</td>
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<td>Ability to understand the Reinforcements and their treatments &amp; use in plastics</td>
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<td>CO5:</td>
<td>Student should be able to understand in detail about the Flame retardants, antistats, nucleating agents, blowing agents</td>
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<td>CO6:</td>
<td>Student should be able to Cross linking agents, antislip, antiblock, mold release and miscellaneous additives</td>
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</table>

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
8. Crosslinking and Network Formation in Polymers, f. R. Jones

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, Tale, 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.

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

Reaction Injection Molding, Pultrusion, Pull winding, Handlay up technique etc

Post extrusion techniques such as - electroplating, Stamping, Welding and bonding

Degradation and stabilization of plastics.

Text/Source Books
11. Understanding Compounding, R. H. Wildi and Maier, Hanser Publisher Inc, 1998.

Elective III
PST 1215: Specialty polymers (Polymers)

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


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, % elongation etc.
6) To find Vicat softening point of given polymer sample.
9) To find electrical proportion like BDV, Arc resistance given sample
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.