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Indian Institute of Technology Jodhpur

M.Tech. (Metallurgical and Materials Engineering)

Topic Clouds

1. **Metallurgical Thermodynamics and Kinetics**
   - Laws of thermodynamics
   - Thermodynamics of solutions
   - Application of Thermodynamics to Chemical reactions
   - Phase diagrams
   - Thermodynamics of interfaces
   - Diffusion in solids
2. **Characterization of Minerals Metals and Materials**
   - Optical Microscopy
   - Scanning Electron Microscopy
   - Transmission Electron Microscopy
   - Scanning Probe Microscopy
   - Spectroscopic characterization
   - X-Ray Diffraction
   - Electron Diffraction.
   - Thermal Analysis
   - Non-destructive testing of materials
3. **Computational Materials Engineering**
   - First principles calculations
   - Molecular dynamics simulations
   - Alloy Design
4. **Phase Transformations and Solidification**
   - Thermodynamics of phase transformations
   - Solid state phase transformations
   - Solidification process
   - Gating and riser design for casting
   - Nucleation and growth
5. **Material Processing**
   - **Light Metal and Alloys**
     - Processing of light metals and alloys
   - **Additive manufacturing**

- Materials for additive manufacturing
- Additive manufacturing methods
- Structure-property control in additive manufacturing

- **Thermo Mechanical Processing**
  - Principles and applications of thermo- mechanical processing

6. **Microstructure Design and Mechanical Properties**
   - Effect of microstructure on mechanical properties
   - Strengthening mechanisms
   - High Temperature deformation
   - Deformation behavior of ceramics and polymeric materials
   - Theory of fracture mechanics
   - Cyclic deformation of materials
   - Creep-Fatigue interaction
7. **Electrochemistry and Corrosion**
   - Fundamentals of electrochemistry
   - Forms of corrosion
   - Corrosion Prevention methods
   - High temperature oxidation
   - Corrosion monitoring
8. **Ceramics and Composites**
   - Structural Ceramics
   - Processing of ceramics
   - Functional ceramics
   - Metal Matrix Composites
   - Polymer Matrix Composites
   - Ceramic matrix composites

List of Electives

Following is the list of courses that can be offered to M.Tech. Students

(A) ELECTIVE I: Materials Modeling and Simulation

Course Number	***Course Title***	***L-T-P-D***	***Credits***
MT7LXX0	Alloy Design : Computational Thermodynamic approach	3-0-2-0	4

(B) ELECTIVE II: Extractive and Process Metallurgy

Course Number	***Course Title***	***L-T-P-D***	***Credits***
MT7LXX0	Mineral Engineering	3-0-0-0	3
MT7LXX0	Iron and Steel Making	3-0-0-0	3
MT7LXX0	Solidification Processing	3-0-0-0	3
MT7LXX0	Industrial Waste: Control and Utilization	3-0-0-0	3

(C) ELECTIVE III: Metallurgical Manufacturing

Course Number	***Course Title***	***L-T-P-D***	***Credits***
MT7LXX0	Light Metals and Alloys	3-0-0-0	3
MT7LXX0	Near Net Forming	3-0-0-0	3
MT7LXX0	Powder Metallurgy	3-0-0-0	3
MT7LXX0	Thermo Mechanical Processing	*3-0-0-0*	*3*
MT7LXX0	Material Aspects in Additive Manufacturing	3-0-0-0	3

(D) ELECTIVE IV: Physical Metallurgy

Course Number	***Course Title***	***L-T-P-D***	***Credits***
MT7LXX0	Plastic Deformation and Microstructure Evolution	*3-0-0-0*	*3*
MT7LXX0	Corrosion Engineering	*3-0-0-0*	*3*
MT7LXX0	Introduction to Dislocations	3-0-0-0	3
MT7LXX0	Structure-Property-Correlation	3-0-0-0	3
MT7LXX0	Mechanical Behavior of Materials	3-0-2-0	4
MT7LXX1	Electron and Scanning Probe Microscopy	1-0-0-0	1
MT7LXX2	Light Microscopy and Spectroscopic Techniques	1-0-0-0	1
MT7LXX3	Diffraction and Thermal Analysis Techniques	1-0-0-0	1
MT7PXX4	Materials Characterization Laboratory	0-0-2-0	1

(E) ELECTIVE V: Functional Materials and Devices

Course Number	***Course Title***	***L-T-P-D***	***Credits***
MT7LXX0	Ceramics	3-0-0-0	3
MT7LXX0	Composites	3-0-0-0	3
MT7LXX0	Polymers and their composites	3-0-0-0	3
MT7LXX0	Principles of Engineering Material Selection	3-0-0-0	3

DETAILED SYLLABUS FOR THE COMPULSORY COURSES

Title	**Metallurgical Thermodynamics and Kinetics**	**Number**	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–1–0 [4]
Offered for	M.Tech. and Ph.D.	Type	Compulsory
Pre-requisite			

Objectives

1. Provide a basis for describing and understanding the stability of various forms of matter.
2. Provide a basis for predicting the properties of an equilibrated system as a function of its content and characteristics.

Learning Outcomes

1. Establish the conditions for stability of a material and derive its properties.
2. Control the evolution of microstructures with respect to different parameters.

Course Content

Laws of thermodynamics and Chemical reactions (14 lectures)

First, second and third laws (3 lectures)
statistical interpretation of entropy (3 lectures)
Free energy functions and criteria for equilibrium (3 lectures)
reaction equilibrium, equilibrium constant; applications to materials and metallurgical systems (5 lectures).

Thermodynamics of solutions and phase diagrams (14 lectures)

Ideal and non-ideal solutions, partial and molar quantities, quasi-chemical model and regular solutions (3 lectures).
Phase rule and binary phase diagrams (2 lectures),
free energy composition diagrams (5 lectures)
phase equilibrium calculations. (4 lectures)

Thermodynamics of interfaces and kinetics (14 lectures)

Interfaces, surface tension and surface energy (3 lectures)
equilibrium at interfaces, nucleation (3 lectures),
coherency (1 lecture),
thermal activation, diffusion, concentration gradients, thermal gradients (3 lectures)
Fick's laws, mechanisms of interface migration (3 lectures)

Text Books

1. Gaskell, D.R., *Introduction to Metallurgical Thermodynamics*, McGraw-Hill 1995.
2. Swalin, R. A., *Thermodynamics of Solids*, reprint Edition, Wiley, 1962.
3. Balluffi, R. W., Samuel, M. A., Carter, W. C., *Kinetics of Materials*, Wiley, 2005.

Self-Learning Material

1. Bird, R.B., Stewart, W.E. and Lightfoot, E.N., *Transport Phenomena*, Wiley, 1960.
2. Hillert, M., *Phase Equilibria, Phase Diagrams and Phase Transformations Their Thermodynamic Basis,* Second edition, Cambridge University Press 2008.

Title	**Characterization of Minerals Metals and Materials**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–2 [4]
Offered for	M.Tech. 1st Year	Type	Compulsory
Pre-requisite			

Objective

1. Understanding the instruments and methods for characterising different materials and their properties.

Learning Outcomes

1. Basic working principles for various instruments.
2. Choice of characterization methods based on their analysis and performance.

Course Content

MTL7XX1: Electron and Scanning Probe Microscopy [1-0-0]

Introduction: Importance of Characterization of Materials, Structural and Functional Characterizations, Review of Crystallography. *(4 Lectures)*
Electron Microscopies: Scanning Electron Microscopy (SEM) & Transmission Electron Microscopy (TEM). *(7 Lectures)*
Scanning Probe Microscopy: Scanning Tunnelling Microscopy (SEM) & Atomic Force Microscopy (AFM). *(3 Lectures)*

MTL7XX2: *Light Microscopy and Spectroscopic Techniques* [1-0-0]

Light Optical Microscopy: Polarization microscopy for minerals, Phase contrast microscopy for metals, DIC Microscopy and Confocal and other special techniques for polymers and biomaterials. (7 Lectures)
Spectroscopic characterization: UV-VIS-NIR, FTIR, Photoluminescence and Raman Spectroscopy. (7 Lectures)

MTL7XX3: *Diffraction and Thermal Analysis Techniques* [1-0-0]

Diffraction Techniques: X-Ray Diffraction, Electron Diffraction. (10 Lectures)
Thermal Analysis: Thermal Mechanical Analysis (TMA), Differential Scanning Calorimetric (DSC), Thermal Gravimetric Analysis (TGA), Differential Thermal Analysis (DTA). (4 Lectures)

MTP7XX4: *Materials Characterization Laboratory* [0-0-2]

Calculation of thermodynamic parameters using DSC analysis; Functional group analysis using FTIR; XRD Pattern Indexing; Lattice parameter and crystallite size calculation; Electron Diffraction Pattern Indexing; Image Analysis.

Text Books

1. Zhang, S., Li, L. and Kumar, A., *Materials Characterization Techniques*, CRC Press, 2008.

Self-Learning Material

1. Evans, C., Brundle. R. and Wilson, *Encyclopaedia of Materials Characterization: Surfaces, Interfaces, Thin Films (Materials Characterization Series),* Butterworth-Heinemann, 1992.
2. Kaufmann, E.N., *Characterization of Materials, 3 Volume Set, 2nd Edition,* Wiley, 2012.

Online Course Material

1. Shankaran, S., Materials Characterization, Department of Metallurgical & Materials Engineering, Indian Institute of Technology, Madras, NPTEL http://nptel.ac.in/courses/113106034/
2. Biswas, K. and Gurao, N.P., Advanced Characterization Techniques, Department of Materials Science and Engineering, Indian Institute of Technology, Kanpur, NPTEL http://nptel.ac.in/courses/113104004

Title	**Computational Materials Engineering**	**Number**	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–2 [4]
Offered for	M.Tech. and Ph.D.	Type	Compulsory
Pre-requisite			

Objective

1. To understand different modeling and simulations techniques for studying various materials.

Learning Outcomes

1. Student will be able to understand and use the first-principles calculations
2. Student will be able to understand and run the Molecular dynamics simulations

Course Content

First-principles calculations (28 lectures)

Introduction, Density functional theory (5 lectures), Kohn-Sham method (4 lectures), Exchange-correlation energy (2 lectures), Crystal structure (1 lecture), Pseudopotential approach (2 lectures), Bloch's theorem (2 lectures), Structure relaxation (1 lecture), Electronic band structure and density of states (3 lectures), Fermi-Dirac distribution (1 lecture), Smearing methods (1 lectures), Lattice dynamics (1 lectures), Phonon dispersion relations (1 lecture), Force constants (3 lectures), Vibrational thermodynamics (1 lecture)

Molecular dynamics simulations (14 lectures)

Introduction (1 lecture), Potentials (2 lectures), Newtons Equation of motion (2 lectures), Algorithms (2 lectures), Simulation parameters (2 lectures), Types of ensembles (2 lectures), Temperature control and data analysis (3 lectures)

Laboratory Experiments

Preparation of input files, Technical parameters optimization, Structure optimization, Electronic band structure calculation, density of states calculation, metallic system simulation, phonon band structure calculation

Text Books

1. Lee, J., *Computational Materials Science: An Introduction*, 2nd Edition, CRC Press 2016.
2. Sholl, D. S., and Steckel, J. A., *Density Functional Theory: A Practical Introduction*, 1st Edition, Wiley, 2009.
3. Dove, M.T., *Introduction to Lattice Dynamics*, 1st Edition, Cambridge University Press, 1993.

Self-Learning Material

1. Parr, R.G., and Yang, W., *Density-Functional Theory of Atoms and Molecules*, 1st Edition, Oxford Science Publications, 1994.
2. Raabe, D., *Computational Materials Science: The Simulation of Materials, Microstructures and Properties*, Wiley VCH, 1998.

Online Course Materials

MIT open courseware: Gerbrand Ceder, and Nicola Marzari. 3.320 Atomistic Computer Modeling of Materials (SMA 5107). Spring 2005. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA

Title	**Phase Transformations in Solids**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–2 [4]
Offered for	M.Tech. and Ph.D.	Type	Compulsory
Pre-requisite			

Objective

1. Understanding the correlation between the phase diagram and chemical thermodynamics for alloy design.

Learning Outcomes

1. Ability to construct multicomponent phase diagrams using computational thermodynamic approach.
2. Understand the variation of properties with the microstructure evolution during phase transformations.

Course Content

Thermodynamics and kinetics: free energy, order of transformation, driving force, homogeneous and heterogeneous nucleation, growth kinetics, coarsening, precipitation. (8 Lectures)

Interfaces: atomic mechanisms of diffusion, activation energy, interfacial free energy, types of interface (coherent, semi-coherent and incoherent interfaces), interface migration. (6 Lectures)

Austenite, transformation of austenite, TTT diagram, eutectoid transformation, pearlite and bainite transformation. (8 Lectures)

Martensite transformation: characteristics and nature, morphology, crystallography, theory of nucleation and growth, and pre-martensite phenomena, martensitic transformation in steel. (6 Lectures)

Precipitation hardening and spinodal decomposition: Solutionising and ageing, GP zones, intermediate phases and structural changes, spinodal decomposition. (8 Lectures)

Order-disorder transformation: common structures in ordered alloys, variation of order with temperature; determination of degree of ordering, effect of ordering on properties, applications. (6 Lectures)

Laboratory Experiments: Hardenability measurement, Solid-liquid transformation, Activation energy calculation, Heat treatment of ferrous metals, Precipitation Hardening, TTT Diagram construction.

Text Books

1. Raghavan, V., *Solid State Phase Transformations*, 1st edition, Prentice Hall India, 1987.
2. Porter, D.A., Easterling, K. E., and Sherif, M.Y., *Phase Transformation in Metals and Alloys*, 3rd edition, CRC Press, 2009.
3. Abbaschian, R., Abbaschian, L., and Reed-Hill, R. E., *Physical Metallurgy Principles*, 4th edition, Cengate Learning, 2009.

Self-Learning Material

1. Khachaturyan, A.G., *Theory of Structural Transformations in Solids*, 1st edition, Dover publications, 2008.
2. Avner, S.H., *Introduction to Physical Metallurgy*, 2nd edition, McGraw Hill Education, 2017.

Online Course Material:

1. Gururajan, M.P., Phase Transformations and Heat Treatment, Indian Institute of Technology Bombay, NPTEL http://nptel.ac.in/courses/113101003/

SYLLABUS FOR ELECTIVES OFFERED BY
DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING:

Title	**Alloy Design : Computational Thermodynamic Approach**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–2 [4]
Offered for	M.Tech	Type	Elective
Prerequisite			

Objectives

1. Understanding the correlation between the phase diagram and chemical thermodynamics for alloy design.

Learning Outcomes

1. Ability to construct multicomponent phase diagrams using computational thermodynamic approach.
2. Ability to learn the assessment of binary phase diagram using PARROT module.

Contents

1. *Thermodynamics of Solution:* Ideal solution, configurational entropy, regular solution model, chemical potential, free energy composition diagram, evolution of phase diagrams quasichemical theory, Sub regular solution model. (8 Lectures)
2. *Alloy Design of multicomponent system:* Redlitch-kister polynomial, Muggianu and kohler extrapolation. Crystallography in thermodynamics, Order and disorder structure, antisite defect and vacancies. Compound energy formalism. Modeling of Interstitial and substitutional phases, stoichiometric and non-stoichiometric compounds. (14 Lectures)
3. CALPHAD modeling of non - metallic system. Cluster variance model. (6 Lectures)
4. *Calculation of thermodynamic parameters:* First principle calculation, Semi-empirical-Miedema approach. Calorimetric measurement, electrochemical measurement, Diffusion couple method. (8 Lectures)
5. *Assessment of thermodynamic system:* Optimization of binary isomorphous and eutectic phase diagram using PARROT module. (6)

Lab Experiments

Construction of equilibrium and non-equilibrium phase diagram, Vertical section phase diagram and Property diagram for multi-component alloys, Scheil and equilibrium solidification simulation, Liquidus projections and monovariant reactions in ternary phase equilibria, Creation of user defined thermodynamic database for Solid solution, Stoichiometric compounds, non-stoichiometric compounds.

Textbooks

1. Saunders and Miodownik, *CALPHAD (Calculation of Phase Diagrams): A Comprehensive Guide,* 1st Edition, Pergamman Press, 1998
2. Hans Lukas, Suzana G. Fries, Bo Sundman, *Computational Thermodynamics: The Calphad Method,* Cambridge University Press, 2007

Self-Learning Material

1. Porter, D.A., Easterling, K. E., and Sherif, M.Y., *Phase Transformation in Metals and Alloys*, 3rd edition, CRC Press, 2009

Online Course Materials

1. Murty, B.S., Advanced Metallurgical Thermodynamics, NPTEL Course Material, Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, https://nptel.ac.in/courses/113106031/.

Title	**Mineral Engineering**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Pre-requisite			

Objective

1. To introduce the importance of mineral processing and engineering**.**

Learning Outcomes

1. Ability to engineer selective mineral processing.

Course Content

1. *Introduction to Mineral Geology:* Geological formation of minerals. Classification and identification of minerals. (4 lectures)
2. *Introduction to Mineral Engineering:* Various ore dressing methods, their principles and applications. Role of cavitation, Gravity separation, Heap bioleaching, Fundamentals and Plant practices of beneficiation, Surface properties and selective flotation, Mineral Liberation: Random and non-random breakage. (10 lectures)
3. *Mineral Processing:* Solid Liquid and Liquid-Liquid processing methods, gas phase extraction. (8 lectures)
4. *Metal Recovery:* Phase extraction in metal recovery, Recovery of metals from slag waste, Heavy metal removal mechanism. (8 lectures)
5. *Mineral Processing of special materials (from brine and mineral resources), rare earths, vanadium, etc.*(8 lectures)
6. *Characterization techniques in mineral processing:* Rheology studies for flotation slurries.
7. *Simulation and control of column flotation.*(4 lectures)

Text Books

1. Wills, B.A. and Napier-Munn, T.J., Mineral *Processing Technology*, Elsevier Science & Technology Books, 7th Edition, 2006.
2. Subbarao, D.V., *Mineral Beneficiation: A Concise Basic Course*, CRC Press, 2011.
3. Flemings, M.C., *Solidification Processing*, McGraw Hill, 1974.
4. German, R. M., *Powder Metallurgy & Particulate Materials Processing*, Metal Powder Industry, 2005.

Title	**Iron and Steel Making**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective

1. Introduce principles of iron and steel making and the field of special steels.

Learning Outcomes

1. Understand the basics of metallurgy involved in iron and steel making.
2. Describe the overview of processing of iron and steel.

Course Content

1. *Iron making:* sequence of operations, raw materials preparation, thermodynamics and kinetics. (6 lectures)
2. *Blast furnace:* design, internal zones and gas flow, productivity, fuel efficiency, products. (4 lectures)
3. *Sponge Iron making and smelting reduction.* (4 lectures)
4. *Reactions in steel making:* removal of C, Si, Mn, P and S. (8 lectures)
5. *Design and selection of steel making slags and refractories.* (8 lectures)
6. *Steel making:* basic oxygen furnace processes, electric arc furnace and induction furnace steel making. (8 lectures)
7. *Secondary steel making processes, alloy steel making.* (2 lectures)
8. *Special steels and their applications.* (2 lectures)

Text Books

1. Ghosh, A., and Chatterji, A., *Ironmaking and Steelmaking: Theory and Practice*, Prentice-Hall (India), 2008.
2. Chatterjee, A., *Beyond the Blast Furnace*, CRC Press, 1994.
3. Peacey, J.C. and W. G. Davenport, *The Iron Blast Furnace: Theory and Practice*, Pergamon, 1979.

Self-Learning materials

1. *Making, Shaping and Treating of Steel*, Vol.1: Iron Making, 11th Ed., AISE Steel Foundation, 1999.

Online Course Materials

1. Koria, S.C., Steel Making, IIT Kanpur, http://nptel.ac.in/courses/113104059

Title	**Solidification Processing**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective:

1. Treat the fundamentals of liquid to solid transformation and practical implication to practice.
2. Processes such as crystal growth, interface stability, splat cooling, ingot casting shape casting will be dealt with paying particular emphasis to fundamentals of mass transport, heat flow and interface kinetics.

Learning Outcomes

1. Build up knowledge on fundamentals of solidification of metals and alloys and correlating with various casting processes.

Course Content

1. *Casting and related phenomena:* Thermodynamics of nucleation and growth phenomena, crystal growth, grain refinement. (4 lectures)
2. *Solidification process:* heat flow, plain front solidification, cellular solidification, constitutional supercooling, , formation of dendrites, eutectic solidification, monotectic solidification, peritectic growth, effect of pressure on solidification. (14 lectures)
3. *Gating system:* fluid flow, gating and riser design, Adams' and Caine's riser design, fluidity. (8 lectures)
4. *Solidification during welding, Directional solidification and single crystal fabrication*. (8 lectures)
5. *Recent developments:* interface kinetics, interface dynamics, phase selection, microstructure selection. Effect of vibration. Theory convection effects. Multicomponent alloys and numerical techniques. (8 lectures)

Text Books

1. Flemings, M.C., *Solidification Processing*, Mcgraw-Hill Book Company, 1974.
2. Campbell, J., *Complete casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design*, Butterworth-Heinmann, 2015.

1. Minkoff, I., *Solidification and Cast Structure*, Wiley, 1986.

Title	**Industrial Waste: Control and Utilization**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective:

1. Classification of waste products and technological management for their environmental sustainability

Learning Outcomes

1. Differentiate among the different kinds of waste.
2. Find optimum method for waste management.

Course Content

1. *Types of waste:* Solid, Liquid and gaseous (4 lectures)
2. *Sources of waste:* Industrial: Metallurgical, Pharma & Chemical, Electronic, Biological (8 lectures)
3. *Recycling of waste:* Metal Scrap remelting, Extraction of precious and harmful metals from electronic waste, (8 lectures)
4. *Waste to wealth:* Waste for energy, Production of commercial nano particles from waste (8 lectures)
5. *Treatment Storage and Disposal of waste:* Long term storage Land filling, incineration; Short term storage and container materials (8 lectures)
6. *Case Studies:* Nuclear industry, Biomedical industry, Steel industry (6 lectures)

Text Books

1. Pichtel, J., *Waste Management Practices: Municipal, Hazardous, and Industrial,* 2nd edition, CRC Press, 2014.
2. Choudhary, C. K., *Waste management and bioremediation*, Oxford Book Company, 2012.

Self-Learning materials

1. Wong, J. W. C, Surampalli, R. Y., Zhang, T. C., Tyagi, R. D., Selvan, A., *Sustainable Solid Waste Management,* American Society of Civil Engineers, 2016.
2. Ojovan, M. I., *Handbook of Advanced Radioactive Waste Conditioning Technologies*, Woodhead Publishing, 2011.

Online Course Material

1. Dubey, B. K., Electronic Waste Management - Issues and Challenges, Division of Environmental Engineering and Management at Indian Institute of Technology, Kharagpur, NPTEL, https://onlinecourses.nptel.ac.in/noc18_ce07/preview
2. Dubey, B. K., Integrated Waste Management for a Smart City, Division of Environmental Engineering and Management at Indian Institute of Technology, Kharagpur, NPTEL, https://onlinecourses.nptel.ac.in/noc17_ce20/preview
3. Ramachandra, T. V., Municipal Solid Waste Management, Centre for Ecological Sciences, Indian Institute of Science, NPTEL, http://nptel.ac.in/courses/120108005/2#

Title	**Light Metal and Alloys**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective

1. Introduce the prospect of competitive structural materials with high specific strength.

Learning Outcomes

1. Appreciate the role of light metals for energy savings in different applications/sectors.

Course Content

1. *Introduction:* Importance of light metals, overview of light metals production. (4 lectures)
2. *Techniques for melting and solidification:* solidification, grain refinement, casting processes. (6 lectures)
3. *Heat treatment:* grain refinement, strengthening by solid solution, precipitation hardening, dispersion of second phase particles. (8 lectures)
4. *Alloy designations and properties:* specific alloy systems ((a) Al-alloys, (b) Mg-alloys, (c) Ti-alloys). (8 lectures)
5. *Manufacturing and applications:* aerospace, biomedical, automobile, domestic appliances. (8 lectures)
6. *Novel processing methods:* composites, metallic foams, rapid solidification, Quasi crystals, amorphous alloys, mechanical alloying, physical vapor deposition, additive manufacturing. (8 lectures)

Text Books

1. Polmear, I. J., St. John, D., Nie, J. F., Qian, M, *Light Alloys*, 5th edition, Elsevier 2016.
2. Brandes E. A. and Brook G. B., *Smithells Light Metals Handbook*, Elsevier, 1998.

Self-Learning materials

1. Totten G.E. and Mackenzie D.S., *Handbook of Aluminum Vol. 1: Physical Metallurgy and Processes*, CRC Press 2003.
2. Friedrich H.E., and Mordike B.L., *Magnesium Technology*, Springer, 2004.
3. Lütjering G., Williams J.C., *Titanium*, 2nd edition, Springer, 2007.

Title	**Near Net Forming**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective

1. Industrial processing technique of near net forming for their applications.

Learning Outcomes

1. Development of methods used by forging industry.

Course Content

1. *Introduction and Application of Near net forming.*(2 lectures)
2. *Manufacturing:*
    a. *Casting:* Robo-casting, additive manufacturing by 3D printing, investment casting, near net casting, direct coagulation casting, low pressure injection molding, state of the art casting & foam casting. (4 lectures)
    b. Pressure less spark plasma sintering, miniature components sintering near net rolling of soft parts, cross wedge rolling process. (3 lectures)
    c. *Spray forming:* electric arc spray forming, spraying-conform process & thermal spray forming. (3 lectures)
    d. Extrusion, infiltration, compound forming, precise shape forming, isothermal and near isothermal processing, friction stir forming & micro forming. (3 lectures)
    e. *Thixo Methods:* semi-solid processing, thixo-forming, thixo extrusion, shape forming from colloidal processing, polymer impregnation and pyrolysis. (4 lectures)
    f. *Powder methods:* Powder technology & die pressing powders. (3 Lectures)
    g. *Other methods:* Net shaped heaping, laser metal deposition, warm spinning of cast iron, diffusion bonding, explosive welding, micro-forming, micro deep drawing, thermo hydrogen processing, spinning, shear forming and flow forming & bulge forming. (8 lectures)
3. *Materials:* Bimetal, Ti and its composites, Al alloys (Al-Mg, Al-Ti, Al-Si), Ni super alloys, intermetallic porous materials, SiC, etc for different applications. (6 lectures)
4. *Biological applications:* Clinical Therapeutics and Health Monitoring. (3 lectures)
5. *Engineering applications:* Turbine Blade, Thermal coatings and Hollow turbine blades.(3 lectures)

Text Books

1. *Near Net Shape Manufacturing of Metal: A Review of Approaches and Their Evolutions*, Proceedings of the Institution of Mechanical Engineers Part B Journal of Engineering Manufacture, 2017.
2. Grant, P. S., *Spray forming*, Progress in Materials Science, 39, 497-545, 1995.
3. Waterman, N. A., *The Selection of Materials*, Engineering Design, 1982.

Further reading

1. G Giuliano, G., *Superplastic Forming of Advanced Metallic Materials*, Woodhead, 2011.

Course Title	**Powder Metallurgy**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective

1. Understand recent concepts in powder metallurgy and product design parameters.

Learning Outcomes

1. Student will be able to conceptualize the powerful tool of powder metallurgy and directly apply to contemporary products.

Course Content

1. *Introduction and application of powder metallurgy.* (2 lectures)
2. *Powder production:* (8 lectures)
    a. Different production methods namely physical, chemical, mechanical methods.
    b. Single fluid atomization: Rotating electrode atomization, roller atomization, rotating disc atomization.
    c. Two fluid atomization: Gas atomization, water atomization, oil atomization etc.
    d. Reduction methods: Carbonyl process, hydride-dehydride process & electrolytic method.
3. *Powder characterization:* (10 lectures)
   Particle size and Size distribution using sieving, sedimentation method, Andreasen pipette method, size distribution functions like normal distribution, log-normal distribution, Rosin-Rammler distribution, particle shape, shape factors, specific surface area of powder, flow rate, tap density, apparent density, compressibility, pyrophoricity, explosivity and toxicity of powder
4. *Powder compaction:* (4 lectures)
   Die compaction, isostatic pressing, single level and multi-level part compaction, repressing, plane strain compression, powder forging, powder roll compaction and powder extrusion
5. *Sintering:* (10 lectures)
   Theory of sintering practice, types of furnaces and atmosphere control, activated sintering techniques, post-sintering treatments; industrial sintering practice for ferrous and non-ferrous products.
6. *Applications of powder metallurgy:* Self-lubricating bearing, magnetic materials, tungsten carbide tool bits, bearing materials, dispersion strengthen materials for high temperature applications and manufacture of diamond based cutting tools, brake pads, etc. (8 lectures)

Text Books

1. German, R.M., Powder Metallurgy and Particulate Materials Processing, MPIF, 2005Sands, R.L. and Shakespeare C.R., Powder Metallurgy Practice and Applications, Newness
2. Publications, 1970.
3. Upadhyaya, G.S., Powder Metallurgy Technology, Cambridge Press 1996.

Self-Learning materials

1. Masuda, H., *Powder Technology Handbook*, Taylor & Francis 2006.*Powder Metal Technologies and Applications*, Metals Handbook, Vol.7, 9th edition, ASM, 1989.

Online Course Material

1. Schuh, C., 3.044 Materials Processing. Spring 2013. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

Course Title	**Thermo Mechanical Processing**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective

1. Methodology for developing varying microstructures to meet a range of properties for industrial applications.

Learning Outcomes

2. Development of methods using mechanical working and heat treatment effectively.

Course Content

3. *Introduction:* microstructure control, application of heat treatment. (4 lectures)
4. *Effect of mechanical working:* low temperature and dislocation structure, high temperature deformation and sub-structure evolution, concurrent relationship between flow properties and microstructure evolution. (12 lectures)
5. *Principles of thermo mechanical processing (TMP):* single phase versus multi-phase materials, sequencing of mechanical working and heat treatment, concurrent manipulation of microstructure. (14 lectures)
6. *Application of TMP:* deformation induced phase transformation, steel for car body, dual phase and TRIP steel, controlled rolling of HSLA steel, electrical steel, patented steel wire, aerospace applications (Aluminium, Special alloys). (12 lectures)

Text Books

1. Krauss G., *Steels: Processing, Structure and Performance*, ASM Int'l Materials Park, 2005.
2. Verlinden, B., Driver, J., Samajdar, I. and Doherty, R. D., *Thermo-Mechanical Processing of Metallic Materials*, Elsevier, 2007.
3. Krauss G., *Principles of Heat Treatment of Steel*, ASM Intl, 1989.

Suggested References

1. Sakaia, T., Belyakov, A., Kaibyshev, R., Miura, H. and Jonas, J.J., *Dynamic and Post-Dynamic Recrystallization Under Hot, Cold and Severe Plastic Deformation Conditions*, Progress in Materials Science 60, 130-207 (2014).
2. Sherby, O.D., Wadsworth, J., and Nieh, T. G., *Superplasticity in Metals and Ceramics*, Cambridge University Press, 2005.

Web Resources

1. Shekhar, S. and Gaur, A. Fundamentals of Materials Processing (Part- II) Department of Materials Science and Engineering Indian Institute of Technology, Kanpur, NPTEL http://nptel.ac.in/courses/113104075/
2. Gururajan, M.P. , Phase Transformations and Heat Treatment, Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology, Bombay, NPTEL, http://nptel.ac.in/courses/113101003/
3. Schuh, C., 3.044 Materials Processing. Spring 2013. Massachusetts Institute of Technology: MIT Open Course Ware, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

Course Title	**Material Aspects in Additive Manufacturing**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective:

1. Understanding the metallurgical and materials engineering aspects of additive manufacturing.

Learning Outcomes

2. Ability to learn the additive manufacturing process physics to design and fabricate the 3D parts with desired structure and property.

3. Ability to monitor and control the additive manufacturing (AM) process.

Course Content

1. AM Overview : Direct Digital Manufacturing and their importance. Different AM processes and relevant Process Physics. (5 Lectures)
2. AM Powder Production and Characterization: Different Mechanical and Chemical methods, Atomization of Powder, other emerging processes. Performance Evaluation of different processes. Chemical and Microstructural Characterization of powders. (6 Lectures)
3. Transport phenomena model for AM process: Temperature, Fluid Flow and Composition. (6 Lectures)
4. Metallurgical Aspects of AM process: Solidification. Texture. Non-equilibrium Microstructure. Residual stress. Process-Structure-Property relationship (8 Lectures)
5. Process monitoring and Control for AM: Defects, Geometry, Temperature, Composition and Phase Transformation (6 Lectures)
6. Post processing of AM parts: Support material removal. Machining. Heat Treatment. Hot Isostatic Processing. Hybrid manufacturing. (6 Lectures)
7. Applications of Additive Manufacturing: Additive Manufacturing in Aerospace, Automotive, Electronics industries and Biomedical applications. (5 Lectures)

Text Books

1. Gibson I., David W. R., Stucker B., Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer, 2nd Ed. (2015).
2. Chua C.K., Leong K.F. and Lim C.S., Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.

Self-learning Materials

1. Sands, R.L. and Shakespeare C.R., *Powder Metallurgy Practice and Applications*, Newness Publications, 1970.
2. Majumdar J.D. and Manna I., Laser-assisted fabrication of materials, Springer Series in Material Science, 2013.

Title	**Plastic Deformation and Microstructure Evolution**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective

1. Provide background to assess the properties and mechanisms which help in optimizing the plastic deformation of metals over a wide range of service conditions.

Learning Outcomes

1. To provide basic understanding of the reasons that make the metal exhibit variation in deformation and strength for metal forming and applications.
2. Imparting knowledge in metals plastic deformation with respect to their microstructure evolution.

Course Content

1. Deformation behaviour: single crystal vs polycrystalline material, stress-strain curves, geometrically necessary dislocations. (4 lectures)
2. Effect of microstructure on flow properties: Hall-Petch relationship, role of grain-boundaries. (6 lectures)
3. Strengthening mechanisms: solid solution strengthening, precipitation hardening, grain refinement. (10 lectures)
4. High Temperature deformation: creep, super-plasticity, dynamic recovery, recrystallization and grain growth. (12 lectures)
5. Deformation behaviour of ceramics and polymeric materials: ductile ceramics, plasticity in specific ceramics, dislocation activity in ceramics, non-crystalline polymer, crystalline polymer, structure-property relationship in polymers. (10 lectures)

Text Books

1. Dieter, G. E., Mechanical Metallurgy, 3rd Edition, McGraw Hill Book Company, 1986.
2. Courtney, T. H., Mechanical Behaviour of Materials, 2nd Edition, Waveland Pr. Inc., 2005.
3. Shetty, M.N., Dislocations and Mechanical Behaviour of Materials, Prentice Hall India Learning Private Limited, 2013.

Suggested References

1. Honeycombe, R.W.K., The Plastic Deformation of Metals, 2nd Edition, ASM, 1984.
2. Meyers, M. A. and Chawla, K. K., Mechanical Metallurgy, Principles and Applications, Prentice-Hall, Inc 1984.

Online Course Material

1. Bauri, R., Introduction to Materials Science and Engineering, Department of Metallurgical & Materials Engineering, Indian Institute of Technology, Madras, NPTEL http://nptel.ac.in/courses/113106032/
2. Sundararaman, M., Defects in Materials, Department of Metallurgical and Materials Engineering, Indian Institute of Technology, Madras, NPTEL http://nptel.ac.in/courses/113106075/
3. Krystyn van Vliet. 3.22 Mechanical Behavior of Materials. Spring 2008. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

Title	**Corrosion Engineering**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective

1. Introduce the principles of corrosion and its prevention methods.

Learning Outcomes

1. Understand the reasons for material degradation under various environments.
2. Know the methods to minimize/prevent the loss due to corrosion.

Course Content

1. *Thermodynamics and Kinetics:* Causes of corrosion, electrochemical mechanisms, corrosion tendency, electrode potentials, The Nernst Equation, Pourbaix Diagrams, Polarization and Passivation. (8 Lectures)
2. *Forms of corrosion:* Galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, erosion corrosion, stress corrosion, hydrogen damage. (10 Lectures)
3. *Prevention methods:* Materials selection, alteration of environment, design, cathodic and anodic protection, coatings. (6 Lectures)
4. *Corrosion in common metals and alloys:* Iron and steel, Copper and Copper alloys, Aluminum and Aluminum alloys, Magnesium and Magnesium alloys, Titanium and Titanium alloys.(6 Lectures)
5. *Corrosion monitoring :* Destructive and Non-destructive methods (6 Lectures)
6. *High temperature oxidation:* Electrochemical and morphological aspects, oxide defect structure, kinetics, effects of alloying, high temperature materials. (6 Lectures)

Text Books

1. Fontana, M.G., *Corrosion Engineering*, 3rd edition, McGraw Hill, 2017.
2. Revie, W.R. and Uhlig, H.H., *Corrosion and Corrosion Control*, 4th edition, Wiley, 2008.

Online Course Material

1. Natarajan, K.A., Advances in Corrosion Engineering, IISc Bangalore, NPTEL, http://nptel.ac.in/courses/113108051/

Title	**Introduction to Dislocations**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective

1. Give a broad overview of dislocations and their interactions in crystals.

Learning Outcomes

1. The student would know the role of dislocations on properties of materials.

Course Content

1. *Defects in crystals:* types of defects, types of dislocations, methods for observation of dislocations. (4 lectures)
2. *Movement of dislocations:* slip and slip plane, cross-slip and climb. (4 lectures)
3. *Elastic properties of dislocations:* forces on dislocations, stress field and strain energy of a dislocation. (10 lectures)
4. *Dislocations in different crystals:* dislocations in FCC, HCP and BCC metals, and other periodic systems. (10 lectures)
5. *Intersection of dislocations:* Jogs, movement of dislocations containing elementary jog, superjogs, intersection of extended dislocations and extended jogs. (4 lectures)
6. *Multiplication of dislocations:* nucleation, Frank-Reed sources, multiple cross-glide, climb & grain boundary. (5 lectures)
7. *Dislocation arrays and crystal boundaries:* dislocation boundaries, low-angle boundaries & steps in interfaces. (5 lectures)

Text Books

1. Hull, D. and Bacon, D. J., *Introduction to Dislocations*, 4th edition, Butterworth-Heinemann, 2001.
2. Hirth, J. P., and Lothe, J. L., *Theory of Dislocations*, 2nd edition, Krieger, 1982.

Course Title	**Structure-Property-Correlation**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective

1. To understand the structure-property-correlation in materials.

Learning Outcomes

1. To design materials based on their structure for various properties.

Course Content

1. *Structure sensitive properties:* classification, dimensional range of various structural features, interrelationship between different structural parameters, effect of structure on properties. (10 lectures)
2. *Dynamics of microstructure evolution:* evolution at different length scales and its effect on properties, factors influencing the properties, concurrent microstructure evolution and properties. (12 lectures)
3. *Application of structure-property correlation:* influence of different service conditions, effect of alloys systems. (10 lectures)
4. *Computational approaches:* constitutive relationship under dynamic conditions, evolution of concurrent structure and properties.(10 lectures)

Text Books

1. Meyers, M. A., Chawla, K. K., *Mechanical Metallurgy: Principles and Application*, Prentice-Hall, 1983.
2. Mugharabi, H., *Plastic Deformation and Fracture of Materials*, VCH Weinheim, 1993.
3. Krauss, G., *Steels: Processing, Structure, and Performance*, 2nd Edition, ASM International, 2005.

Suggested Reference

1. Krauss, G., *Deformation, Processing, and Structure*, ASM Materials Science Seminar, American Society for Metals, 1984.

Title	**Mechanical Behavior of Materials**	**Number**	MT7XX
Department	Metallurgical and Materials Engineering	L-T-P-D [C]	3–0–2-0 [4]
Offered for	M.Tech. and Ph.D.	Type	Compulsory
Pre-requisite			

Objectives

1. To provide background on the mechanisms of deformation in engineering materials, and on the evolution of material microstructure when subjected to mechanical stress during materials processing and engineering applications

Learning Outcomes

1. Ability to design materials with improved mechanical properties and identify failure mechanisms in materials for engineering applications
2. To measure important mechanical properties and correlate with the microstructure

Contents

Continuum Theory of Deformation: 3D-state of stress and strain, Mohr's Circle, Generalized Hooke's Law and introductory theory of elasticity, stress and strain invariants, Yield Criteria, Yield surface and normality (6 lectures)

Defects in Crystals: Vacancies and interstitials, edge, screw and mixed dislocations, Burgers vector, slip, cross-slip and climb, stress fields around edge and screw dislocations, strain energy of dislocations, dislocation-dislocation interaction: Peach-Koehler force on dislocation, image forces, dislocations in different crystal structures (10 lectures)

Twinning in Crystalline Solids: Deformation twinning, geometry of twin formation, twin shape, stress requirement for twinning, twinning in HCP, BCC, and FCC crystals (4 lectures)

Fracture and Toughening Mechanisms Fatigue: theoretical fracture strength of a material and Griffith's Law, modes of fracture, fracture toughness, G and R-curve, brittle and ductile fracture, toughening mechanisms in metals, ceramics, and polymers (8 lectures)

Fatigue and Creep: Introduction to fatigue, stress and strain-life approach, cyclic stress-strain curve, fatigue crack propagation, high temperature deformation, fatigue-creep interaction (8 lectures)

Deformation of Polymers: Elasticity in dilute and semi-dilute polymer networks, nonlinear elastic deformation, rubber elasticity: Mooney-Rivlin and Ogden models (6 lectures)

Laboratory Experiments

Measurement of uniaxial monotonic stress-strain response of metals, ceramics, and polymers, Measurement of hardness via spherical and Vickers indentation and correlation with yield strength for ductile and brittle materials, The effect of grain size on mechanical properties, The effects of strain rate and temperature on yield strength, Recrystallization of cold rolled metals, Measurement of impact fracture toughness using Charpy/Izod impact test, Fracture surface interpretation, Creep of a 60%Sn-40%Pb Solder wire at room temperature.

Text Books

1. Dieter, G.E. (1986), Mechanical Metallurgy, 3rd Edition, McGraw-Hill Book Company.
2. Courtney, T. H., (2005), *Mechanical Behaviour of Materials*, 2nd Edition, Waveland Press Inc.
3. Shetty, M. N., (2013), *Dislocations and Mechanical Behavior of Materials*, Prentice Hall India Learning Private Limited

Self-Learning Materials

1. Hertzberg, R.W., (1976), *Deformation and Fracture Mechanics of Engineering Materials,* John Wiley and Sons
2. McClintock,F.A., and Argon,A.S., (1966), *Mechanical Behavior of Materials*, Addison-Wesley.

Title	**Ceramics**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective

1. Exposure to range of ceramics and their properties based on structure.

Learning Outcome

1. Selection of ceramics for various applications.

Course content

1. *Introduction to ceramics:* oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, non-stoichiometry and typical properties. (8 Lectures)
2. *Ceramics with special properties:* ductile ceramics, transparent ceramics, single crystal, thick and thin film ceramics, porous ceramics and ceramic membrane. (10 Lectures)
3. *Properties of ceramics:* physical, chemical, mechanical, electrical and optical. (8 Lectures)
4. *Application of different types of ceramics in various industries.* (8 Lectures)
5. *Exotic ceramics:* functionally graded, smart/intelligent, bio-mimetic and nano-ceramics. (8 Lectures)

Text Books

1. Norton, F.H., *Elements of Ceramics*, Addison-Wesley Press, 1952.
2. Barsoum, M. and Barsoum, M.W., *Fundamentals of Ceramics*, CRC Press, 2002.
3. Kingery, W.D., Bowen, H.K., and Uhlmann, D.R., *Introduction to Ceramics*, 2nd Ed., 1976.

Title	**Composites**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective

1. To provide comprehensive background on the processing, properties, and mechanics of deformation of composite materials for engineering applications

Learning Outcome

1. Design and selection of composites for specific applications.

Course content

1. *Introduction and classification of composites:* Composites, matrix, reinforcements metal matrix composites, polymer matrix composites, ceramic matrix composites (6 Lectures)
2. *Manufacturing of Composite Materials:* Manufacturing techniques, Defects in manufactured composites (4 Lectures)
3. *Macro and micromechanics of a lamina:* stress-strain relations for anisotropic and orthotropic materials, lamina in an arbitrary orientation, strengths of an orthotropic lamina, mechanics of materials approach to stiffness and strength, elasticity approach to stiffness (9 Lectures)
4. *Macromechanics of a laminate:* stress-strain relations for a laminate, in-plane and flexural modulus of a laminate, strength of laminates (9 Lectures)
5. *Fracture and Toughening of Composites:* fracture processes in composites, toughening mechanisms in fibre reinforced plastics and ceramic-matrix composites (6 Lectures)
6. *Designing of Composites:* Selection of matrix and reinforcement, Wettability and role of interface (4 Lectures)
7. *Applications of different types of composites in various industries and Emerging trends* (4 Lectures)

Text Books

1. Barbero, E.J., *Introduction to Composite Materials Design*, Second Edition, CRC Press, 2011.
2. Kar, K. K., Composite Materials: Processing, Applications, Characterizations, Springer, 2017.

Course Title	**Polymers and Their Composites**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite	None		

Objective

1. Introduce students to the wide range of polymers and their possible combinations with other materials for getting desired properties.

Learning Outcomes

1. The student will be able to apply the properties of polymers and their composites to construction, transport and storage industries.

Course Content

1. *Introduction:* Classification and synthesis of polymers Basic definitions and nomenclature, molar mass and degree of polymerization, synthesis, glass transition temperature and crystallinity in polymers, structure and its relation to thermal, chemical, electrical and optical properties**.** (8 Lectures)
2. *Mechanical and thermo mechanical characteristics*: General characteristics, viscoelasticity, deformation behavior of elastomers, deformation mechanisms, fractures, and toughened polymers. (8 Lectures)
3. *Polymer processing, characterization and applications*: Introduction, plastics, elastomers and fibers, compounding and processing techniques, practical aspects of polymer blending, standards and engineering applications of polymers. (8 Lectures)
4. *Polymer composites and their applications* (2 Lectures)
5. *Carbon nanomaterials and synthesis*: C-C bonding, types of carbon fullerenes, crystal structure of selected carbon nanomaterials: CNT, graphene, nano crystalline diamond, synthesis by arc discharge, thermal CVD, microwave plasma CVD, Laser ablation; growth mechanism; special synthesis techniques- vertical aligned growth of CNT, selective area growth of CNT, single walled CNT growth, large area graphene synthesis, nano-patterning on graphene (16 Lectures)

Text Books

1. Young, R.J., and Peter A. Lovell, *Introduction to Polymers*, 3rd revised edition, CRC Press, 2011.
2. Rudin, A., *The Elements of Polymer Science and Engineering*, 3rd edition, Academic Press, 2012.
3. Koo, J.H., *Polymer Nanocomposites: Processing, Characterization, and Applications*, McGraw-Hill, 2010.

Online Course Material

1. Adhikari, B., Science and Technology of Polymers, Materials Science Centre, Indian Institute of Technology, Kharagpur, NPTEL, http://nptel.ac.in/courses/113105028/
2. Garg, A., Electro Ceramics, Department of Materials science and Engineering, Indian Institute of Technology Kanpur, NPTEL, http://nptel.ac.in/courses/113104005/

Course Title	**Principles of Engineering Material Selection**	Number	MT7LXX0
Department	Metallurgical and Materials Engineering	L-T-P [C]	3–0–0 [3]
Offered for	M.Tech.	Type	Elective
Prerequisite			

Objective:

1. Develop comprehensive knowledge on the procedure for selection of materials for a wide range of products in engineering applications.

Learning Outcomes

1. Relationship between material properties with product and component design.
2. The methodology of materials selection, use of computer-aided selection and material data and knowledge sources and their usefulness in industry.

Course Content

1. *Importance of materials*: Crystal structure, bonding, processes, and mechanical factors in construction/design. Diffusion in materials and interpretation of phase diagrams. (6 Lectures)
2. *Selection of materials for a specific application depending on the property and performance using CES Selector for materials selection*: A generalized material selection strategy will be introduced together with use of material property charts, computer-aided selection, and case studies. (8 Lectures)
3. *Finding and understanding structured information on materials and processes for material selection*: How to screen information on materials and arrive at a conclusion? How to create hybrid materials with combined properties of two or three materials? (10 Lectures)
4. *Component/structural failures:* Fracture, fatigue, creep, embrittlement, corrosion, etc. Detailed survey of typical real life examples of failures from different applications – lectures and videos. (10 Lectures)
5. *Applications in technological sectors:* Bio-medical, building, high temperature, industrial applications, micro-electronics, packaging, transportation, etc. (8 Lectures)

Text Books

1. Ashby, M.F., *Materials Selection in Mechanical Design*, 4th Edition, Butterworth-Heinemann, 2010.
2. Callister, W. D., *Materials Science and Engineering- An Introduction*, John Wiley & Sons, 1985.

Suggested References

1. Shackelford, J. F., *Introduction to Materials Science for Engineers*, Mac Millan Publishing, 1992.
2. Cottrell, A., *An Introduction to Metallurgy*, Universities Press, 2000.
3. Smith, W. F., *Materials Science and Engineering*, 4th Edition, Tata McGraw Hill, 2008.
4. Van Vlack, L. H., *Elements of Material Science and Engineering*, 6th Edition, Pearson Education, 2006.

Online Course Material

1. Granta Design, CES EduPack Software, 2016.