Core Courses

571601 Structure and Transformation of Materials 3(3-0-9)

Condition : Consent of the School

Review on classification of materials such as metals, ceramics and polymers as well as their engineering applications; Atomic structures and bonding; Crystal structures of metals and ceramics, polymer structures, Polycrystalline and defects in solid, Structure Characterization; Diffusion; Phase diagrams and transformation of materials

Course Outline

1. Classification of materials and applications (3 hours)
2. Atomic structures and bonding (3 hours)
3. Crystal structures of metals and ceramics (3 hours)
4. Polymer structures (3 hours)
5. Polycrystalline and defects in solid (3 hours)
6. Structure Characterization (6 hours)
7. Diffusion (3 hours)
8. Phase diagrams and transformation (12 hours)

571602 Materials Properties and Designs 3(3-0-9)

Condition : Consent of the School

Properties, processing and designs of materials including metals, ceramics and polymers. Important material properties including mechanical properties, thermal properties, electrical properties, magnetic properties, optical properties and degradations of materials

Course outline

1. Mechanical properties of materials (3 hours)
2. Thermal and optical properties of materials (3 hours)
3. Electrical and magnetic properties of materials (3 hours)
4. Degradations of materials (3 hours)
5. Material processings (9 hours)
6. Principle of engineering design (6 hours)
7. Effects of material properties and manufacturing process on design (6 hours)
8. Materials selection (3 hours)

571603 Experimental Design for Materials Engineering **2(2-0-6)**

Condition : Consent of the School

This course emphasizes problem solving methods for manufacturing and research applications. The techniques can be used to design efficient experiments, distinguish differences in materials/ processes/ machines, identify key variables, develop equations which quantify cause-effect relationships and optimize a process or material property. Several classes are conducted in a computer lab where computer programs are applied to design experiments and solve problems

Course Outline

1.	Introduction; Common Distributions; Testing Data for Normality	(1 hours)
2.	Differences in Sample Mean: t-test	(1 hours)
3.	Paired Comparisons; Confidence Intervals; Sample Size	(1 hours)
4.	Differences in Sample Variance: F-test	(1 hours)
5.	Analysis of Variance (ANOVA)	(1 hours)
6.	Computer Lab 1: t-tests, F-tests, Confidence Intervals Analysis of Variance: Model Adequacy Checking	(1 hours)
7.	Analysis of Variance: Model Adequacy Checking & Comparisons Among Means	(1 hours)
8.	Computer Lab 2: ANOVA; Random Effects ANOVA	(1 hours)
9.	Regression Models: Calculating Coefficients, Variable & Model Significance, & Model Error	(1 hours)
10.	Computer Lab 3: Regression Models	(1 hours)
11.	Regression Models: X & Y Transforms for Non-linear Effect & Interactions	(1 hours)
12.	Computer Lab 4: Models for Non-linear Effects & Interactions	(1 hours)
13.	Regression Models: Other Check & Diagnostics	(1 hours)
14.	Model Techniques for Material Properties	(1 hours)
15.	Computer Lab 5: Models for Non-linear Effects & Interactions	(2 hours)
16.	Computer Lab 6: Model Predictions & Plots	(1 hours)
17.	ANOVA in Regression Analysis	(1 hours)
18.	Computer Lab 7: Models with Discrete Variables	(1 hours)
19.	D-optimal Designs	(1 hours)
20.	Computer Lab 8: D-optimal designs	(1 hours)
21.	Screen Experiments: 2^k Fractional Factorial Designs	(1 hours)
22.	Computer Lab 9: Design Expert program demo for 2^k designs	(2 hours)

Elective Courses

Metallic Material Courses

571701 Thermodynamics and Phase Equilibria 3(3-0-9)

Condition : Consent of the School

Definition of terms; Laws of thermodynamics; Thermodynamic variables and relations; Behavior of solution; Thermodynamics equilibria; Phase equilibria; Phase diagrams; Statistical thermodynamics; Applied electrochemistry

Course outline

1. Definition of terms and laws of thermodynamics (3 hours)
2. Thermodynamic variables and relations (3 hours)
3. Behavior of solutions (3 hours)
4. Thermodynamics equilibria (6 hours)
5. Phase equilibria and phase transformation (6 hours)
6. Thermodynamics of phase diagrams (9 hours)
7. Statistical thermodynamics (3 hours)
8. Applied electrochemistry (3 hours)

571702 Advanced Physical Metallurgy 3(3-0-9)

Condition : Consent of the School

Structure and bonding of atoms; Crystallography e.g. crystal structures, symmetry in crystals, etc.; Electrons in metals and alloys, formations of intermetallic phases, ordering in alloys; Defects in crystals; Applications of themodynamics, crystallography, and defects in crystals for explanations of metallic materials behaviors e.g. theory of dislocations and plastic deformation; Inteface between marix and precipitate; Strengthening mechanisms in metals and alloys; Solidification of metals and alloys, formations of defects during the growth of crystals and their effects on the morphology of crystals; Solid state transformations; Order paremeter; Cahn-Hilliard Equation

Course outline

1. Structure and bonding of atoms; crystallography (4 hours)
2. Theory of metallic phases and ordering in alloys (3 hours)
3. Defects in crystals (3 hours)
4. Theory of dislocations (3 hours)
5. Dislocations and plastic deformation (3 hours)
6. Grain boundaries and interphase boundaries (3 hours)
7. Role of defects on the strengthening mechanisms (3 hours)
8. Solidification of metals and alloys (4.5 hours)
9. Solid state transformations in metals and alloys (6 hours)
10. Cahn-Hilliard Equation (4.5 hours)

571703 Transport Phenomena **3(3-0-9)**

Condition : Consent of the School

Transport phenomena equations; Applications of transport phenomena equations for metallurgical engineering; Viscosity; Thermal conductivity; Diffusion coefficient; Applications of transport phenomena principles

Course outline

1. Transport phenomena equations (7.5 hours)
2. Applications of transport phenomena equations for metallurgical engineering (7.5 hours)
3. Viscosity (3 hours)
4. Thermal conductivity (3 hours)
5. Diffusion coefficient (9 hours)
6. Applications of transport phenomena principles (6 hours)

571704 Phase Transformation in Metals and Alloys **3(3-0-9)**

Condition : Consent of the School

Thermodynamics and phase equilibriums; Diffusions in solids, Interfaces; Solidification of metals and alloys, nucleation rate, growth rate according to Onsager relationship; Solid state transformations, Johnson–Mehl–Avrami–Kolmogorov (JMAK) equation; Diffusional transformations, Cahn-Hilliard kinetic; Diffusionless transformations; Landau theory

Course outline

1. Thermodynamics and phase equilibriums (3 hours)
2. Diffusions in solids (6 hours)
3. Interfaces (3 hours)
4. Solidification of metals and alloys (6 hours)
5. Solid state transformations (3 hours)
6. Diffusional transformations (6 hours)
7. Second order transformation (3 hours)
8. Diffusionless transformations (3 hours)
9. Landau theory

571705 Advanced Techniques for Materials Characterization **3(3-0-9)**

Condition : Consent of the School

Concepts of physical and chemical analysis of materials; Vacuum technology and principle of detectors; Diffraction analysis of crystal structure; X-ray diffraction; Optical microscopy; Electron microscopy and microanalysis; Surface chemical analysis; X-ray fluorescence technique; Atomic absorption spectrometry

Course outline

1. Concepts of physical and chemical analysis of materials (3 hours)
2. Vacuum technology and principle of detectors (3 hours)
3. Diffraction analysis of crystal structure (3 hours)
4. X-ray diffraction technique (3 hours)
5. Optical microscopy technique (1.5 hours)
6. Scanning electron microscopy technique (4.5 hours)
7. Transmission electron microscopy technique (6 hours)

8. Microanalysis in electron microscopy (3 hours)
9. Surface chemical analysis (3 hours)
10. X-ray fluorescence technique (3 hours)
11. Atomic absorption spectrometry (3 hours)

571706 Electron Microscopy and Diffraction Techniques 3(3-0-9)

Condition : Consent of the School

Scanning Electron Microscopy; Transmission Electron Microscopy; Electron-Specimen Interaction: Scattering and Diffraction; Lattice Geometry, Reciprocal Space and Miller Indices; Stereographic Projection; Crystal Structures; Selcted Area Diffraction Patterns; Indexing Electron Diffraction Patterns; Kikuchi Diffraction Patterns; Electron Backscattered Diffraction

Course Outline

1. Fundamental Principles of Electron Microscopy
   - 1.1 Scanning Electron Microscopy (3 hours)
   - 1.2 Transmission Electron Microscopy (6 hours)
   - 1.3 Electron-Specimen Interaction: Scattering and Diffraction (3 hours)
2. Crystallography
   - 2.1 Lattice Geometry, Reciprocal Space and Miller Indices (3 hours)
   - 2.2 Stereographic Projection (6 hours)
   - 2.3 Crystal Structures (3 hours)
3. Electron Diffraction Techniques
   - 3.1 Selcted Area Diffraction (3 hours)
   - 3.2 Indexing Electron Diffraction Patterns (3 hours)
   - 3.3 Kikuchi Diffraction Patterns (3 hours)
   - 3.4 Electron Backscattered Diffraction (3 hours)

571707 Kinetics in Metallurgical Processes 3(3-0-9)

Condition : Consent of the School

Chemical reaction rate: effect of concentration, rate of reaction, effect of temperature; Catalysis in chemical reactions; Determination of the order of reaction; Theories of reaction kinetics; Chemical-controlled reaction; Diffusion-controlled reaction; Reaction between two fluids; Kinetics of nucleation and growth; Non-isothermal kinetics

Course Outline

1. Chemical reaction rate, effect of concentration, effect of temperature, catalysis (6 hours)
2. Determination of the order of reaction (6 hours)
   - 2.1 Integration method
   - 2.2 Half-life method
   - 2.3 Van't Hoff's differential method
3. Theories of reaction kinetics (6 hours)
   - 3.1 Collision theory
   - 3.2 Absolute reaction rate theory
4. Chemical-controlled reaction and Diffusion-controlled reaction (9 hours)
5. Reaction between two fluids (3 hours)

6. Kinetics of nucleation and growth (3 hours)
7. Non-isothermal kinetics (3 hours)

571708 Physical Chemistry of Iron and Steel Manufacturing 3(3-0-9)

Condition : Consent of the School

Iron and Steel Manufacture: Raw Materials, Blast Furnace Ironmaking, Alternative Ironmaking, Basic Oxygen Steelmaking, Electric Steelmaking, Secondary Steelmaking, Continuous Casting; Physicochemical Fundamentals: Thermodynamics of Solutions, Kinetics of Chemical Reactions; Slag Metallurgy of Iron and Steelmaking; Treatment of Liquid Steel: Desiliconisation, Dephosphorization, Decarburisation, Deoxidation, Desulphurisation; Degassing of Molten Steel; Concept of Clean Steel Processing

Course Outline

1. Ironmaking (3 hours)
   - 1.1 Raw Material
   - 1.2 Blast Furnace
   - 1.3 Alternative Ironmaking
2. Steelmaking (3 hours)
   - 2.1 Basic Oxygen Steelmaking
   - 2.2 Electric Steelmaking
   - 2.3 Secondary Steelmaking
   - 2.4 Continuous Casting
3. Chemical Reaction of Iron and Steelmaking (6 hours)
   - 3.1 Thermodynamics of Solutions, Dilute Solutions
   - 3.2 Kinetics of Chemical Reactions
4. Slag Metallurgy (9 hours)
   - 4.1 Fundamentals of Slag System
   - 4.2 Interaction of Slag and Liquid Steel
   - 4.3 Refining Slag
5. Treatment of Liquid Steel (9 hours)
   - 5.1 Desiliconisation
   - 5.2 Dephosphorization
   - 5.3 Decarburisation
   - 5.4 Deoxidation
   - 5.5 Desulphurisation
   - 5.6 Degassing of Molten Steel
6. Concept of Clean Steel Processing (6 hours)

571709 Gas-Metal Reactions for Heat Treatment **3(3-0-9)**

Condition : Consent of the School

Metallurgical thermodynamics; review of the calculations of some basic thermodynamic functions, chemical potential and chemical equilibrium; Furnace atmospheres; gas reactions in the furnace atmosphere, classifications of prepared atmospheres, composition of atmospheres inert to heated steels; Furnace atmosphere control; Surface hardening of steels by gas-metal reactions; Control of surface carbon content in heat-treated steels and process control in gas carburizing; Special assignment of selected topics on gas-metal reactions for heat treatment

Course Outline

1. Metallurgical thermodynamics (8 hours)
   - 1.1 Review of the calculation of Metallurgical thermodynamics
   - 1.2 Chemical potential
   - 1.3 Chemical equilibrium
2. Furnace atmospheres (10 hours)
   - 2.1 Furnace atmosphere gas reactions
   - 2.2 Classifications of prepared atmospheres
   - 2.3 Composition of atmospheres inert to heated metal (steel)
3. Furnace atmosphere control (2 hours)
4. Surface hardening of steels by gas-metal reactions (8 hours)
   - 4.1 Gas carburizing
   - 4.2 Carbonitriding
   - 4.3 Gas nitriding
   - 4.4 Gaseous nitrocarburizing
5. Control of surface carbon content in heat treating of steels (8 hours)
   - 5.1 Control of carbon potential
   - 5.2 Process control in gas carburizing

571710 Practical Heat Treatment for Metals and Alloys **3(3-0-9)**

Condition : Consent of the School

Strengthening in metals and alloys; Principle of phase transformation including recrystallization, precipitation, allotropy; Principle of heat treatment in steels and heat treatment processes; Heat treatment in aluminum and other alloys; Surface hardening: thermo treatment and thermochemical treatment; Furnace atmosphere controlling; Vacuum Heat treatment; Furnace technology; Quality control; Seminar.

Course Outline

1. Strengthening in metals and alloys (3 hours)
2. Principle of phase transformation: recrystallization, precipitation, allotropy (3 hours)
3. Principle of heat treatment in steels and heat treatment processes (6 hours)
4. Heat treatment in aluminum and other alloys (3 hours)
5. Surface Hardening: thermo treatment and thermochemical treatment (3 hours)
6. Furnace atmosphere controlling (3 hours)
7. Vacuum heat treatment (3 hours)
8. Furnace technology (3 hours)
9. Quality control (3 hours)
10. *Seminar:* development industrial technology for heat treatment (3 hours)

11. *Seminar:* Quenching Technology and Distortion (3 hours)

571711 Advanced Corrosion 3(3-0-9)

Condition : Consent of the School

Engineering aspects of corrosion and its control; Classification of electrochemical corrosion cells; Types of corrosion damage, simplified mechanisms of corrosion and methods for combating corrosion; Pourbaix diagrams; Electrode kinetics; Potentiostatic studies and applications to engineering designs; Environment aspects of aqueous corrosion; Prevention of aqueous corrosion; Oxidation- dry corrosion; Fundamentals of mechanochemistry for corrosion

Course outline

1. Classification of electrochemical corrosion cells (3 hours)
2. Types of corrosion damage (3 hours)
3. Pourbaix diagrams (3 hours)
4. Electrode kinetics (9 hours)
   - 4.1 The electrical double layer
   - 4.2 Exchange current density
   - 4.3 Thermodynamic irreversibility and polarization
   - 4.4 Type of polarization
   - 4.5 Potential-current diagram
   - 4.6 Passivity and anodic
5. Potentiostatic studies and applications to engineering designs (6 hours)
6. Environment aspects of aqueous corrosion (3 hours)
7. Prevention of aqueous corrosion (3 hours)
8. Oxidation-dry corrosion (3 hours)
9. Fundamentals of mechanochemistry for corrosion (3 hours)

571712 Electrochemical Processing of Materials 3(3-0-9)

Condition : Consent of the School

Principles of electrochemical cells; Electric current in ionic conductors; Electrode potentials Thermodynamic of cells; Transport process in electrolytic solutions; Electrode kinetics and interfacial phenomena; Electrochemical measurement techniques; Industrial electrochemical processes; Batteries and fuel cells

Course outline

1. Electric current in ionic conductors (1.5 hours)
2. Electrode potentials (1.5 hours)
3. Thermodynamics of cells, electrolyte, and Debye-Huckel theory (3 hours)
4. Transport process in electrolytic solutions (3 hours)
5. Electrode kinetics and interfacial phenomena (6 hours)
6. Electrochemical measurement techniques (6 hours)
7. Industrial electrochemical processes (9 hours)
8. Batteries and fuel cells (6 hours)

571713 Mechanical Behavior of Metals and Materials **3(3-0-9)**

Condition : Consent of the school

Review of continuum mechanics, stress-strain analysis; Yield criteria and plastic deformation in materials; Standard mechanical properties assessment, micro-macro-nano hardness, compression, tension, torsion, bending, impact, creep and rupture tests, standard test methods, interpretation of test parameters; Fracture mechanics, LEFM-EPFM, application of fracture mechanics for engineering design; Fatigue life assessment and fatigue crack growth, theory and factors affecting fatigue properties; Damage mechanisms and design against mechanical failure

Course Outline

1. Reviews of continuum mechanics (3 hours)
2. Yield criteria and plastic deformation in materials (3 hours)
3. Standard mechanical properties assessment (9 hours)
   - 3.1 Standard test methods
   - 3.2 Interpretation of test parameters
4. Fracture mechanics for engineering materials (6 hours)
   - 4.1 Linear-Elastic Fracture Mechanics (LEFM) and Elastic-Plastic Fracture Mechanics (EPFM)
   - 4.2 Application of fracture mechanics for engineering design
5. Fatigue properties (12 hours)
   - 5.1 Theory of fatigue
   - 5.2 Fatigue life assessment
   - 5.3 Fatigue crack growth
   - 5.4 Factors affecting fatigue properties
6. Damage mechanisms and design against mechanical failure (3 hours)

571714 Advanced Metal Forming **3(3-0-9)**

Condition : Consent of the School

Advanced mechanical metallurgy for metal forming; Plastic deformation in polycrystalline materials; Ideal work and actual work in metal forming; Friction in metal forming; Analysis of metal behavior during metal forming process; Problem analysis on metal forming and its solutions; Development of new metal forming technologies

Course Outline

1. Advanced mechanical metallurgy for metal forming (9 hours)
2. Plastic deformation in polycrystalline materials (3 hours)
3. Ideal work and actual work in metal forming (3 hours)
4. Friction in metal forming (3 hours)
5. Analysis of metal behavior during metal forming process (6 hours)
6. Problem analysis on metal forming and its solutions (6 hours)
7. Development of new metal forming technologies (6 hours)

571715 Failure Analysis in Metals and Materials **3(3-0-9)**

Condition : Consent of the School

Failure analysis in engineering applications; deformation, fracture mechanics. Fracture modes, brittle fracture, ductile fracture, intergranular fracture, fatigue failure, corrosion failure, high temperature failure; Factors affecting failure modes in materials, influences of temperature and environment on failure analysis of engineering materials, Procedure of failure analysis, tools and techniques for the analysis of fracture in metals and materials; Case studies of failure analysis in metals and materials

Course Outline

1. Failure analysis in engineering applications (6 hours)
2. Fracture modes in materials (6 hours)
3. Factors affecting failure modes in materials (6 hours)
4. Procedure of failure analysis, tools and techniques (6 hours)
5. Case studies of failure analysis in metals and materials (12 hours)

571716 Science and Engineering of Casting Solidification **3(3-0-9)**

Condition : Consent of the School

Thermodynamics of solidification; energy, momentum and mass transfer during solidification; numerical modelling of solidification; morphological instability of a solid/liquid interface; Cells and dendrites; Eutectic and peritectic solidifications; Directional solidification and solute redistribution; Rapid solidification; Solidifications in metal processing

Course outline

1. Thermodynamics of solidification (3 hours)
2. Energy, momentum and mass transfer during solidification (9 hours)
3. Numerical modelling of solidification (6 hours)
4. Morphological instability of a solid/liquid interface (3 hours)
5. Cells and dendrites (3 hours)
6. Eutectic and peritectic solidifications (3 hours)
7. Directional solidification and solute redistribution (3 hours)
8. Rapid solidification (3 hours)
9. Solidifications in metal processing (3 hours)

571717 Sciences and Technology of Welding **3(3-0-9)**

Condition : Consent of the School

Development of joining process; Definition of Welding; Types of Welding; Welding heat sources characteristics; Heat and mass transport in welding process; chemical reactions in welding; Distortion, residual stress, and crack; Phase transformation in welding; Weld degradation; Welding design under standards

Course outline

1. Development of joining process (3 hours)
2. Definition of welding and Types of welding (2 hours)
3. Welding heat sources characteristics (4 hours)
4. Heat and mass transport in welding process (6 hours)
5. Chemical reactions in welding (3 hours)
6. Distortion, residual stress, and crack (3 hours)
7. Phase transformation in welding (5 hours)

8. Weld degradation (1 hour)
9. Welding design under standards (9 hours)

571718 Nonferrous Process Metallurgy 3(3-0-9)

Condition : Consent of the School

The processes , operations, technologies and processing routes of extractive metallurgy, i.e. the extraction of metals from ores, concentrates, scraps and wastes and their refining; Case studies

Course outline

1. Principle of ore dressing ; Physical separation and recovery of metals from scraps and wastes (6 hours)
2. Process metallurgy of tin (3 hours)
3. Process metallurgy of lead (3 hours)
4. Process metallurgy of antimony (3 hours)
5. Process metallurgy of zinc (3 hours)
6. Process metallurgy of copper (3 hours)
7. Process metallurgy of nickel (3 hours)
8. Process metallurgy of aluminium (3 hours)
9. Process metallurgy of gold, silver and Platinum Group Metals (PGMs) (3 hours)
10. Process metallurgy of niobium, tantalum and rare metals (3 hours)
11. Case studies (3 hours)

571719 Tribology of Engineering Materials 3(3-0-9)

Condition : Consent of the School

Tribology: terminology, scope and engineering significance; Tribological surfaces and contact mechanics; Friction and lubrication; Wear mechanisms and testing; Surface engineered materials and coatings, properties and characterization; Case studies, problem solving for Industrial tribology and design against tribological failure

Course Outline

1. Tribology : terminology, scope and engineering significance (3 hours)
2. Tribological surfaces and contact mechanics (6 hours)
   - 2.1 Tribological surfaces and statistical nature
   - 2.2 Contact between surfaces
   - 2.3 Tribological loading
3. Friction and lubrication (6 hours)
   - 3.1 Kinematic and static friction: stick-slip effects
   - 3.2 Friction measurement and friction coefficient
   - 3.3 Friction and lubrication conditions
   - 3.4 Rheology and chemistry of lubricants
4. Wear (9 hours)
   - 4.1 Wear mechanisms
   - 4.2 Surface fracture and wear products
   - 4.3 Wear tests and paremeters
5. Surface engineered materials and coatings (9 hours)
   - 5.1 Tribological properties of engineered surfaces and coatings

5.2 Characterization and evaluation of engineered surfaces and coatings

5.3 Design guidelines for the selection of engineered surfaces and coatings

6. Case studies (3 hours)

6.1 Problem solving for Industrial tribology

6.2 Design against tribological failure)

Ceramics Material Courses

571720 Advanced Physical Chemistry for Ceramics 3(3-0-9)

Condition : Consent of the School

Theory of thermodynamic equilibrium, Phase equilibrium in pure substances. Systems of variable compositions. Chemical equilibrium, Ionic solution, Debye-Huckel theory, Electrochemical cells, Electric potential at interfaces. Empirical treatment of reaction rates. Experimental methods and treatment of data. Complex reaction. Reaction in solution

Course Outline

1. Theory of thermodynamic equilibrium (3 hours)
2. Phase equilibrium in pure substances (4 hours)
3. Systems of variable compositions (4 hours)
4. Chemical equilibrium (4 hours)
5. Ionic solution (3 hours)
6. Debye - Huckel theory (2 hours)
7. Electrochemical cells (3 hours)
8. Electric potential at interfaces (3 hours)
9. Empirical treatment of reaction rates (3 hours)
10. Experimental methods and treatment of data (3 hours)
11. Complex reaction (2 hours)
12. Reaction in solution (2 hours)

571721 Solid State Chemistry 3(3-0-9)

Condition : Consent of the School

Thermodynamics, kinetics, and mechanisms of solid state reactions, phase transformations and solidification in ceramic material systems

Course Outline

1. Synthesis and characterization (4 hours)
2. Structure (12 hours)

2.1 Crystal structure

2.2 Descriptive crystal chemistry

2.3 Crystal defects and nonstoichiometry

2.4 Solid solution

3. Solid state reaction and industrial applications (8 hours)
4. Complex crystal structures : (12 hours)

4.1 Silicates

4.2 Titanates

4.3 Ferrites

4.4 Superconductors

571722 Solid State Physics **3(3-0-9)**

Condition : Consent of the School

The microscopic origins of the physical properties of solids are discussed. First part of the course includes atomic lattices and associated mechanical, thermal and dielectric properties. The second part focuses on energy band structure; the electronic properties of metals, semiconductors and insulators. magnetic properties; optical properties; superconductivity ; and the dielectric, ferroelectric and piezoelectric properties of insulators

Course Outline

1. Crystallinity and the Form of Solids (6 hours)
   - 1.1 Crystal Structure and Binding
   - 1.2 Structural Defects
   - 1.3 Amorphous Structures
   - 1.4 Liquid Crystals
2. Phonons: Crystal Vibrations and Thermal Structures (9 hours)
   - 2.1 Vibrations of crystals
   - 2.2 Quantization of Elastic waves
   - 2.3 Phonon momentum
   - 2.4 Inelastic Scattering by Phonons
   - 2.5 Phonon Heat Capacity
   - 2.6 Thermal Conductivity
3. Energy Bands(9 hours)
   - 3.1 Nearly Free Electron Model
   - 3.2 Bloch Function and Kronig-Penny Model
   - 3.3 Bragg Reflection and Energy Gap
   - 3.4 Brillouin Zones for Multi-Dimensional Solids
   - 3.5 Metals, Insulators and Semiconductors
4. Dielectric, Ferroelectrics and Magnetic Properties of Solids (12 hours)
   - 4.1 Macroscopic and Microscopic Views of Dielectric Response
   - 4.2 Ferroelectric Behavior
   - 4.3 Piezoelectric and Electrostriction
   - 4.4 Magnetic Dipole Strengths
   - 4.5 Forms of Magnetism: Diamagnetism, Paramagnetism, Ferromagnetism, Antiferromagnetism and Ferrimagnetism
   - 4.6 Magnetic Resonance

571723 Thermodynamics of Materials **3(3-0-9)**

Condition : Consent of the School

Basic thermodynamic concepts of solids cover first, second and third laws of thermodynamics and their applications to materials, solution theory, phase equilibrium, phase transformation, electro–chemistry and solid electrolytes, and advanced thermodynamic problem solving

Course Outline

1. Introduction and definition of terms (2 hours)
2. The first law of thermodynamics ; (4 hours)
   Heat and work, enthalpy and heat capacity, heat of formation heat of reaction
3. The second law of thermodynamics ; (6 hours)
   Entropy and change of entropy during reaction processes, free energy function, summary of thermodynamic relations, statistical interpretation of entropy
4. The third law of thermodynamics and applications (4 hours)
5. Relationship between thermodynamic and physical properties (6 hours)
6. Free energy of heterogeneous reactions (3 hours)
7. Solutions (3 hours)
8. Equilibrium between phases of variable composition (2 hours)
9. Free energy of binary systems (2 hours)
10. Thermodynamics of interfaces (2 hours)
11. Introduction to defects in crystals ; elemental crystals and compounds (2 hours)

571724 Mathematical Methods in Material Science and Engineering **3(3-0-9)**

Condition : Consent of the School

Review of properties of infinite series, Inner product spaces. Fourier series. Fourier integrals, the exponential Fourier representation, properties of Fourier integral, convolution, Fourier transforms, Sturm-Liouville boundary value problems. Bessel function. Classification of linear second order partial differential equations with two independent variables. Hyperbolic differential equations, The heat equation, Elliptic equations. Laplace transform. Difference equations. Discrete Fourier transform. Fast Fourier transforms

Course Outline

1. Review of properties of infinite series (2 hours)
2. Inner product spaces (3 hours)
3. Fourier series (3 hours)
4. Fourier integrals, the exponential Fourier representation, (4 hours)
   properties of Fourier integral, convolution, Fourier transform
5. Sturm-Liouville boundary value problems (2 hours)
6. Bessel function (4 hours)
7. Classification of linear second order partial differential equation (2 hours)
8. Hyperbolic differential equations (2 hours)
9. The heat equation (1 hours)
10. Elliptic equation (2 hours)
11. Laplace transform (4 hours)
12. Difference equations (1 hour)
13. Discrete Fourier transform (4 hours)
14. Fast Fourier transforms (2 hours)

571725 Advanced Ceramic Materials **3(3-0-9)**

Condition : Consent of the School

Review of advanced ceramic materials including structural, electrical, magnetic, electronic, thermal, chemical, nuclear, optical and biological ceramic materials, raw materials and processes, key properties in design and selection for engineering applications

Course Outline

1. Introduction to advanced ceramic materials (3 hours)
2. Classification of advanced ceramic materials (3 hours)
3. Processing and properties of advanced ceramic materials: (26 hours)
   - 3.1 Structural ceramics
   - 3.2 Electrical, electronic and magnetic ceramics
   - 3.3 Thermal, chemical and nuclear ceramics
   - 3.4 Optical ceramics
   - 3.5 Bioceramic and composites
   - 3.6 Smart materials
4. Report(s) and presentation(s) on topics based on advanced ceramic materials (4 hours)

571726 Advanced Ceramic Processing I **3(3-0-9)**

Condition : Consent of the School

State-of-the art industrial processes in ceramics with emphasis on theoretical fundamentals and controls. The course is designed to give insight to all relevant issues concerning the processing and sintering of advanced ceramic materials including advanced powder preparation and characterization, colloidal and sol-gel techniques, powder consolidation and forming, sintering theory and practice, microstructure evolution. Also emphasize on the important of each step and the critical interconnection among the steps, in the overall advanced fabrication processes of ceramics

Course Outline

1. Introduction to advanced ceramic processing (2 hours)
2. Processing parameters and process control (2 hours)
3. Synthesis , preparation methods, properties and characterization of starling materials and active powders (4 hours)
4. Casting process for plastic and non-plastic materials , controls and applications (4 hours)
   - 4.1 Rheology of ceramic powder-liquid suspension
   - 4.2 Mechanisms of particle-additive interactions
   - 4.3 Electrical double layer theory and zeta potential
5. Tape casting process , controls and applications (4 hours)
   - 5.1 Equipments and controlled parameters
   - 5.2 Compositions and effect of additives
6. Dry pressing process for technical ceramics, controls and applications (4 hours)
   - 6.1 Theory of particle packing
   - 6.2 Granulation techniques
   - 6.3 Equipments and controlled parameters

7. Cold isostatic pressing, controls and applications (4 hours)
   7.1 Equipments and controlled parameters
   7.2 Wet bag versus dry bag processes
   7.3 Mold materials and effect of pressure on properties
8. Sintering theory and controls (6 hours)
9. Report(s) and presentation(s) on topics in advanced ceramic processing (6 hours)

571727 Advanced Ceramic Processing II 3(3-0-9)

Condition : Consent of the School

State-of-the art industrial processes in ceramics with emphasis on theoretical fundamentals, processing parameters and controls. Topics covered injection molding, hot pressing, hot isostatic pressing, coating processes and thermal processing of technical ceramics

Course Outline

1. Overview of processing techniques in ceramics (3 hours)
2. Theoretical fundamentals, processing parameters, controls and applications (27 hours)
   2.1 Injection molding process in ceramics
   2.2 Hot press and hot isostatic press
   2.3 Coating processes
   2.4 Thermal processing of ceramics
3. Report(s) and presentation(s) based on topics in advanced ceramic processing (6 hours)

571728 Characterization in Material Engineering I: X-ray diffraction 3(3-0-9)

Condition : Consent of the School

Advanced analytical and characterization techniques for research and development of ceramic materials with emphasis on structural and phase analysis by x-ray diffraction

Course Outline

1. Introduction (2 hours)
2. X-ray diffraction analysis for ceramics
   2.1 Characteristics of x-radiation and properties of x-rays (2 hours)
   2.2 The crystalline state and geometry of crystals (6 hours)
   2.3 X-ray diffraction theory ; origin of diffraction pattern (6 hours)
   Bragg law, location and intensity of diffraction lines
   2.4 Instrumentation : sources, detectors, alignment and maintenance (6 hours)
   2.5 Experimental techniques,
   Laue photographs, powder photographs, diffractometer and (6 hours)
   spectrometer measurements
   2.6 Applications for ceramic analysis ; (8 hours)
      2.6.1 Single crystal , orientation and quality
      2.6.2 Structure of polycrystalline ceramics and glasses
      2.6.3 Crystal structure determination
      2.6.4 Phase diagram determination
      2.6.5 Order-disorder transformation
      2.6.6 Phase analysis, qualitative and quantitative

571729 Characterization in Material Engineering II: Physical Characterization 3(3-0-9)

Condition : Consent of the School

Advanced analytical and characterization techniques for research and development of ceramic materials with emphasis on powder, and consolidated product characteristics which included i.e. particle characteristics, porosity and distribution, surface topography and area, and other important properties related to industrial or research field

Course Outline

1. Introduction ; processing and characterization of powder (2 hours)
2. Particle size, particle shape and diameters (2 hours)
3. Distribution of particle size ; (4 hours)
   Histograms, normal (Gaussian) , log-normal and Rosin-Rammler Distributions
4. Practical work ; (8 hours)
   Characterization of powder using hydrometer, laser diffraction, optical microscopic and electron microscopic techniques
5. Specific surface area by gas adsorption and methods for determining surface area (4 hours)
6. Practical work ; (4 hours)
   Characterization of powder and consolidated materials using BET equation and BET equipment
7. Density, porosity, pore size and distribution (6 hours)
8. Practical work ; (6 hours)
   Characterization of pore size and distribution by mercury porosimetry

571730 Characterization in Material Engineering III : Thermal Characterization 3(3-0-9)

Condition : Consent of the School

Advanced analytical and characterization techniques for research and development of ceramic materials with emphasis on thermal characteristics analysis techniques using differential thermal analysis, thermogravimetric analysis, differential scanning calorimetry, thermal expansion by dilatometer. Other related thermal analysis methods will also be discussed. Instrumentation and limitation of each technique will be covered

Course Outline

1. Introduction to instrumental methods for thermal characterization in ceramic materials research ; (3 hours)
   Principles in measurement of heat, energy and temperature as related to thermal properties of materials
2. Diiferential thermal analysis (DTA) and differential scanning calorimeter (DSC) ; (10 hours)
   Priciples and instrumentations, thermodynamic data from DTA and DSC, calibration, applications to materials i.e. transformations, specific heat determination, effect of operation parameters, experimental concerns, manipulation of data
3. Thermogravimetric analysis (TGA) ; (5 hours)
   Priciples and instrumentations, calibration, effect of operation parameters,

experimental concerns, manipulation of data

4. Dilatometry and interferrometry ; Linear and volume expansion coefficient, theoretical origin of thermal expansion, instrumentations, calibration , experimental concerns (6 hours)
5. Review of other instrumental methods for thermal analysis ; General principles , instrumentations and application for ; thermal conductivity, thermal stresses, viscosity of glass (6 hours)
6. Student assignment(s) ; Case study in the applications of thermal analysis for ceramic materials research and development (6 hours)

571731 Characterization in Material Engineering IV: Microscopic Characterization **3(3-0-9)**

Condition : Consent of the School

Advanced analytical and characterization techniques for research and development of ceramic materials with emphasis on powder and microstructural characteristics and phase analysis using optical and electron microscopic techniques

Course Outline

1. Introduction to microscopic methods of analysis (2 hours)
2. Optical microscopy (12 hours)
   - 2.1 Principles and instrumentation
   - 2.2 Isotropic crystals, uniaxial and biaxial crystals
   - 2.3 Applications in ceramic research and development
3. Scanning electron microscopy (SEM) (10 hours)
   - 3.1 Principles and instrumentation
   - 3.2 Sample preparation techniques
   - 3.3 EPMA system
   - 3.4 Applications in ceramic research and development
4. Transmission electron microscopy (TEM) (8 hours)
   - 4.1 Principles and instrumentation
   - 4.2 Sample preparation techniques
   - 4.3 Applications in ceramic research and development
5. Student assignment(s) ; Case study in the application(s) of microscopic analysis for ceramic materials research and development (4 hours)

571732 Characterization in Material Engineering V: Chemical Characterization **3(3-0-9)**

Condition : Consent of the School

Advanced analytical and characterization techniques for research and development of ceramic materials with emphasis on chemical analysis techniques including atomic absorption , flame emission, atomic emission, x- ray fluorescence spectrometry. Other related chromatographic, spectroscopic and spectrometric techniques in chemical analysis will also be introduced. Instrumentations will be discussed. Accuracy and limitation of each technique will be described in terms of statistical parameters

Course Outline

1. Introduction to instrumental methods for chemical characterization in ceramic materials research (2 hours)
2. The evaluation of the reliability of data ; Basic statistics mean, median, precision, accuracy, errors, Deviation, confidence intervals, significant figure, rejection of data (6 hours)
3. Atomic absorption and flame emission spectroscopy ; Principles of measurements, instrumentations, correction for Interferences, sensitivity and detection limits (6 hours)
4. Atomic emission spectroscopy ; Optical emission spectrophotometry (OES), excitation by inductively coupled plasma (ICP), ionization by arc, spark or electronic impact, spectral lines, simultaneous and sequential instruments (6 hours)
5. X-ray fluorescence spectrometry ; General principle, x-ray fluorescence spectrum, excitation modes, x-ray absorption, sample preparation, types of instruments, accuracy and detection limits (8 hours)
6. Review of other instrumental methods for chemical analysis ; General principles and instrumentations for ; gas-, liquid-, ion-chromatography ; nuclear magnetic resonance (NMR), infrared spectroscopy (IR), and ultraviolet - visible absorption spectroscopy; mass spectrometry (8 hours)

571733 Advanced Topics in Biomaterials **3(3-0-9)**

Condition : Consent of the School

Advanced topics in biomaterials and related fields which are not covered in details in the general curriculum will be discussed. The topics will be of current or future areas of research and development for industrial interest. Students are required to do up-to-date literature survey, experiments, report(s), and class presentation(s). Lectures and discussion with invited researchers from government and private sectors will also be arranged

571734 Advanced Topics in Glass **3(3-0-9)**

Condition : Consent of the School

Advanced topics in glass and related fields which are not covered in details in the general curriculum will be discussed. The topics will be of current or future areas of research and development for industrial interest such as chalcogenide glasses, optical waveguides, bioglasses, nitrided glasses, advanced structure analysis of glass, glass to metal seals, glass matrix composites, etc.. Students are required to do up-to-date literature survey search, experiments, report(s), and class presentation(s). Lectures and discussion with invited researchers will also be arranged

571735 Advanced Topics in Composite Materials 3(3-0-9)

Condition : Consent of the School

Advanced topics in composite materials and related fields which are not covered in details in the general curriculum will be discussed. The topics will be of current or future areas of research and development for industrial interest. Students are required to do up-to-date literature survey, experiments, report(s), and class presentation(s). Lectures and discussion with invited researchers from government and private sectors will also be arranged

571736 Advanced Topics in Functional Ceramics 3(3-0-9)

Condition : Consent of the School

Advanced topics in functional ceramics and related fields which are not covered in details in the general curriculum will be discussed. The topics will be of current or future areas of research and development for industrial interests in chemically functional, electrical and electronic, magnetic, optical, thermal and biological ceramics. Students are required to do up-to-date literature survey, experiments, report(s), and class presentation(s). Lectures and discussion with invited researchers from government and private sectors will also be arranged

571737 Advanced Topics in Electrical and Electronic Ceramics 3(3-0-9)

Condition : Consent of the School

Advanced topics in electrical and electronic ceramic materials and related fields which are not covered in details in the general curriculum will be discussed. The topics will be of current or future areas of research and development for industrial interest. Students are required to do up-to-date literature survey, experiments, report(s), and class presentation(s). Lectures and discussion with invited researchers from government and private sectors will also be arranged

571738 Advanced Topics in Structural Ceramics 3(3-0-9)

Condition : Consent of the School

Advanced topics in structural ceramic materials and related fields which are not covered in details in the general curriculum will be discussed. The topics will be of current or future areas of research and development for industrial interest. Students are required to do up-to-date literature survey, experiments, report(s), and class presentation(s). Lectures and discussion with invited researchers from government and private sectors will also be arranged

571739 Advanced Topics in Magnetic Ceramics 3(3-0-9)

Condition : Consent of the School

Advanced topics in magnetic ceramic materials and related fields which are not covered in details in the general curriculum will be discussed. The topics will be of current or future areas of research and development for industrial interest. Students are required to do up-to-date literature survey, experiments, report(s), and class presentation(s). Lectures and discussion with invited researchers from government and private sectors will also be arranged

Polymeric Material Courses

571740 Polymer Engineering **3(3-0-9)**

Condition : Consent of the School

Handling of particulate solids, Heat transfer in polymer processing, Crystalline and amorphous state, Elasticity and viscoelasticity, Creep and stress relaxation, Four- parameter model, Time temperatue superposition, Failure of polymers, Impact behavior, Static and dynamic fatigue, Reinforced polymers.

Course Outline

1. Handling of particulate solids (5 hours)
2. Heat transfer in polymer processing (12 hours)
3. Crystalline and amorphous state (3 hours)
4. Elasticity and viscoelasticity (5 hours)
5. Failure of polymers (3 hours)
6. Impact behavior (3 hours)
7. Fatigue (3 hours)
8. Reinforced polymers (2 hours)

571741 Polymer Rheology **3(3-0-9)**

Condition : Consent of the School

Newtonian versus non-Newtonian behavior, Constitutive equations and their use in solving polymer fluid problems, Steady/unsteady shear/shearfree flow material functions, Viscoelastic models, Rheometers and rheological measurements, Molecular theories.

Course Outline

1. Review of stress/strain/rate of strain tensor (1.5 hours)
2. Flow phenomena in polymeric liquids (1.5 hours)
3. Review of basic transport phenomena (Newtonian) (6 hours)
4. Generalized Newtonian fluids (GNF) (6 hours)
5. Linear viscoelasticity (6 hours)
6. Rheological characterization (6 hours)
7. Rheometry (6 hours)
8. Molecular theories for viscoelasticity of polymer (3 hours)

571742 Advanced Polymer Processing **3(3-0-9)**

Condition : Consent of the School

Basic screw geometry, Extruder screw design, Extrusion through die, Process Design for twin screw extruder, Post die processing, Molding and forming.

Course Outline

1. Basic screw geometry (4 hours)
2. Extruder screw design (11 hours)
3. Extrusion through die (3 hours)
4. Process design for twin screw extruder (3 hours)
5. Post die processing (9 hours)
6. Molding and forming (6 hours)

571743 Industrial Safety and Process Control for Polymer Engineers **3(3-0-9)**

Condition : Consent of the School

Safety in polymer industries chemical hazard and safety, Fire control and safety, Material safety and data sheet, Trend in safety and environmental protection, Control by six sigma, Process measurement, Process analysis, Process improvement, Process control.

Course Outline

1. Safety in polymer industries (3 hours)
2. Chemical hazard and safety (4 hours)
3. Fire control and safety (4 hours)
4. Material safety and data sheet (4 hours)
5. Trend in safety and environmental protection (3 hours)
6. Process control by six sigma (2 hours)
7. Process measurement (4 hours)
8. Process analysis (4 hours)
9. Process improvement (5 hours)
10. Process control (3 hours)

Elective Courses : Polymer Engineering

571744 Experimental Design for Polymer Engineers **3(3-0-9)**

Condition : Consent of the School

Study of statistical methods for engineers, Design of experiment for polymer industries, Full and fractional factorial 2^k DOEs, Other DOE consideration, Variability reduction through DOE and Taguchi consideration, Respond surface methodology

Course Outline

1. Statistical Methods for Engineers (6 hours)
2. Design of Experiment for Polymer Industries (3 hours)
3. Full and Fractional Factorial 2^k DOEs (6 hours)
4. Other DOE Consideration (3 hours)
5. Variability Reduction Through DOE and Taguchi Consideration (6 hours)
6. Respond Surface Methodology (6 hours)

571745 Design Formulas for Polymer Engineers 3(3-0-9)

Condition : Consent of the School

Study and understanding formulas of rheology, Thermodynamic and heat transfer formulas, Designing plastics parts, Designing for extrusion machine, Designing for injection machine.

Course Outline

1. Study and understanding formulas of rheology (6 hours)
2. Thermodynamic and heat transfer formulas (6 hours)
3. Designing plastics parts (6 hours)
4. Designing for extrusion machine (9 hours)
5. Designing for injection machine (6 hours)

571746 Polymer Mixing and Compounding **3(3-0-9)**

Condition : Consent of the School

Basic mixing mechanism, Distributive and dispersive mixing, Mixing in single screw extruder, Mixing in twin screw extruder, Mixing in internal and external mixer, Static mixing devices, Polymer compounding.

Course Outline

1. Introduction (2 hours)
2. Distributive Mixing (6 hours)
3. Dispersive Mixing (6 hours)
4. Mixing in Single Screw Extruder (4 hours)
5. Mixing in Twin Screw Extruder (6 hours)
6. Mixing in Internal and External Mixer (3 hours)
7. Static Mixing Devices (3 hours)
8. Polymer Compounding (6 hours)

571747 Materials Selection and Design **3(3-0-9)**

Condition : Consent of the School

Material and manufacturing consideration in product design, Fundamentals of materials: their behavior and manufacturing properties, Element of engineering design, Effect of material properties and manufacturing process on design, Economics of materials and process, Materials Selection, Quality assurance, Testing and inspection, Safety and product liability, Future trends and materials substitution.

Course Outline

1. Material and Manufacturing Consideration in Product Design (2 hours)
2. Fundamentals of Materials: Their Behavior and Manufacturing Properties (4 hours)
3. Element of Engineering Design (4 hours)
4. Effects of Material Properties and Manufacturing Process on Design (6 hours)
5. Economics of Materials and Process (2 hours)
6. Materials Selection (9 hours)
7. Quality Assurance, Testing and Inspection (4 hours)
8. Safety and Product Liability (2 hours)
9. Future Trends and Material Substitution (3 hours)

571748 Plastic Product Design **3(3-0-9)**

Condition : Consent of the School

Review of design practices, Designing for manufacturing, The design process and material selection, Part design features, Part dimension control and shrinkage, Strength of shape, Finishing techniques for plastics, Part design problems and solutions, Computer assisted mold design, Design project.

Course Outline

1. Introduction and Review of Design Practices (3 hours)
2. Designing for Manufacturing (3 hours)
3. The Design Process and Material Selection (3 hours)
4. Part Design Features (6 hours)
5. Part Dimension Control and Shrinkage (3 hours)
6. Strength of Shape (3 hours)
7. Finishing Techniques for Plastics (3 hours)

8. Part Design Problems and Solutions (3 hours)
9. Computer Assisted Mold Design (3 hours)
10. Design Project (6 hours)

571749 Mold and Die Design 3(3-0-9)

Condition : Consent of the School

Course overview. Mold and die materials, Manufacturing and machining processes, Injection molds, Compression and transfer molds, Blow molds, General aspects for die design, Computer-assisted mold and die design, Case study.

Course Outline

1. Introduction (2 hours)
2. Mold and Die Materials (3 hours)
3. Manufacturing and Machining Processes (6 hours)
4. Injection Molds (9 hours)
5. Compression and Transfer Molds (6 hours)
5. Blow Molds (3 hours)
7. General Aspects for Die Design (3 hours)
8. Computer Assisted Mold and Die Design (3 hours)
9. Case Study (1 hour)

571750 Structure and Rheology of Complex Fluids 3(3-0-9)

Condition : Consent of the School

Fundamentals of complex fluids, basic forces, and rheological measurements. Rheology/Viscoelasticity/Thermodynamics/ Dynamics of complex fluids: dilute polymer solution, entangled polymer, particulate suspensions, emulsion and blends, block copolymers.

Course Outline

1. Complex Fluids (3 hours)
2. Basic Forces (3 hours)
3. Rheological Measurements (6 hours)
4. Rheology/Viscoelasticity/Thermodynamics/Dynamics of
   - 4.1 Dilute Polymer Solutions/Entangled Polymer (6 hours)
   - 4.2 Particulate Suspensions (6 hours)
   - 4.3 Emulsion and Blends (9 hours)
   - 4.4 Block Copolymers (6 hours)

571751 Mechanics of Solid Polymers 3(3-0-9)

Condition : Consent of the School

Structure of solid polymers, Elasticity, Principle of viscoelasticity, Yield and Fracture, Impact behavior, Fatigue.

Course Outline

1. Structure of Solid Polymers (6 hours)
2. Elasticity (6 hours)
3. Principle of Viscoelasticity (6 hours)
4. Yield and Fracture (6 hours)

5. Impact Behavior (6 hours)
6. Fatigue (6 hours)

571752 Polymer Morphology 3(3-0-9)

Condition : Consent of the School

Overview of polymer morphologies, Chain structure of amorphous and semicrystalline polymers, Morphologies of polymer single crystals and spherulites, Theories of crystallization, Effects of temperature and pressure on crystallization, Strain and flow induced crystallization, Thermodynamics of phase separation, Phase morphology development in polymer blends, Morphology characterization by microscopy techniques, Phase morphology of multiphase polymer systems and polymer composites, Complex phase morphologies.

Course Outline

1. Introduction (4 hours)
2. Morphologies of Polymer Crystals (4 hours)
3. Theories of Crystallization (5 hours)
4. Effect of Crystallization Temperature and Pressure (4 hours)
5. Strain and Flow Induced Crystallization (2 hours)
6. Thermodynamics of Phase Separation (2 hours)
7. Phase Morphology Development in Polymer Blends (3 hours)
8. Morphology Characterization by Microscopy Techniques (3 hours)
9. Phase Morphology of Multiphase Polymer Systems and Polymer Composites (6 hours)
10. Complex Phase Morphologies (3 hours)

571753 Structural Characterization of Polymers 3(3-0-9)

Condition : Consent of the School

Introduction, Separation and purification techniques, Spectroscopic techniques, Chromatographic methods, Thermal analysis, Microscopy Techniques.

Course Outline

1. Introduction (1 hour)
2. Separation and purification techniques (2 hours)
3. Spectroscopy Techniques (15 hours)
   UV-Visible/ Infrared (IR)/ X-ray diffraction (XRD)/ Nuclear Magnetic Resonance (NMR) Spectroscopy
4. Chromatographic Methods (6 hours)
   Size exclusion chromatography (SEC)/ High pressure liquid chromatography (HPLC)
5. Thermal Analysis (7 hours)
   Differential scanning calorimetry (DSC)/ Thermogravimetric analysis (TGA)/ Dynamic mechanical analysis (DMA)
6. Microscopy Techniques. (5 hours)
   Optical microscopy (OM)/ Scanning electron microscopy (SEM)/ Transmission electron microscopy (TEM)

571754 Environmental Effects on Polymer Properties and Behavior **3(3-0-9)**

Condition : Consent of the School

Environmental factors, such as ambient moisture, chemicals (liquid or vapor), exposure to sunlight, high temperatures, hot water and/or steam, bacterial/fungi (underground conditions), and irradiation all tend to attack polymeric materials. Materials may not only change appearance, but have a significant decrease in properties, such as impact and tensile strength. Stability and degradation mechanisms offer the means to better control polymer behavior.

Course Outline

1. Introduction (1 hour)
2. Polymer Structure and Stability (5 hours)
3. Environmental Factors and Their Effects on Polymeric Materials (6 hours)
4. Environmental Stability and Degradation Mechanisms of Polymeric Materials (9 hours)
5. Stabilization of Polymeric Materials against Environmental Effects (6 hours)
6. Environmental Weathering Tests (6 hours)
7. Industrial Aspects of Material Degradation and Its Control (3 hours)

571755 Advanced Mechanics of Fiber-Reinforced Composites **3(3-0-9)**

Condition : Consent of the School

Mathematical analysis and modeling of fiber-reinforced composites: continuous fiber-reinforced lamina, Discontinuous fiber-reinforced lamina, Laminating theories, Failure theories, Environmentally induced stresses in laminates.

Course Outline

1. Lamina Stress-Strain Analysis (3 hours)
2. Effective Moduli of a Continuous Fiber-Reinforced Lamina (5 hours)
3. Strength of a Continuous Fiber-Reinforced Lamina (5 hours)
4. Analysis of a Discontinuous Fiber-Reinforced Lamina (5 hours)
5. Analysis of Laminates (6 hours)
6. Analysis of Failure and Theories (6 hours)
7. Environmental Induced Stresses in Laminates (6 hours)

571756 Advanced Rubber Engineering **3(3-0-9)**

Condition : Consent of the School

Course overview, Perspective in rubber manufacturing, Properties of natural and synthetic rubber, Thermoplastic elastomers, Rubber chemicals and additives, Rubber processing and product design, Mechanical properties, Testing, and analysis, Rubber blends, Waste reduction and disposal.

Course Outline

1. Introduction (1 hour)
2. Perspective in Rubber Manufacturing (2 hours)
3. Properties of Natural Rubber and Synthetic Rubber (5 hours)
4. Thermoplastic Elastomers (6 hours)
5. Rubber Chemical and Additives (5 hours)
6. Rubber Processing and Product Design (5 hours)
7. Mechanical Properties, Testing, and Analysis (5 hours)

8. Rubber Blends (5 hours)
9. Waste Reduction and Disposal (2 hours)

571757 Advanced Plastics Waste management 3(3-0-9)

Condition : Consent of the School

Perspective on the solid waste, Engineering with solid waste management, Plastic waste overview; composition, quantities and disposal alternatives, Plastic waste recycling, Recycling of individual plastics, Plastic aging, Alternative materials for environmental friendly products, Energy from waste.

Course Outline:

1. Introduction: Perspective on The Solid Waste (1 hour)
2. Engineering with Solid Waste Management (8 hours)
3. Plastic Waste Overview: Composition, Quantities and Disposal Alternatives (3 hours)
4. Plastic Waste Recycling (8 hours)
5. Recycling of Individual Plastics (4 hours)
6. Plastic Aging (4 hours)
7. Alternative Materials for Environmental Friendly Products (4 hours)
8. Energy from Waste (4 hours)

571758 Selected Topics in Polymer Engineering I 3(3-0-9)

Condition : Consent of the School

Study of selected topics in particular areas of polymer engineering under supervision of teaching staff or inviting staff(s).

571759 Selected Topics in Polymer Engineering II 3(3-0-9)

Condition : Consent of the School

Study of selected topics in particular areas of polymer engineering under supervision of teaching staff or inviting staff(s).

Advanced Materials and Technology

571760 Nanostructured Metals and Alloys 3(3-0-9)

Condition : Consent of the School

Processing bulk nanostructured metals and alloys; Microstructures; Mechanical Properties and thermal stability; Influence of nanoscale microstructures on mechanical property and failure modes; Deformation mechanisms; Principles and examples of nanostructured materials designing for superior mechanical properties

Course outline

1. Processing of bulk nanostructured metals and alloys (9 hours)
2. Microstructures (3 hours)
3. Mechanical Properties and thermal stability (6 hours)
4. Influence of nanoscale microstructures on mechanical property and failure modes (6 hours)
5. Deformation mechanisms (9 hours)
6. Principles and examples of nanostructured materials designing for superior mechanical properties (3 hours)

571761 Powder Metallurgy **3(3-0-9)**

Condition : Consent of the School

Advanced theory of powder metallurgy; Atomization theory and industrial practice; Consolidation theory of metal powders; Sintering theory and practices; Thermodynamics of sintering atmosphere; Powder metallurgy materials; Design of powder metallurgy processes and parts; Design consideration for the production of powder metallurgy parts; Metallographic interpretation of sintered products; Advanced analytical method for powder metallurgy; Case studies in powder metallurgy; New developments in powder metallurgy processes

Course outline

1. Advanced theory of powder metallurgy (3 hours)
2. Atomization theory and industrial practice (3 hours)
3. Consolidation theory of metal powders (3 hours)
4. Sintering theory and industrial practices (3 hours)
5. Thermodynamics of sintering atmosphere (3 hours)
6. Powder metallurgy materials (3 hours)
7. Design of powder metallurgy processes and parts (3 hours)
8. Design consideration for the production of powder metallurgy parts (3 hours)
9. Metallographic interpretation of sintered products (3 hours)
10. Advanced analytical method for powder metallurgy (3 hours)
11. Case studies in powder metallurgy (3 hours)
12. New developments in powder metallurgy processes (3 hours)

571762 Metal Matrix Composites **3(3-0-9)**

Condition : Consent of the School

Introduction to composites, metal matrix composites, Metal matrices and reinforcing materials; Mechanics of unidirectional and particulate composites, elasticity, viscoelasticity, fiber-reinforced, particulate and porous composites, Fabrication and design; Property assessment, mechanical, physical, electrical and chemical properties; Failure analysis, degradation and damage mechanisms of metal matrix composites; Concept of materials design and recycling

Course Outline

1. Introduction to composites, classification (3 hours)
2. Metal matrices and reinforcing materials (3 hours)
3. Mechanics of unidirectional and particulate composites (9 hours)
4. Fabrication and design (9 hours)
5. Property assessment (6 hours)
6. Failure analysis, degradation and damage mechanism (3 hours)
7. Concept of materials design and recycling (3 hours)

571763 High Performance Metals and Alloys 3(3-0-9)

Condition : Consent of the School

Classification and applications of high performance metals and alloys for extreame environment, elevated temperature mechanical properties, corrosion and oxidation; High performance alloys; Superalloys; Refractory metals and materials; Intermetallics and metal aluminides; Forming technology and coating; Property control for extreame service conditions and case studies

Course Outline

1. Classification and applications of high performance metals and alloys for extreame environment (3 hours)
2. High performance alloys (12 hours)
   - 2.1 High performance steels
   - 2.2 High performance stainless steels
   - 2.3 Titanium alloys
   - 2.4 Nikel-copper and nikel-chromium alloys
3. Superalloys (9 hours)
   - 3.1 Iron-based supperalloys
   - 3.2 Nikel-based supperalloys
   - 3.3 Cobalt-based supperalloys
4. Refractory metals and materials (3 hours)
   - 4.1 Refractory metals (molybdenum, tungsten, niobium, tantalum and rhenium)
   - 4.2 Intermetallics and metal aluminides
5. Forming technology and coating (3 hours)
6. Property control for extreame service conditions and case studies (6 hours)

571764 Metallurgical Design of Steels 3(3-0-9)

Condition : Consent of the School

Characteristic of Steels; Basic sspects of mechanical behaviors of steels; Phase transformation in steel; Effect of alloying element; Metallurgical design of interested steels: High strength steel for automotive application, High strength structural steels, High temperature steels, Multi-phase steels, Special deep-drawing steels, Rail steels and others interested steels

Course Outline

1. Main Characteristic of Steel (3 hours)
2. Mechanical Behavior and Deformation of Steel (6 hours)
3. Phase Transformations in Steel (6 hours)
4. Relation of Alloying Element on Properties of Steel (3 hours)
5. Metallurgical Design of High strength steels for automotive application (3 hours)
6. Metallurgical Design of High Strength Structural Steels (3 hours)
7. Metallurgical Design of High Temperature Steels (3 hours)
8. Metallurgical Design of Multi-Phase Steels (3 hours)
9. Metallurgical Design of Special Deep-Drawing Steels (3 hours)
10. Metallurgical Design of Rail and Others Interested Steels (3 hours)

571765 Technology of Metal Recycling **3(3-0-9)**

Condition : Consent of the School

Wastes in industrial metal processing; Control, elimination and treatment of pollutions and wastes industrial metal processing; Study on metal manufacturing processes for environmental; Study on recycling of metals

Course Outline

1. Emission, pollutions and hazardous wastes in industrial metal processing (6 hours)
2. Control and treatment of wates from industrial metal processing (9 hours)
3. Review of extractive metallurgy (6 hours)
4. Recycling and refining processes (15 hours)
   - 4.1 Iron and steel
   - 4.2 Aluminum
   - 4.3 Copper
   - 4.4 Lead, zinc and tin
   - 4.5 Other interested metals

571766 Advanced Steel Rolling Technology **3(3-0-9)**

Condition : Consent of the School

Fundamental characteristics of steel; Theory of plastic deformation; Calculation of rolling parameters, tribology and heat transfer in rolling processes; Metallurgical aspect of rolling of steel: structural changes, strengthening mechanism and thermomechanical treatment; Rolling mills-operation and control

Course Outline

1. Ironmaking and steelmaking, steel rolling processes (3 hours)
2. Fundamental of physical metallurgy of steel (6 hours)
3. Theory of plastic deformation (3 hours)
4. Calculation of rolling parameters (3 hours)
5. Tribology in the rolling process (3 hours)
6. Heat transfer in rolling mills (3 hours)
7. Microstructural change (3 hours)
8. Strengthening mechanism (3 hours)
9. Thermomechanical treament (3 hours)
10. Rolling mills-operation and control (6 hours)

571767 SurfaceTechnology **3(3-0-9)**

Condition : Consent of the School

Scope and definition of surface technology; Surface characteristics; Tribology and degradation of material surfaces; Various techniques of surface technology; Thermal hardening, Mechanical hardening; Thermochemical treatments; Vapour deposition processes; Ion implantation; Surface engineering by laser beam and electron beam; Coating processes; Characterization of surface engineered materials, case studies of surface engineered materials; Special assignment of selected topics on surface technology

Course Outline

1. Scope and definition of surface technology (1.5 hours)
2. Surface characteristics (3 hours)
3. Tribology and surface degradations (3 hours)

4. Thermal hardening (3 hours)
5. Mechanical hardening (1.5 hours)
6. Thermochemical treatments (6 hours)
7. Vapour deposition processes (6 hours)
8. Ion implantation (3 hours)
9. Surface engineering by laser beam and electron beam (3 hours)
10. Coating processes (3 hours)
11. Characterisation and case studies of surface engineered materials (3 hours)

571768 Laser Materials Processing 3(3-0-9)

Condition : Consent of the School

Fundamental of laser; Interaction of laser and matter; Thermal processes in laser-materials Interactions; Plasma phenomena in laser materials processing; Mechanism during laser materials processing; The development of laser materials processing for future

Course outline

1. Fundamental of laser (6 hours)
2. Interaction of laser and matter (6 hours)
3. Thermal processes in laser-materials Interactions (6 hours)
4. Plasma phenomena in laser materials processing (6 hours)
5. Physical mechanism during laser materials processing (6 hours)
6. The development of laser materials processing for future (6 hours)

571769 Friction Stir Welding Technology 3(3-0-9)

Condition : Consent of the School

Introduction to friction stir welding (FSW) process; FSW process parameters; FSW process modelling; Microstructure evaluations in FSW joints; FSW joint properties; FSW characteristics in engineering materials; Applications and Development of friction stir processing (FSP)

Course outline

1. Introduction to friction stir welding (FSW) (2 hours)
2. FSW Process parameters (4 hours)
3. FSW Process modeling (2 hours)
4. Microstructure evaluations (6 hours)
5. FSW joint properties (6 hours)
6. FSW characteristics in various engineering materials (6 hours)
7. FSW applications (6 hours)
8. Development of friction stir processing (FSP) (4 hours)

571770 Analysis of Die Casting Processes 3(3-0-9)

Condition : Consent of the School

Overview of die casting processes; die casting machine systems; P-Q2 analysis; process control in die casting; gating design and analysis; design of die casting dies; melting and metallurgical control; die casting defects; numerical modeling of die casting processes; simulation of die castings

Course Outline

1. Overview of die casting processes (3 hours)
2. Die casting machine systems (3 hours)
3. P-Q^2 analysis (6 hours)
4. Process control in die casting (3 hours)
5. Gating design and analysis (6 hours)
6. Design of die casting dies (3 hours)
7. Melting and metallurgical quality control (3 hours)
8. Die casting defects (3 hours)
9. Numerical modeling of die casting processes (3 hours)
10. Simulation of die castings (3 hours)

571771 Particulate Engineering 3(3-0-9)

Condition : Consent of the School

Introduction to particulate engineering, Advanced powder processing of metals and ceramics, Theoretical and experimental advances in powder processing**,** Particle size reduction and enlargement, Characterization of mechanical and physical properties of powders, Blending of solid particles, Granulation and scale up, Nanoparticle engineering

Course Outline

1. Introduction to particulate engineering (3 hours)
2. Advanced powder processing of metals and ceramics (5 hours)
   - 2.1 Powder synthesis techniques
   - 2.2 Composite powder synthesis techniques
3. Theoretical and experimental advances in powder processing (4 hours)
4. Particle size reduction and enlargement (6 hours)
   - 4.1 Mechanism of size reduction
   - 4.2 Energy for size reduction
   - 4.3 Methods of operating crushers
5. Characterization of mechanical and physical properties of powders (6 hours)
   - 5.1 Single particles
   - 5.2 Measurement of particle size
   - 5.3 Particle shape analysis
   - 5.4 Surface characterization
   - 5.5 Bulk powder behavior
6. Blending of solid particles (5 hours)
   - 6.1 The degree of mixing
   - 6.2 The rate of mixing
7. Granulation and scale up (3 hours)
8. Nanoparticle engineering (4 hours)

571772 Advanced Ceramic Composite Materials 3(3-0-9)

Condition : Consent of the School

Ceramic matrix composites and applications, advanced manufacturing technology and processes, control parameters, atomic and molecular background, relationships of macro-microstructure to properties of composites in design and fabrication. Also discussed is the methods for property evaluations and material limitations

Course Outline

1. Grain and particle effects on ceramic and ceramic composite properties (10 hours)
   - 1.1 Grain dependence on monolithic ceramic properties
   - 1.2 Dependence of ceramic, especially particulate, composite Properties on grain and particle parameters
   - 1.3 Particle and grain effects on mechanical properties of Composites at elevated temperature
2. Mechanical properties of ceramic matrix composites (8 hours)
   - 2.1 Continuous fiber-reinforced ceramic-matrix composites
   - 2.2 Whisker-,ligament-, and platelet-reinforced ceramic-matrix composite
3. Analysis and performance of fiber composites (10 hours)
   - 3.1 Fiber matrices and fabrication of composites
   - 3.2 Behaviour of unidirectional composite
   - 3.3 Analysis of laminated composite
   - 3.4 Advanced topics in fiber composite
   - 3.5 Performance of fiber composites; fatique, impact and environmental effects
   - 3.6 Experimental characterization of ceramic composites
4. Piezoceramic composites (8 hours)
   - 4.1 Principal objective and design
   - 4.2 Type of composites and connectivity
   - 4.3 Fabrication and applications

571773 Advanced Electrical and Electronic Ceramics 3(3-0-9)

Condition : Consent of the School

Theories and applications of ceramic materials in electrical and electronic fields are discussed. Basic properites and processing methods such as semiconductor IC packaging technology and ceramic substrates are also covered

Course Outline

1. Electroceramics (18 hours)
   - 1.1 Ceramic conductors
   - 1.2 Dielectrics, Relaxors and Insulators
   - 1.3 Piezoelectric ceramics
   - 1.4 Pyroelectric materials
   - 1.5 Electro-optic ceramics
   - 1.6 Fabrication

2. Semiconductor (18 hours)
   2.1 Intrinsic semiconductors and Impurity semiconductors
   2.2 Hall effect and Magnetoresistance
   2.3 Excess carriers in semiconductors
   2.4 Materials Technology and the measurement of Bulk Properties
   2.5 Theory of Semiconductor p-n junctions
   2.6 Unipolar, Bipolar and Photonic Devices

571774 Advanced Magnetic Ceramics 3(3-0-9)

Condition : Consent of the School

Fundamental and advanced topics in magnetic ceramics are discussed to give a more in-depth understanding about magnetism and magnetic ceramic materials. Topics covered include electronic magnetic moments, quantum theory of magnetism magnetic properties, magnetic domains, magneto-optic phenomena, magnetic measurements and types of magnetic ceramic materials (soft and hard ferrites, garnets and ferrites for microwave applications). Manufacturing methods will also be discussed in relation to specific applications

Course Outline

1. Magnetism and magnetic materials ; (2 hours)
   Historical developments and present role in industry and technology
2. Magnetic field, terms and related units; type of magnetism, (6 hours)
   ferromagnetic domains
3. Ferrites for non-microwave applications (5 hours)
4. Microwave ferrites (5 hours)
5. Permanent magnets (8 hours)
6. Ferrite preparation ; powder preparation, compact forming, (10 hours)
   sintering and machining

571775 Advanced Bioceramics 3(3-0-9)

Condition : Consent of the School

Ceramic materials for biological applications including processing and control, material selection, variables that control compatibility and performance of bioceramics such as physical and chemical properties,corrosion or solubility, fatigue and interfacial histochemical changes

Course Outline

1. Introduction (2 hours)
2. Bioinert ceramics (4 hours)
3. Bioactive ceramics ; (14 hours)
   Dense and pororus hydroxyapatite, hydroxyapatite coating,
   composites and bone cement
4. Bioactive glasses (2 hours)
5. Bioactive glass-ceramics (4 hours)
6. Design of bioactive ceramic and polymer systems (3 hours)
7. Characterization of bioceramics (3 hours)
8. Regulation of medicine devices (2 hours)
9. ASTM standards for bioceramics (2 hours)

571776 Advanced Structural Ceramics **3(3-0-9)**

Condition : Consent of the School

Review of processing and control of structural ceramics, oxide and non-oxide systems, designs and applications, advantages and limitations, properties and evaluation of materials

Course Outline

1. Introduction ; overview of structural applications of ceramic materials (2 hours)
2. Structural ceramics ; materials, processing and properties (16 hours)
   - 2.1 Oxide base materials
     - 2.1.1 Aluminosilicates
     - 2.1.2 High alumina
     - 2.1.3 Zirconia
     - 2.1.4 Other oxide ceramics
   - 2.2 Non-oxide base materials
     - 2.2.1 Silicon carbide
     - 2.2.2 Silicon nitride
     - 2.2.3 Sialon
     - 2.2.4 Boron nitride and carbide
   - 2.3 Composites
3. Important mechanical properties , methods of evaluation and control (8 hours)
   - 3.1 Hardness and wear resistance
   - 3.2 Strength and elastic properties
   - 3.3 Toughness
   - 3.4 Fatique under cyclic loading
   - 3.5 High temperature mechanical properties and creep
4. Case study in design and application of structural ceramics (6 hours)
   - 4.1 Ceramic cutting tools
   - 4.2 Wear parts and industrial applications
   - 4.3 Adiabatic diesel engines
   - 4.4 Advanced gas turbines
   - 4.5 Aerospace and defense-related applications
   - 4.6 Heat exchanger
5. Paper(s) and presentation(s) base on application of structural ceramics (4 hours)

571777 Advanced Industrial Glass and Glass Ceramics **3(3-0-9)**

Condition : Consent of the School

Overview of the development of industrial glass and glass-ceramic products in terms of compositions, process design, properties, and applications. The interrelation of glass composition and manufacturing processes will be described based on chemistry and physics. Future development of glass and glass-ceramics is discussed

Course Outline

1. Industrial glass development (2 hours)
2. Special glasses ; properties and composition relations (8 hours)
3. Glass-ceramics ; processes, properties and applications (8 hours)
4. Functional glasses ; porous glass, photosensitive glass, photochromic glass, (10 hours)

solder glass etc., and their applications

5. Ion-exchange processing (3 hours)
6. Sol-gel processing (3 hours)
7. Possibilities of the development of industrial glass and glass ceramics (2 hours)

571778 Advanced Glass Technology 3(3-0-9)

Condition : Consent of the School

Basic and theoretical consideration of thermodynamics and kinetics of glass formation, crystallization and phase separation,glass transformation behavior.The properties and composition relations of glass, and their applications.Advanced instrumental techniques for the determination of glass structure

Course Outline

1. Thermodynamics and kinetics of glass formation and phase separation (12 hours)
2. Glass transformation behaviors (8 hours)
3. Properties and composition relations of glasses and their applications (10 hours)
4. Advanced instrumental techniques for the determination of glass structure (6 hours)

Advanced Topic Courses

571780 Advanced Topics in Computer Aided Engineering 3(3-0-9)

Condition : Consent of the School

Select an advanced topic on the application of computer software aided for thermodynamic calculations or finite element analysis or mathematical analysis. Analytical calculation on a selected topic; Algorithm for computer software calculation; Solving of problems using the selected computer software; Programming of auxiliary programs for the selected computer software

Course Outline

1. Analytical calculation on a selected topic (12 hours)
2. Algorithm for computer software calculation (9 hours)
3. Solving of problems using the selected computer software (9 hours)
4. Programming of auxiliary programs for the selected computer software (6 hours)

571781 Advanced Topics in Metallurgical Engineering I 3(3-0-9)

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of metallurgical engineering and materials

571782 Advanced Topics in Metallurgical Engineering II 3(3-0-9)

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of metallurgical engineering and materials

571783 Advanced Topics in Metallurgical Engineering III 3(3-0-9)

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of metallurgical engineering and materials

571784 Advanced Topics in Ceramic Engineering I **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of ceramic engineering and materials

571785 Advanced Topics in Ceramic Engineering II **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of ceramic engineering and materials

571786 Advanced Topics in Ceramic Engineering III **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of ceramic engineering and materials

571787 Advanced Topics in Polymer Engineering I **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of polymer engineering and materials

571788 Advanced Topics in Polymer Engineering II **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of polymer engineering and materials

571789 Advanced Topics in Polymer Engineering III **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of polymer engineering and materials

571790 Advanced Topics in Materials Engineering I **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of materials engineering

571791 Advanced Topics in Materials Engineering II **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of materials engineering

571792 Advanced Topics in Materials Engineering III **3(3-0-9)**

Condition : Consent of the School

Study of advanced topics or new technology development in various fields of materials engineering

Seminar Courses

571881 Graduate Seminar I **1(1-2-4)**

Condition : Consent of the School

Characteristics of research; Scientific methods; Defining research problem, Research plan, Research hypothesis, Critical evaluation of research; Literature review, Methodologies of research design, Observational and experimental method; Writing of scientific research article; References, format and styles, bibliographic management programs; Presentations of innovative/advanced topics in materials engineering by invited academic speakers, students practice for oral presentation

571882 Graduate Seminar II **1(1-2-4)**

Condition : Consent of the School

Introduction to ethics in scientific research, terminology, moral justifications; Ethical issues before the research commences, Legal issues; Ethical issues during the research; Publication and dissemination of research, plagiarism, expression of academic judgments; Confidentiality and restriction on the use of research data; The role of the researcher and case studies; Presentations of innovative/advanced topics in materials engineering by invited academic speakers, students practice for oral presentation

Master Thesis Courses

571981 Master Thesis Scheme A1 **46 credits**

Condition : Consent of the School

Original research work leading to the preparation of a master thesis in the fulfillment of the master degree requirement in the filed of material engineering.

571982 Master Thesis Scheme A2 **15 credits**

Condition : Consent of the School

Original research work leading to the preparation of a master thesis in the fulfillment of the master degree requirement in the filed of material engineering.

Prerequisite Courses : Nonpolymer Degree Holders

571501 Polymer Science **3(3-0-9)**

Condition : Consent of the School

Classification of polymers, Molecular weights of polymer, Classification of polymerization reactions: step and chain polymerizations, Solid state of polymers Polymer solution, Rubber elasticity, Viscoelasticity, Mechanical behavior, Properties of polymer blends, composites and nanocomposites.

Course Outline

1. Introduction (1 hour)
2. Step Polymerization (4 hours)
3. Chain Polymerization (7 hours)
4. Solid State of Polymers (9 hours)
5. Polymer Solution (3 hours)
6. Cross-linked Polymers and Rubber Elasticity (3 hours)
7. Viscoelasticity (3 hours)
8. Mechanical Behavior of Polymers (3 hours)
9. Multicomponent Polymeric Materials (blends, composites, nanocomposites) (3 hours)

571502 Polymer Engineering and Processing **3(3-0-9)**

Condition : Consent of the School

Understanding polymer processing technology, Extrusion based processes, Molding processes and rubber and composite processes.

Course Outline

1. Polymer Processing Technology (6 hours)
2. Extrusion Based Processes (12 hours)
3. Molding Processes (12 hours)
4. Rubber and Composite Processes (6 hours)