

XE	Engineering Sciences
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XE5	Polymer Science and Engineering
Section XE5.1:	Polymer Chemistry
Monomers; Degree of polymerization; Classification of polymers; Polymerization reactions: addition and condensation, their kinetics; Metallocene polymers and other newer methods of polymerization; Copolymerization; Monomer reactivity ratios and its significance; Kinetics; Different copolymers; Random, alternating, azeotropic copolymerization; Block and graft copolymers; Techniques for polymerization-bulk, solution, suspension, emulsion.	
Section XE5.2:	Polymer Characterization
Solubility and swelling; Concept of molecular weight distribution and its significance; Concept of average molecular weight; Determination of number average, weight average, viscosity average and Z-average molecular weights; Glass transition; Melting transition; Amorphous and crystalline states of polymers; Orientation in polymers and polymer crystallinity; Factors affecting crystallinity; Analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA); Microscopic (optical and electronic) techniques; GPC; Mooney viscosity; Morphology and microstructure (SEM, TEM, AFM).	
Section XE5.3:	Synthesis, Manufacturing and Properties
Commodity and general-purpose thermoplastics: PE, PP, PS, PVC; Polyesters; Acrylic; PU polymers; Engineering Plastics: Nylon, PC, PBT, Polyphenylene oxide, ABS, Fluoropolymers; Thermosetting polymers: Polyurethane, PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds; Natural and synthetic rubbers: recovery of NR hydrocarbon from latex; SBR; Nitrile; CR; CSM; EPDM; IIR; BR; Silicone; TPE; Specialty plastics: PEK, PEEK, Polyphenylene sulfide, Polysulfone, Polyethersulfone, etc.; Bio-compostable polymers such as PCL, PLA, PBAT, PHA/PHB, natural and biodegradable polymers such as cellulose, starch, alginate.	
Section XE5.4:	Polymer Blends and Composites
Polymer blends and composites, their significance; Choice of polymers for blending, blend miscibility: miscible and immiscible blends; Thermodynamics; Phase morphology; Polymer alloys; Polymer eutectics; Plastic-plastic, rubber-plastic and rubber-rubber blends; FRP, particulate, long and short fibre reinforced composites; Polymer reinforcement, reinforcing fibres – natural and synthetic.	
Section XE5.5:	Additives, Compounding and Formulations
Polymer compounding-need and significance; Different compounding ingredients for rubber and plastics (crosslinkers, antioxidants, heat stabilizers, UV stabilizers, lubricants, processing aids, impact modifiers, flame retardant, antistatic agents. PVC stabilizers and plasticizers) and their function; Use of carbon black; Polymer mixing equipment; Vulcanization and kinetics.	
Section XE5.6:	Polymer Rheology
Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions; Measurements of rheological parameters by capillary, parallel plate, cone-plate rheometer. viscoelasticity, creep and stress relaxation, oscillatory or dynamic testing, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR.	

Section XE5.7:	Polymer Processing
Spin coating; Electrospinning; Solution and melt spinning; Film casting; Compression molding; Transfer molding; Injection molding; Blow molding; Reaction injection molding; Filament winding; SMC; BMC; DMC; Extrusion; pultrusion; Calendaring; Rotational molding; Thermoforming; Powder coating; Rubber processing in two-roll mill, internal mixer, twin screw extruder.	
Section XE5.8:	Polymer Testing
Mechanical-static and dynamic, tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness; Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance, limiting oxygen index; Heat deflection temperature – Vicat softening temperature, ductile to brittle transition, glass transition temperature, coefficient of thermal expansion, shrinkage, flammability, dielectric constant, dissipation factor, power factor; Optical Properties - Refractive Index, Luminous Transmittance and Haze, Melt flow index.	
Section XE5.9:	Polymer Recycling, Waste Management and Sustainability
Polymer waste and its impact on environment; Sources, identification and separation techniques; Recycling classification: mechanical and chemical recycling, recycling of thermoplastics, thermosets and rubbers, applications of recycled materials; Life cycle assessment of polymer products (case studies like PET bottles, packaging bags); Recycling, segregation and disposal strategies of biodegradable and bio-compostable polymers, microplastics.	