Revised Curriculum

M.Tech

in

Materials Science and Engineering

Effective from August 2024

DEPARTMENT OF
METALLURGICAL AND MATERIALS ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY TIRUCHIRAPPALLI
TIRUCHIRAPPALLI-620015,
TAMIL NADU, INDIA

VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

To evolve into a globally recognized department in the frontier areas of Metallurgical and Materials Engineering.

MISSION OF THE DEPARTMENT

- To produce Metallurgical and Materials Engineering graduates having professional excellence.
- To carry out quality research having social & industrial relevance.
- To provide technical support to budding entrepreneurs and existing industries

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Pursuing a career in traditional and cutting-edge areas of Materials Engineering and related fields.
PEO2	Enable them to make consistent progress towards a higher degree in Materials Engineering and allied fields.
PEO3	Managing challenging industrial issues and excelling in global industries with strong leadership skills.

PROGRAMME OUTCOMES (POs)

PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

CURRICULUM FRAMEWORK / FLEXIBLE CURRICULUM / NEP 2020 / M.Tech. / M.Arch.

Components	Number of Courses	Number of Credits	Senate Suggestions
Programme Core (PC)	3 / Semester (6 / Year)	44	4 or 3 credits can be the combination of Programme Core (PC) and Programme Elective (PE)
Programme Elective (PE)	3 / Semester (6 / Year)		
Essential Laboratory Requirements (ELR)	2/ Year	4	2 Credits / ELR (If the department opts for 2 Essential Laboratory Requirements (ELR) per year, totalling 4 credits, the remaining 2 credits can be allocated to PC or PE courses)
Internship / Industrial Training / Academic Attachment (I/A)	1	2	-
Open Elective (OE) / Online Course (OC)	2	6	Open Elective (OE) / Online Course (OC) can be completed between 1 – 4 Semester
Project Phase-I	1	12	-
Project Phase-II	1	12	-
Total	**20**	**80**	**-**

CURRICULUM

SEMESTER I

Code	Course of Study	Credit
MA613	Programme Core 1: Engineering Mathematics	4
MT621	Programme Core 2: Thermodynamics and Kinetics	4
MT623	Programme Core 3: Electrical, Magnetic and Optical Materials	4
	Programme Elective I	4
	Programme Elective II	3
	Programme Elective III /Online (NPTEL)	3
MT629	Laboratory I: Materials Characterisation Laboratory	2
		24

SEMESTER II

Code	Course of Study	Credit
MT622	Programme Core 4: Ceramic Science and Technology	4
MT624	Programme Core 5: Polymers and Composites	4
MT626	Programme Core 6: Metallic Materials	4
	Programme Elective IV	4
	Programme Elective V	3
	Programme Elective VI /Online (NPTEL)	3
MT630	Laboratory II: Functional Materials Laboratory	2
		24

SUMMER TERM (evaluation in the III semester)

Code	Course of Study	Credit
MT631	Internship / Industrial Training / Academic Attachment (I/A) (6 weeks to 8 weeks)	2

SEMESTER III

Code	Course of Study	Credit
MT639	Project Work (Phase I)	12

SEMESTER IV

Code	Course of Study	Credit
MT640	Project Work (Phase II)	12

SEMSTER (I-IV)

Code	Course of Study	Credit
MTXXX	Open Elective/Online Course 1	3
MTXXX	Open Elective/Online Course 2	3

PROGRAMME ELECTIVES (PE)

Sl. No.	Code	Course of Study	Credit
PE courses for all MME MTech specializations			
1.	MT661	Physical Metallurgy	4
2.	MT662	Testing, Inspection and Characterisation	4
3.	MT663	Mechanical Behaviour of Materials	3
4.	MT664	Corrosion Engineering	3
5.	MT665	Computational Techniques	3
6.	MT666	Metallurgical Failure Analyses	3
7.	MT667	Surface Engineering	3
8.	MT668	Modeling in Materials Processing	3
9.	MT669	Automotive Materials	3
10.	MT670	Nanomaterials and Technology	3
11.	MT671	Advanced Electrochemical Techniques	3
12.	MT672	Developments in Iron-Making and Steel-Making	3
13.	MT673	Additive Manufacturing	3
14.	MT674	Phase Transformations	3
15.	MT675	Crystallography	3
16.	MT676	Particulate Technology	3
17.	MT677	Process Modeling	3
18.	MT678	Advanced Material Characterisation Techniques	3
19.	MT679	Non-Destructive Testing	3
PE courses for MSE specialization			
20.	MT721	High-Temperature Materials	3
21.	MT722	Biomaterials	3
22.	MT723	Severe Plastic Deformation	3
23.	MT724	Nuclear Materials	3
24.	MT725	Manufacturing Processes	3
25.	MT726	Structure-Property Relations in Nonferrous Metals	3
26.	MT727	Polymer Processing	3

OPEN ELECTIVES (OE) / ONLINE COURSE (OC) (To be completed between I to IV semester)

Sl. No.	Code	Course of Study	Credit
1.	MT761	Design and Selection of Materials	3
2.	MT762	Statistical Quality Control and Management	3
3.	MT763	Intellectual Property Rights	3
4.	MT764	Innovation and Product Development	3
5.	MT765	Energy Storage Systems	3
6.	MT766	Artificial Intelligence in Materials Engineering	3
7.	MT767	Molecular Modeling of Materials	3

OPEN ELECTIVES (OE) (List some courses from Programme Electives that will be Open Electives for other Specialization if it is not offered as Programme Electives for the respective specialization)

Sl. No.	Code	Course of Study	Credit
OE for specialisations other than MSE			
1.	MT721	High-Temperature Materials	3
2.	MT722	Biomaterials	3
3.	MT723	Severe Plastic Deformation	3
4.	MT724	Nuclear Materials	3
5.	MT726	Structure-Property Relations in Nonferrous Metals	3
6.	MT727	Polymer Processing	3

MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Sl. No.	Code	Course of Study	Credit
1.			
2.			

Course Code	**:**	MA613
Course Title	**:**	**Engineering Mathematics**
Type of Course	**:**	PC
Prerequisites	**:**	NA
Contact Hours	**:**	4 (3 L, 1 T)
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students mathematically strong for solving engineering and scientific problems.
CLO2	To train students with mathematical aspects so as to comprehend, analyse, design and create novel products and solution for the real life problems.
CLO3	To familiarize the students with Euler-Lagrange's equation and fundamental concepts in calculus of variations.

Course Content

Partial Differential equations – basic concepts – One dimensional heat flow equation - Two dimensional heat flow equation in steady flow in Cartesian and Polar coordinates.

Calculus of variations - Euler's equation - Variational problems in parametric form - Natural boundary condition – Conditional Extremum - Isoperimetric problems.

Numerical Solution of ODE's – Euler's, Taylor's and Runge Kutta methods – Milne's and Adams' predictor-corrector methods.

Finite difference scheme for elliptic, parabolic, and hyperbolic partial differential equations.

Introduction to Finite Element Method - Rules for forming interpolation functions – Shape functions - Application to fluid flow and heat transfer problems.

References

1.	*Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers, New Delhi, India, 2012.*
2.	*Elsgolts, L., Differential Equations and the Calculus of Variations, Mir Publishers, MOSCOW, 1977*
3.	*Jain, M.K., Iyengar, S.R. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age International (P) Limited, New Delhi, India, 2019.*
4.	*Veerarajan, T., Numerical Methods, Volume III, Tata McGraw Hill Edition, New Delhi, 2009.*
5.	*Reddy, J.N., Introduction to Finite Element Method, Mcgraw Hill, Hightstown, New Jersey, 1993.*
6.	*Desai, C.S. and Abel, J. P., Introduction to Finite Element Method, CBS Publishers & Distributors Pvt Ltd, New Delhi, India, 2005.*

Course Outcomes (CO)

At the end of the course student will be able.

CO1	To identify, formulate and solve engineering problems such as one dimensional and two-dimensional heat transfer problems.
CO2	Formulate and solve variational problems in parametric form, Ostrogradsky equation and isoperimetric problems.
CO3	Compute numerical solution of ordinary differential equations using various numerical techniques.
CO4	Discretize and solving the partial differential equations associated with general engineering problems using finite difference scheme.
CO5	Apply advanced numerical method such as finite element method to solve heat transfer problems.

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MA613	Engineering Mathematics	CO1	To identify, formulate and solve engineering problems such as one-dimensional and two-dimensional heat transfer problems.	H	L	H
		CO2	Formulate and solve variational problems in parametric form, Ostrogradsky equation and isoperimetric problems.	H	L	H
		CO3	Compute numerical solution of ordinary differential equations using various numerical techniques.	H	L	M
		CO4	Discretize and solving the partial differential equations associated with general engineering problems using finite difference scheme.	H	L	H
		C05	Apply advanced numerical method such as finite element method to solve heat transfer problems.	H	L	H

Course Code	**:**	MT621
Course Title	**:**	**Thermodynamics and Kinetics**
Type of Course	**:**	PC
Prerequisites	**:**	Nil
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the principles of thermodynamics and kinetics and illustrate their applications in the design of alloy systems.

Course Content

Introduction to thermodynamics and kinetics – different approaches – emphasis on metallurgical thermodynamics, transport phenomena and applications

Laws of thermodynamics and related applications – concepts of free energy and entropy – criteria for spontaneity

Introduction to solutions – partial molar entities – Gibbs Duhem relations - thermodynamic aspects of metallic solutions and salt melts – Raoult's Law and Henry's Law - regular and quasi chemical models

Thermodynamic aspects of phase diagrams – similarity in thermodynamic approach towards different classes of materials – thermodynamic aspects of defect formation in metals and ceramics – approaches used in chemical modeling

Principles of metallurgical kinetics – reaction rates and reaction mechanisms – overview of mass transfer, heat transfer and fluid flow – related applications in metallurgical processes – role of transport phenomena in mathematical and physical modeling

References

1. Gaskell, David R., 'Introduction to Metallurgical Thermodynamics', McGraw Hill, 1973
2. Mohanty, A. K., "Rate Processes in Metallurgy", Prentice Hall of India (EEE), 2000

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the terminology associated with engineering thermodynamics and have knowledge of contemporary issues related to metallurgical thermodynamics.
CO2	Knowledge of phase equilibria in two-component and multi-component systems Estimate thermodynamic properties of an alloy in solid or liquid state of ideal and real mixture
CO3	Predict the phase transformations in an alloy system with an understanding ofphase diagrams

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT621	Thermodynamics and Kinetics	CO1	Understand the terminology associated with engineering thermodynamics and have knowledge of contemporary issues related to metallurgical thermodynamics.	H	L	M
		CO2	Knowledge of phase equilibria in two-component and multi-component systems Estimate thermodynamic properties of an alloy in solid or liquid state of ideal and real mixture	M	M	H
		CO3	Predict the phase transformations in an alloy system with an understanding of phase diagrams	H	L	H

Course Code	**:**	MT622
Course Title	**:**	**Ceramic Science and Technology**
Type of Course	**:**	PC
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Comprehend the fundamental principles of ceramic materials, including their structure, properties, and processing methods.
CLO2	Recognize and evaluate the advantages and limitations of ceramic materials in various contexts.
CLO3	Apply fundamental knowledge of ceramic materials when selecting appropriate materials for specific engineering applications.
CLO4	Develop expertise in using the fundamentals of ceramic materials to innovate and optimize their use in diverse engineering projects.

Course Content

Ceramics as a class of material, classification of ceramics, bonding and structure of various ceramic materials; crystal structure and defects; chronological developments, structure of silicates; polymorphic transformations, raw materials.

Non crystalline materials - structure, requirement for glass formation, Zachariasen rules, viscosity based transition points, devitrification; glass forming methods; important ceramic systems: one component system- silica; binary and ternary systems. Silicate glasses and glass ceramics.

Powder processing, pre-consolidation - shape forming processes; Fundamental Sintering mechanisms, various advanced sintering techniques; Mechanical behaviour of structural ceramics-Brittleness of ceramics, Concept of fracture toughness and different toughness and strength measurement techniques; Concept of various toughening mechanisms. Thermal properties of ceramics

Electrical, magnetic and optical properties of ceramic materials - emphasis on the effects of composition, microstructure, processing, temperature and atmosphere on these properties, Thin film techniques for electronic applications, growth of single crystals.

Introduction to specific ceramic materials – structure property correlation, processing and applications – Bioceramics and bio-glass, ceramic sensors, cermets, superconducting ceramics, cements, refractories, thermal barrier coatings and other functional coatings.

References

1.	Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006
2.	Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997
3.	Kingery W. D., Bowen, H. K., Uhlhmen D. R., 'Introduction to Ceramics', 2nd Edition,

	John Wiley, 1976
4.	James E. Shelby., 'Introduction to Glass Science and Technology' 2nd Edition, The Royal Society of Chemistry Publications, 2005

Course Outcomes (CO)

At the end of the course, student will be able.

CO1	Recognize and distinguish the structure and properties of different ceramic materials.
CO2	Understand the phase diagrams and comprehend the phase transformations in ceramic materials.
CO3	Understand the testing methods for evaluating the mechanical properties of ceramic materials.
CO4	Understand the electrical, magnetic and optical properties of important ceramic systems.
CO5	Appreciate the properties of ceramic materials for different engineering applications.

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT622	Ceramic Science and Technology	CO1	Recognize and distinguish the structure and properties of different ceramic materials.	H	L	M
		CO2	Understand the phase diagrams and comprehend the phase transformations in ceramic materials.	H	L	H
		CO3	Understand the testing methods for evaluating the mechanical properties of ceramic materials.	H	L	H
		CO4	Understand the electrical, magnetic and optical properties of important ceramic systems.	H	L	M
		CO5	Appreciate the properties of ceramic materials for different engineering applications.	M	H	M

Course Code	**:**	MT623
Course Title	**:**	**Electrical, Magnetic and Optical Materials**
Type of Course	**:**	PC
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Acquire a foundational understanding of the electrical, magnetic, and optical properties of materials.
CLO2	Develop the ability to apply knowledge of materials composition, structure, and environment to properties and applications.
CLO3	Select appropriate materials for various engineering applications based on their electrical, magnetic, and optical properties.
CLO4	Enhance skills in developing materials tailored to specific engineering needs.

Course Content

Review of electrical conduction - resistivity and dielectric phenomena - concept of polarization - effects of composition, frequency and temperature on these properties - discussion on specific materials used as conductors - discussion on specific materials used as dielectrics - dielectric loss, dielectric breakdown - ferroelectricity, piezo and pyroelectricity.

Review of semiconducting materials - the concept of doping - simple and compound semiconductors – intrinsic and extrinsic semiconductors; effect of composition and temperature on properties; operating principles of solid state devices: diodes, transistor, MOSFET.

Introduction to dia, para, ferri and ferromagnetism - hard and soft magnetic materials - iron- silicon alloys – iron, nickel alloys - ferrites and garnets - (Ag - Mn - Al) alloys - (Cu - Ni- Co) alloy - fine particle magnets - applications of hard and soft magnetic materials - Giant magnetoresistance- Nanomaterials, Concept of superconductivity, Types of superconductors, applications.

Review of electronic materials - crystal growth methods forbulk single crystals -FZ method and CZ method- zone melting-refining, New crystal growth methods, synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques – wafer manufacturing and doping, oxidation and nitridation; production of MG silicon and SG silicon

Introduction to electromagnetic radiation, atomic and electronic interactions with electromagnetic radiation, optical properties of metals, optical properties of nonmetals, opacity and translucency in insulators, the colour of materials, applications of optical phenomena-luminescence, photoconductivity, lasers, optical fibres in communications

References

1.	Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.
2.	Pradeep Fuley, Electrical, magnetic, and Optical Materials, 1st edition, CRC Press, 2010
3.	Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New International Publishers, 1997.
4.	Handbook of Electronic and Photonic Materials, Safa Kasap, Peter Capper, Springer,2006
5.	Physics of Materials: Essential Concepts of Solid-State Physics, by Prathap Haridoss, Wiley, 2015

Course Outcomes (CO)

At the end of the course, students will be able

CO1	Understand materials' conducting, semiconducting, superconducting, dielectric, ferroelectric and piezoelectric behaviour.
CO2	Differentiate between diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, and anti- ferromagnetic behavior of materials
CO3	Comprehend the effect of composition, structure and temperature on the properties of the materials.
CO4	Explain the working principles of solid-state devices, etc.
CO4	Describe the interactions of light with materials and its effects at the interface.

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT623	Electrical, Magnetic and Optical Materials	CO1	Understand materials' conducting, semiconducting, superconducting, dielectric, ferroelectric and piezoelectric behaviour.	H	L	L
		CO2	Differentiate between diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, and anti- ferromagnetic behavior of materials	H	L	H
		CO3	Comprehend the effect of composition, structure and temperature on the properties of the materials.	H	L	M
		CO4	Explain the working principles of solid-state devices, etc.	L	H	H
		CO5	Describe the interactions of light with materials and its effects at the interface.	H	M	H

Course Code	**:**	MT624
Course Title	**:**	**Polymers and Composites**
Type of Course	**:**	PC
Prerequisites	**:**	Nil
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the basics of polymers and composites- classifications and their properties and applications.

Course Content

Structure of polymers, characterization and applications of polymers: mechanical behavior of polymers, strengthening of polymers, crystallization and glass transition phenomenon and types of polymers.

Design and selection of plastics, structure property correlation, mechanical properties, degradation, wear and friction, thermal, electrical and optical properties, flammability of plastics and processing of plastics and FRP

Composites: Particle reinforced composites, fiber reinforced composites – influence of fiber length, orientation and concentration. Fiber phase, matrix phase, metal matrix composites, polymer matrix composites, ceramic matrix composites, carbon – carbon composites, hybrid composites and structural composites.

Processing of composites: Processing of MMC, liquid metal infiltration, squeeze casting, stir casting, compo casting, solid state route and diffusion bonding, powder metallurgy route slip casting.

In-situ composites, eutectic alloy composites and directional solidification, constitutional super cooling and deviation from eutectic with variation in volume fraction of hard face, co extrusion of Cu-Nb composites and manufacturing of superconductors, self propagating high temperature synthesis, melt oxidation, precipitation reactions

References

1. *W.D Callister. Jr, Materials Science and Engineering, Wiley India Pvt. Ltd, 2007*
2. *R.J. Crawford, plastics engineering, Pergamon Presss, II edition, 1987*
3. *K.K.Chawala, Cermic Matrix composite Materials, Kluwer Academic Publishers, 2002*
4. *R.J.Young, Introduction to Polymers, Chapman and Hall,,London, 1981*
5. *F.W.Billmeyer, Text book of polymer science, John Wiley &Sons, Newyork,1984*

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Classify different types of polymers and composites and their structure – propertyrelationships
CO2	Understanding the properties of different types of polymers and composites
CO3	Designing and processing new types of polymers and composites

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT624	Polymers and Composites	CO1	Classify different types of polymers and composites and their structure –property relationships	H	L	M
		CO2	Understanding the properties of different types of polymers and composites	H	L	H
		CO3	Designing and processing new types of polymers and composites	M	H	M

Course Code	**:**	MT626
Course Title	**:**	**Metallic Materials**
Type of Course	**:**	PC
Prerequisites	**:**	Nil
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the basics of metallic materials- classifications and their properties and applications

Course Content

Classification of metallic materials - Ferrous and non ferrous.

Ferrous metals and alloys-Introduction to specifications – types of steels, alloy steels, tool steels; stainless steels, HSLA, TRIP steels, TWIP steels. Types of cast irons – compositions, properties and applications, specific heat treatment.

Aluminium and its alloys; physical chemical and mechanical properties, classifications, heat treatable and non heat treatable types - structural features corrosion behaviour; cladding and other methods of corrosion protection. Copper and its alloys, electrical conductivity as influenced by other elements, alloys for high conductivity.

Titanium and its alloys; physical, chemical and mechanical properties of titanium, effect of other elements on its properties, types of titanium alloys, microstructural features, properties and applications.

Magnesium and its alloys; structure, properties and applications of magnesium and some of its alloys; metallurgy of magnesium castings; Lead, tin, zinc, antimony, silver, gold and platinum alloys, relevant phase diagrams and microstructural features, properties and applications

References

1. Avner S. H., 'Introduction to Physical Metallurgy', 2nd Edition, McGraw Hill, 1974
2. Leslie W. C., 'The Physical Metallurgy of Steels', McGraw Hill, 1982
3. Pickering P. B., 'Physical Metallurgy and the Design of Steels', Applied Science Publishers, 1983
4. Brick R. M., Gorden R. B, Phillips A., 'Structure and Properties of Alloys', McGraw Hill, 1965
5. Polmear I. J., 'Light Alloys -Metallurgy of the Light Metals', 3rd Edition, Arnold, 1995

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand major types of special steels such as HSLA, TRIP, Dual and Tool steelsand cast-irons
CO2	Understand the structure and properties of nonferrous metals and alloys
CO3	Identify the phases present in different alloy systems by analyzing the phase diagrams
CO4	Apply the basic principles of ferrous and non-ferrous physical metallurgy for selecting materials for specific applications

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT626	Metallic Materials	CO1	Understand major types of special steels such as HSLA, TRIP, Dual and Tool steelsand cast-irons	H	L	H
		CO2	Understand the structure and properties of nonferrous metals and alloys	H	L	M
		CO3	Identify the phases present in different alloy systems by analyzing the phase diagrams	M	H	M
		CO4	Apply the basic principles of ferrous and non-ferrous physical metallurgy for selecting materials for specific applications	H	L	H

Course Code	**:**	MT629
Course Title	**:**	**Materials Characterization Laboratory**
Type of Course	**:**	Laboratory
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment And End Assessment

Course Learning Objectives (CLO)

CLO1	.To study the microstructures of ferrous materials
CLO2	To study the microstructures of nonferrous ferrous materials
CLO3	Understand the mechanical testing procedures and interpretation of results
CLO4	To learn the principles and application of XRD and SEM

Course Content

List of Experiments

1. Study of metallurgical microscope and sample preparation
2. Microscopic examination of low, medium and high carbon steels
3. Microscopic examination of alloy steels and cast irons
4. Microscopic examination of non-ferrous materials (Magnesium alloys, Aluminiumalloys, Titanium alloys, Copper alloys)
5. Tensile Testing using Hounsfield and UTM
6. Hardness Measurements (Rockwell, Vickers and Brinell)
7. Impact Testing (Izod and Charpy)
8. Determination of crystal structure and lattice parameters from XRD data
9. Crystallite size determination of materials using XRD
10. Fractography using a scanning electron microscope

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Prepare the specimens for metallographic examination with best practice, operate the optical microscope and understand, interpret, and analyze the microstructure of materials.
CO2	Classify the different mechanical testing methods with their inherent merits and limitations.
CO3	Apply various test methods for characterizing the physical properties of materials.
CO4	Recommend materials testing techniques based on required properties, perform basic statistical analysis on data, and summarily present test results concisely.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT629	Metallography, Materials Testing, And Characterization Laboratory	CO1	Prepare the specimens for metallographic examination with best practice, operate the optical microscope and understand, interpret, and analyze the microstructure of materials.	H	H	M
		CO2	Classify the different mechanical testing methods with their inherent merits and limitations.	H	H	M
		CO3	Apply various test methods for characterizing the physical properties of materials	H	H	M
		CO4	Recommend materials testing techniques based on required properties, perform basic statistical analysis on data, and summarily present test results concisely.	H	H	H

Course Code	**:**	MT630
Course Title	**:**	**Functional Materials Laboratory**
Type of Course	**:**	Lab
Prerequisites	**:**	Nill
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous assessment and end assessment

Course Learning Objectives (CLO)

CLO1	To learn various advanced synthesis methods for fabricating functional materials
CLO2	To understand and determine the functional properties of materials using appropriate characterization tools
CLO3	To analyze and interpret the functional properties of materials
CLO4	Perform experiments with best practices and understand the advantages and limitations of different functional materials.

Course Content

List of Experiments

1. Cyclic voltammetry measurements of EDLC (electric double layer capacitor) and pseudocapacitors, and estimation of capacitance
2. Band gap determination of oxide films using UV-visible spectroscopy
3. Ionic conductivity measurement of solid-state electrolytes by electrochemical impedance spectroscopy
4. Development of semiconducting characterisation (Hall/I-V measurements)
5. Electrospinning of triboelectric nanogenerators and testing
6. Development of carbon nanostructured electrodes for supercapacitors
7. Synthesis of 2D materials and MOFs
8. Performance evaluation of metal-ion batteries using galvanostatic charge/discharge studies.
9. Functional group analysis/Wettability analysis of a given material by FTIR spectroscopy/contact angle goniometer
10. 3D Printing of electronic material/bio-materials/energy materials

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Analyze and interpret battery and supercapacitor performance.
CO2	Fabricate materials using various synthesis methods for functional applications.
CO3	Characterize and understand the properties of various functional materials.
CO4	Recommends material synthesis and modification techniques based on desired performance for intended functional applications.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT630	Functional Materials Laboratory	CO1	Analyze and interpret battery and supercapacitor performance.	H	H	M
		CO2	Fabricate materials using various synthesis methods for functional applications.	H	L	M
		CO3	Characterize and understand the properties of various functional materials.	H	M	H
		CO4	Recommends material synthesis and modification techniques based on desired performance for intended functional applications.	H	H	H

Course Code	**:**	MT661
Course Title	**:**	**Physical Metallurgy**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To develop an understanding of the basis of physical metallurgy and correlate structure of materials with their properties for engineering applications.

Course Content

Introduction to structure (atomic structure, micro and macrostructure) and their importance to relate with properties and processing. Overview of engineering alloys and their applications. Details on transformations: Liquid to solid and Solid to solid transformation and their importance in fine tuning the properties of engineering alloy and processing

Diffusion, energetic of solidification Nucleation and growth-dealing homogeneous and heterogeneous nucleation and growth of solids, dendritic growth in pure metals, constitutional super cooling and dendritic growth in alloys.

Phase diagrams – solid solution –types, Hume –Rothery rule. Phase diagrams – Binary-types – Lever rule. Solidification of different types of solid solutions – Iron-Carbon diagram – Effect of alloying element on Iron- carbon diagram. Ternary phase diagrams-Understanding of isotherms and isopleths.

Strengthening mechanisms strengthening by grain-size reduction, solid solution Strengthening, strain hardening, dispersion hardening and other recent modes of hardening. Heat treatment of ferrous alloys; Annealing, Normalising, TTT and CCT diagrams, Hardening – hardenability measurements, tempering. Thermo mechanical treatments. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.

Engineering alloys: Types, composition and processing and their structure -property correlation. Metallurgy of newer alloys (High entropy alloys, intermetallic compounds-Aluminides, silicides,etc)

References

1. Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.
2. William F. Hosford, Physical Metallurgy, Taylor & Francis Group, 2008
3. Raghavan, V., "Physical Metallurgy", Prentice Hall of India, 1985
4. Donald R Askland and Pradeep P Phule "Essentials of Materials Science and Engineering, Baba Barkha NathPrinters, Delhi.
5. William D. Callister Jr., David G. Rethwisch, Materials Science and Engineering: An Introduction, 10th Edition, Wiley India Pvt. Ltd., 2018
6. Vijendra Singh, Physical Metallurgy, Standard Publishers Distributors, 1999 .

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the structures of various engineering alloys and relate to their properties and processing.
CO2	Learn the transformation kinetics and apply in developing microstructure-controlled engineering alloys
CO3	Design and scheduling of heat treatment process for various engineering in order to meet the industrial requirements
CO4	Tailor the engineered alloy with the help suitable strengthening methods
CO5	Know the various newer alloys and their applications and suitably place in different engineering structures

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT661	Physical Metallurgy	CO1	Understand the structures of various engineering alloys and relate to their properties and processing.	H	M	H
		CO2	Learn the transformation kinetics and apply in developing microstructure-controlled engineering alloys	H	M	M
		CO3	Design and scheduling of heat treatment process for various engineering in order to meet the industrial requirements	H	M	M
		CO4	Tailor the engineered alloy with the help suitable strengthening methods	H	M	H
		CO5	Know the various newer alloys and their applications and suitably place in different engineering structures	H	M	H

Course Code	**:**	MT662
Course Title	**:**	**Testing, Inspection and Characterization**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To provide an understanding of the basic principles of various testing, Inspection and characterization tools and use those tools to analyze metallurgical components.

Course Content

Purpose and importance of destructive tests – Concepts, and method of Tensile, hardness, bend, torsion, fatigue and creep testing; Adopting these testing methods as per standards and analysing the outcome of the testing

Purpose and limitations of NDT, Concepts, operating principles, advantages, limitations of liquid penetrant testing and magnetic particle inspection, eddy current testing, ultrasonic testing, radiography. Comparison of NDT methods and selection of NDT methods. Identifying suitable method(s) and analysing the outcome of the testing.

Light optical microscopy, basic principles and special techniques. X-raydiffraction and its applications in materials characterization. Identifying suitable method(s) and analysing the outcome of the testing.

Electron microscopy, Construction, operation and applications of scanning electron microscope (SEM), transmission electron microscope (TEM) along with their attachments like energy dispersive spectroscopy, wavelength dispersive spectroscopy, electron back scattered diffraction. Analysis of the imaging and diffraction results; tomography.

Thermal analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetry and dilatometry.

References

1.	*Suryanarayana A.V.K., 'Testing of Metallic Materials', 2nd edition, B S Publications, 2018.*
2.	*Non-destructive testing, B.Hull And V.John, Springer-Verlag New York Inc., 2012.*
3.	*Modern Physical Metallurgy and Materials Engineering, R. E. Smallman, R. J. Bishop, sixth edition, Butterworth- Heinemann, 1999.*
4.	*Materials Characterisation, P.C.Angelo, Cengage Learning India Pvt. Ltd., 2016.*

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Know various destructive testing methods of materials and analysing its results
CO2	Know various non-destructive testing methods of materials and analysing its results
CO3	Understanding the basic characterization techniques like OM and XRD and also understanding which technique can be used in a specific requirement
CO4	Understanding the advanced microscopic characterization techniques SEM, TEM, EBSD and also understanding which technique can be used in a specific requirement
CO5	Evaluate the specimen by thermal analysis and dilatometry

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT662	Testing, Inspection And Characterization	CO 1	Know various destructive testing methods of materials and analysing its results	M	H	H
		CO 2	Know various non-destructive testing methods of materials and analysing its results	M	H	M
		CO 3	Understanding the basic characterization techniques like OM and XRD and also understanding which technique can be used in a specific requirement	H	H	H
		CO 4	Understanding the advanced microscopic characterization techniques SEM, TEM, EBSD and also understanding which technique can be used in a specific requirement	H	H	H
		CO5	Evaluate the specimen by thermal analysis and dilatometry	H	H	H

Course Code	**:**	MT663
Course Title	**:**	**Mechanical Behaviour of Materials**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concepts on materials failure and fracture analysis of materials and to design new materials that can with stand catastrophic failures at different environment

Course Content

Definition of stress, strain, transformation of coordinate systems, tensor notations, relationship between stress and strain in elastic materials, concept of principal stress and principal strain, stress invariants, modulus, Hook's law and understanding of stiffness and compliance tensors, elastic anisotropy,

Yield criteria, equivalent stress and plastic strain, Theoretical shear of perfect crystal, Mohs circle, concept of dislocations and dislocation theory, edge and screw dislocations, dislocation interactions, kink and jog, sessile and glissiles, partial dislocations, dissociation of dislocations, Thomson tetrahedral, Lomer-Cottress barriers.

Strengthening mechanisms, work hardening, solid solution strengthening, grain boundary strengthening, particle hardening, polymer elasticity and viscoelasticity, types of reinforcements and their influence, types of composites, high temperature degradation, creep and stress rupture, deformation mechanism maps, superplasticity and hot working.

Hardness, types of hardness measurements, comparison among hardness methods and scales, nanoindentation, compression testing, comparison between tension and compression studies of materials, shear testing, shear modulus, torsion and twist.

Fatigue of materials, S-N curves, life data presentation, influence of stress, linear elastic fracture mechanics in fatigue, crack growth studies, Paris law, metallurgical aspects of fatigue failures, concepts of remedial measures, creep-fatigue interaction, theoretical strength, Griffith equation, Brittle fracture, ductile fracture, fracture maps

References

1. Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988
2. Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979.
3. Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984
4. Thomas H. Courtney, "Mechanical Behavior of Materials", 2nd Edition, 2013, Overseas Press India Private Limited, ISBN : 81-88689-69-6
5. Norman E. Dowling, "Mechanical Behavior of Materials", International Editirion (4th), Contributed by K. Sivaprasad and R. Narayanasamy, 2013, Pearson

Education Limited. ISBN : 13:978-0-273-76455-7

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the relationship between stress and strain
CO2	Understand the yielding behavior and dislocation influence on plastic deformation
CO3	Understand the various strengthening mechanisms and high temperature deformation
CO4	Understand testing methods like hardness, compression, and fatigue.

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT663	Mechanical Behavior of Materials	CO1	Understand the relationship between stress and strain	H	L	H
		CO2	Understand the yielding behavior and dislocation influence on plastic deformation	H	L	M
		CO3	Understand the various strengthening mechanisms and high temperature deformation	H	L	H
		CO4	Understand testing methods like hardness, compression, and fatigue.	H	L	M

Course Code	**:**	MT664
Course Title	**:**	**Corrosion Engineering**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To provide a practical knowledge about corrosion and its prevention in engineering field.

Course Content

Principles of corrosion phenomenon: Thermodynamics and kinetics: emf/galvanic series, Pourbaix diagram, exchange current density, passivity, Evans diagram, flade potential.

Different forms of corrosion: atmospheric/uniform, pitting crevice, intergranular, stree corrosion, corrosion fatique, dealloying, high temperature oxidation-origin and mechanism with specific examples.

Corrosion testing and monitoring: Non-Elecrochemical and Electrochemical methods: weight loss method, Tafel Linear polarization and Impedance techniques, Lab, semi plant & field tests, susceptibility test.

Corrosion prevention through design, coatings, inhibitors, cathodic, anodic protection, specific applications, economics of corrosion control.

Corrosion & its control in industries: Power, Process, Petrochemical, ship building, marine and fertilizer industries. Some case studies-Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers.Corrosion auditing in industries, Corrosion map of India.

References

1. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.
2. Jones.D.A. Principles and Prevention of Corrosion, 2nd Edition, Prentice Hall, 1996.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Do electro and electroless plating of Cu, Al alloys
CO2	Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion

	using color indicator method
CO3	Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking.
CO4	Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT664	Corrosion Engineering	CO1	Do electro and electroless plating of Cu, Al alloys	H	L	H
		CO2	Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using color indicator method	M	H	M
		CO3	Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking	H	M	H
		CO4	Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness	H	H	H

Course Code	**:**	MT665
Course Title	**:**	**Computational Techniques**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To become familiar with experimental design and analysis of variance
CLO2	To understand finite difference method to solve complex heat transfer problems
CLO3	To learn the finite element method to simulate various manufacturing processes
CLO4	To learn the basics of machine learning techniques and how to use it in materials engineering

Course Content

Computational Techniques: Introduction, importance, applications; Various techniques, Modeling and simulation, Introduction to ICME (integrated computational materials engineering)

Design of Experiments: Introduction, Basic Concepts, Analysis of Variance (ANOVA), Factorial Design, Taguchi, Response Surface Methodology

Finite Difference Method: Introduction, Mathematical formulation, Solving steady state and transient one dimensional and two-dimensional heat transfer problems

Finite Element Method: Introduction, fundamentals, applications; solving heat transfer and fluid flow problems. Simulation of manufacturing processes.

Machine learning: Introduction, fundamentals, supervised learning – classification and regression, unsupervised learning, semi-supervised learning; usage of machine learning techniques in materials engineering

References

1.	Jiju Antony, Design of Experiments for Engineers and Scientists, 3rd Edition, Elsevier, 2023.
2.	Douglas C. Montgomery, Design and Analysis of Experiments, 8th edition, John Wiley & Sons, Inc., 2012
3.	S.V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 2009.
4.	Tirupathi Chandrupatla, Ashok Belegundu, Introduction to Finite Elements in Engineering, 5th Edition, Cambridge University Press, 2022.
5.	John D. Kelleher, Brian Mac Namee, and Aoife D'Arcy, Fundamentals of

	Machine Learning for Predictive Data Analytics, 2nd edition, MIT Press, 2022

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	To choose a suitable computational technique for solving different engineering problems
CO2	To use analysis of variance and design of experiments for any engineering applications
CO3	To solve heat transfer problems using finite difference method
CO4	To perform manufacturing simulations using finite element method
CO5	To identify the suitable machine learning techniques for solving materials engineering related problems

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT665	Computational Techniques	CO1	To choose a suitable computational technique for solving different engineering problems	M	L	M
		CO2	To use analysis of variance and design of experiments for any engineering applications	M	L	H
		CO3	To solve heat transfer problems using finite difference method	M	M	H
		CO4	To perform manufacturing simulations using finite element method	H	L	H
		CO5	To identify the suitable machine learning techniques for solving materials engineering related problems	H	M	H

Course Code	**:**	MT666
Course Title	**:**	**Metallurgical Failure Analysis**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To highlight factors governing the failure of materials and types of failures, to evaluate the mechanisms and environmental effects associated with failure and to identify various failures in heat treatment and deformation processing, and methods to prevent them.

Course Content

Aims of failure analysis, general procedures of failure analysis. Important factors causing the premature failure of metallic components and structures., classification of failure sources: Design deficiencies, material deficiencies, processing deficiencies, assembly errors, service conditions, neglect and improper operation. Methods and equipment for failure analysis, Sample selection and treatment, equipment for materials examination, materials analysis equipment for failure analysis, commonly used NDT methods.

Fractography. Types of failures: ductile, brittle, fatigue, creep, corrosion, wear.
Fatigue failures, fractography, effect of variables: part shape, type of loading, stress concentration, metallurgical factors, etc. Wear failures, adhesive, abrasive, erosive, corrosivewear. Corrosion failures, types of corrosion: uniform, pitting, selective leaching, intergranular, crevice, etc. Elevated temperature failures, creep, thermal fatigue, microstructural instability, oxidation.

Failure mechanisms. Embrittlement phenomena. Environmental effects.

Failures due to faulty heat treatments. Failures in metal forming and welding.

Case studies in failure analysis and prevention of failures.
.

References

1. Failure Analysis of Engineering Materials, 1st Edition - Charles R. Brooks, Ashok Choudhury, published by Mc Graw-Hill Professional, 2001.
2. Metallurgical Failure Analysis: Techniques and Case Studies, 1st Edition Kannadi Palankeezhe Balan, published by Elsevier, 2018.
3. Failure Analysis: Fundamentals and Applications in Mechanical Components - Jose Luis Otegui, Springer, 2016.
4. Failure Analysis Case Studies: A Source Book of Case Studies Selected from the

Pages of Engineering Failure Analysis 1994 -1996 - D.R. H. Jones published by Peragmon, 1998.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	The ability to identify the types of failures in engineering components under service
CO2	Able to determine fracture toughness of ductile and brittle materials
CO3	Knowledge of the tools and techniques to perform failure analysis
CO4	Ability to perform fractographic analysis after various failures
CO5	The ability to identify different failure mechanisms resulting from manufacturing Processes
CO6	Able to analyse the failures with the help of case studies and suggest prevention methods for failure

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT666	Metallurgical Failure Analysis	CO1	The ability to identify the types of failures in engineering components under service	L	M	H
		CO2	Able to determine fracture toughness of ductile and brittle materials	M	H	L
		CO3	Knowledge of the tools and techniques to perform failure analysis	L	H	M
		CO4	Ability to perform fractographic analysis after various failures	H	M	L
		CO5	The ability to identify different failure mechanisms resulting from manufacturing Processes	H	L	M
		CO6	Able to analyse the failures with the help of case studies and suggest prevention methods for failure	M	L	H

Course Code	**:**	MT667
Course Title	**:**	**Surface Engineering**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To analyse the various concepts of surface engineering and comprehend the design difficulties

Course Content

Introduction tribology, surface degradation, wear and corrosion, types of wear, roles of friction and lubrication- overview of different forms of corrosion, introduction to surface engineering, importance of substrate

Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes -industrial practices

Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electrocomposite plating, electroless plating of copper, nickel-phosphorous, nickel-boron; electroless composite plating; application areas, properties, test standards (ASTM) for assessment of quality deposits.

Definitions and concepts, physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemical vapour deposition (CVD), metal organic CVD, plasma assisted CVD, specific industrial applications

Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, D- Gun and high velocity oxy-fuel processes, laser surface alloying and cladding, specific industrial applications, tests for assessment of wear and corrosion behaviour.

References

1. Sudarshan T S, 'Surface modification technologies - An Engineer's guide', Marcel Dekker, Newyork, 1989
2. Varghese C.D, 'Electroplating and Other Surface Treatments - A Practical Guide', TMH, 1993

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Define different forms of processing techniques of surface engineering materials

CO2	Know the types of Pre-treatment methods to be given to surface engineering
CO3	Select the Type of Deposition and Spraying technique with respect to the application
CO4	Study of surface degradation of materials
CO5	Asses the surface testing methods and Comprehend the degradation properties

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT667	Surface Engineering	CO1	Define different forms of processing techniques of surface engineering materials	H	L	H
		CO2	Know the types of Pre-treatment methods to be given to surface engineering	H	L	H
		CO3	Select the Type of Deposition and Spraying technique with respect to the application	H	L	H
		CO4	Study of surface degradation of materials			
		CO5	Asses the surface testing methods and Comprehend the degradation properties	H	H	M

Course Code	**:**	MT668
Course Title	**:**	**Modeling in Materials Processing**
Type of Course	**:**	PE
Prerequisites	**:**	NIL
Contact Hours	**:**	Three hours per week
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn principles of physical and mathematical modeling
CLO2	To gain experience in solving simple non-linear equations
CLO3	To gain hands-on experience in using software packages
CLO4	To familiarize with various modeling methods and strategies

Course Content

Overview of Physical and Mathematical modeling principles, advantages and limitations

Physical modeling pricinples – Similarity criteria, Hot and Cold models, Pilot scale models, Dimensional Analysis, case studies related to steelmaking processes.

Mathematical modeling principles – Static vs dynamic models, Goals and Strategies, Turbulent and multiphase flows, Coupled phenomena, Governing equations, boundary conditions, overview of solution methodologies, Boussinesq approximation, convergance criteria, numerical stability criteria, steady and transient problems, heating of slab example, Monte Carlo Simulation.

Introduction to CFD software (ANSYS Fluent and open source softwares) – CAD geometry building, solution and postprocessing exercises – Practise problems – 2D laminar pipe flow and 2D plane channel turbulent flow, near wall treatment, validation with benchmark cases,

Mathematical modeling of industrial processes – Mixing behavior in Ladle (batch process), Residence time distribution in tundish (continuous process), Continuous casting process complexities, Alloy melting, Mass balance model of a gas circuit in DR process, Kinetic modeling of ladle refining process, Thermal and Mechanical Simulation of welding processes.

References

1. Szekely J., Themelis N. J., ‘Rate Phenomena in Process Metallurgy’, Wiley, 1971
2. Dipak Mazumdar and James W. Evans, ‘Modeling of Steelmaking Processes’, CRC Press, 2009
3. S. K. Dutta, ‘Fundamental of Transport Phenomena and Metallurgical Process Modeling’, Springer, 2021
4. ‘CFD Modeling and Simulation in Materials Processing’, Proceedings of

Symposium held during TMS 2012, Annual Meeting and Exhibition, Orlando USA.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	To assess the similarity criteria to build valid physical models
CO2	To formulate the appropriate building blocks of mathematical models
CO3	To solve set of non-linear equations iteratively without and with the use of softwares
CO4	To visualise modeling of complex industrial scale processes in material processing

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT668	Modeling in Materials Processing	CO1	To assess the similarity criteria to build valid physical models	M	L	M
		CO2	To formulate the appropriate building blocks of mathematical models	H	M	H
		CO3	To solve set of non-linear equations iteratively without and with the use of softwares	M	L	M
		CO4	To visualise modeling of complex industrial scale processes in material processing	H	H	H

Course Code	**:**	MT669
Course Title	**:**	**Automotive Materials**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To impart the knowledge in auto mobile materials and to equip the students to meet the demands of automobile engineering.

Course Content

Otto cycle, diesel cycle, working principle and constructional details of two stroke and four stroke engine, carburetor, fuel feed systems, mechanical and electrical pumps. Petrol injection. Working principle of compression ignition engine, diesel injection systems, recent trends in engine technology

Engine cylinder: Structure and functions, types, cylinder blocks materials and manufacturing processes, improving engine components with surface modifications, Piston: Structures and functions, types, piston materials, piston manufacturing processes

Structure, function and materials for piston rings, camshaft, valves and valve seats, valve springs, connecting rod, crankshaft, turbocharger and exhaust manifold; ULSAB initiative from steel industry; tailor welds.

Types of chassis layout and chassis materials, vehicle frames, materials used for car body, front axle and steering system, drive line, propeller shaft, universal joints, wheels and suspension system.

Environmental impact of emissions from IC engines, Catalyst: catalysts for petrol engines, structures and functions, catalyst to reduce NOx, controlling pollution at cold start, On-board diagnosis. Exhaust gas treatment for diesel engine: particulate filters, regenerative methods, expendable catalyst additive, deNox catalyst.

References

1. Ganesan.V, Internal Combustion Engines, Tata-McGraw Hill Publishing Co., New Delhi, 1994.
2. Hiroshi Yamagata, The Science and Technology of Materials in Automotive Engines, Woodhead Publishing in Materials, 2005.
3. Hajra Choudhury, Elements of Workshop Technology, Vol-I and Vol-II Asia Publishing House, 1996.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the fundamentals of automobile engineering and different components in automobile
CO2	Describe the importance and reasons for using different types of material used in automobiles
CO3	Understand future challenges and expectations in automobile engineering.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT669	Automotive Materials	CO1	Understand the fundamentals of automobile engineering and different components in automobile	H	L	H
		CO2	Describe the importance and reasons for using different types of material used in automobiles	H	H	H
		CO3	Understand future challenges and expectations in automobile engineering.	H	L	H

Course Code	**:**	MT670
Course Title	**:**	**Nanomaterials and Technology**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To know the fundamental concepts of nanomaterials, synthesizing methods, their properties at nanosclae and possible technological applications in various fields of science and engineering

Course Content

Concept of nano materials – scale / dimensional aspects, Top-down and bottom-up approaches for preparing nano materials

Advantages and limitations at the nano level – thermodynamic aspects at the nano level, health and environmental issues.

Characterization of nano materials and nano structures, important characterization techniques for nano size measurement.

Overview of properties of nano materials, Introduction to nano composites, processing of nanocomposites.

Applications in different areas such as semiconductors, sensors, nanostructured bioceramics and nanomaterials for drug delivery, Energy related, fuel cells, Photocatalysis applications

References

1. Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd., 2007
2. Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt. Ltd., 2005.
3. Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology", Wiley, 2003.
4. Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the concepts of nanomaterials and their properties
CO2	Learn different routes of synthesizing methods of nanomaterials
CO3	Know the change in properties at the nanoscale level and their applications
CO4	Understanding the risks on producing nanomaterials and safety precautions.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT670	Nanomaterials And Technology	CO1	Understand the concepts of nanomaterials and their properties	H	L	H
		CO2	Learn different routes of synthesizing methods of nanomaterials	H	M	M
		CO3	Know the change in properties at the nanoscale level and their applications	H	L	H
		CO4	Understanding the risks on producing nanomaterials and safety precautions.	M	L	M

Course Code	**:**	MT671
Course Title	**:**	**Advanced Electrochemical Techniques**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To learn basic concepts of electrodes, electrolytes, electrode potentials and reference electrodes
CLO2	To learn fundamental principles of electrode-electrolyte interface and electrode kinetics
CLO3	To learn and understand DC and AC electrochemical techniques
CLO4	To learn underlying mechanisms, applications of different electrochemical techniques

Course Content

Thermodynamic and Transport properties of electrolytes - aqueous and molten; solution models: Debye-Hückel (aqueous), Temkin (molten salts); electrode potentials (the underlying physics, i.e., electron excess or electron deficiency on the electrode); emf series (aqueous and molten salts); reference electrodes (thermodynamics and kinetics)

Fundamental aspects of electrochemical processes – Electrode-electrolyte interface, nature of the double layer; kinetics of electrode processes, charge transfer at the electrode/electrolyte interface, cell potential, current distribution and analytical techniques

DC methods such as cyclic voltammetry, linear sweep voltammetry, intermittent titration techniques, potentiodynamic polarization, chronopotentiometry, chronoamperometry, galvanostatic cycling with potential limitation

AC methods, i.e., AC voltammetry and electrochemical impedance spectroscopy, including fitting and analysis of equivalent circuits.

Electrochemical mechanisms involved in electrocatalysis, general & localized corrosion and energy systems. Application of techniques in various fields – corrosion & surface engineering, energy conversion & storage devices like fuel cells, supercapacitors, batteries etc., electrochemical processing of materials such as winning, refining, plating, synthesis and electrochemical recycling.

References

1. Bard, A. J., and L. R. Faulkner. Electrochemical Methods. 2nd Edition. New York: Wiley, 2004.
2. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.

3. Crompton R.G., Batchelur-Mculey C., Dikinson E. J. F., Understanding Voltammetry. Imperial College Press, 2012.
4. Barsoukov E., McDonald J.R., Impedance Spectroscopy Theory, Experiment, and Applications, Wiley-Interscience, 2nd Edition, 2005.
5. Shriram S, Kandler S, Jeremy N, Gi-Heon K, Ahmad P, Matthew K, Design and Analysis of Large Lithium-Ion Battery Systems, Artech House, 2014.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Asses electrode & electrolyte properties, electrode potentials and distinguish different reference electrodes
CO2	Explain importance of electrode-electrolyte interface and kinetics occurring at the interfaces
CO3	Analyze and apply different DC and AC electrochemical techniques
CO4	Explain mechanisms involved and applications of different electrochemical techniques

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT671	Advanced Electrochemical Techniques	CO1	Asses electrode & electrolyte properties, electrode potentials and distinguish different reference electrodes	H	L	M
		CO2	Explain importance of electrode-electrolyte interface and kinetics occurring at the interfaces	H	M	H
		CO3	Analyze and apply different DC and AC electrochemical techniques	H	H	M
		CO4	Explain mechanisms involved and applications of different electrochemical techniques	M	L	M

Course Code	**:**	MT672
Course Title	**:**	**Developments in Iron-Making and Steel-Making**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To study the concepts and various processing techniques involved in the field of iron and steel making.

Course Content

Principles of ferrous process metallurgy; review of related concepts from metallurgical thermodynamics and kinetics; sequence of operations in steel
plants; basic aspects of furnaces, refractories and fuels; differences between the production of carbon steels and highly alloyed steels

Overview of iron making, steel making, refining and continuous casting processes; indicative process calculations; environmental considerations; quality issues in steel plant operations

Modifications of steel making converter operations; developments such as sub lance and dynamic control of steel making, secondary treatment including ladle metallurgy and injection metallurgy; continuous steel making; illustrative numerical problems

Modifications of continuous casting process; developments such as flow control devices in tundish, sequence casting, high speed casting, detection / prevention of caster breakouts, electromagnetic stirring, thin slab casting; strip casting; illustrative numerical problems

Current research on metallurgical slags, measurement of critical properties, use of process modeling; design and selection of slags and refractories; discussion on related binary and ternary phase diagrams

References

1. Current literature on related topics.
2. Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004 (primary text).
3. Bashforth G.R, 'Manufacture of Iron and Steel', Volume I - IV, Asia Publications, 1996.
4. B. Deo, R. Boom, 'Fundamentals of steel making metallurgy', Prentice Hall International, New York, 1993 (primary reference).
5. Continuous casting – Vol. 1, 'Chemical and Physical Interactions during transfer operations', Iron and Steel Society, Warrendale, PA, USA, 198.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the basics of metallurgy involved in iron and steel making
CO2	Describe the overview of processing of iron and steel
CO3	Understand the recent developments, modifications, and applications in the iron and steel making process and apply them in real time problems associated with the making of iron and steel industry

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT672	Developments in Iron-Making and Steel-Making	CO1	Understand the basics of metallurgy involved in iron and steel-making	H	L	H
		CO2	Describe the overview of processing of iron and steel	M	H	M
		CO3	Understand the recent developments, modifications, and applications in the iron and steel-making process and apply them in real time problems associated with the making of iron and steel industry	H	M	H

Course Code	**:**	MT673
Course Title	**:**	**Additive Manufacturing**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To know the principal methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies. .
CLO2	To be familiar with the characteristics of the different materials those are used in Additive Manufacturing

Course Content

Overview – History – Need-Classification -Additive Manufacturing Technology in product development-Materials for Additive Manufacturing Technology – Tooling – Applications.

Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology: CAD model preparation – Part Orientation and support generation – Model Slicing –Tool path Generation – Softwares for Additive Manufacturing Technology: MIMICS, MAGICS.

Classification – Liquid based system – Stereolithography Apparatus (SLA) - Principle, process, advantages and applications – Solid based system –Fused Deposition Modeling Principle, process, advantages and applications, Laminated Object Manufacturing, Wire Arc Additive Manufacturing

Selective Laser Sintering – Principles of SLS process – Process, advantages and applications, Three-Dimensional Printing – Principle, process, advantages and applications- Laser Engineered Net Shaping (LENS), Electron Beam Melting.

Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing-Computer Aided Tissue Engineering (CATE) – Case studies

References

Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Upon completion of this course, the students can able to compare different methods and discuss the effects of the Additive Manufacturing technologies.
CO2	Analyse the characteristics of the different materials in Additive Manufacturing.
CO3	Select the appropriate techniques according to the applications.

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT673	Additive Manufacturing	CO1	Upon completion of this course, the students can able to compare different methods and discuss the effects of the Additive Manufacturing technologies.	H	L	H
		CO2	Analyse the characteristics of the different materials in Additive Manufacturing.	M	H	H
		CO3	Select the appropriate techniques according to the applications	M	L	H

Course Code	**:**	MT674
Course Title	**:**	**Phase Transformations**
Type of Course	**:**	PE
Prerequisites	**:**	Physical Metallurgy
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To become familiar with various phase transformation processes and their influence on structure-property correlations
CLO2	To understand the classical nucleation theory and different modes of solidification
CLO3	To develop a comprehensive understanding on Fe-Fe3C Phase diagram and Time–Temperature Transformation diagram and study their structural transformation with varying temperature
CLO4	To study the kinetics and mechanism of solid-solid phase transformation and understand the structure –property relation

Course Content

Introduction to phase transformations & classification. Diffusion in solids: phenomenological approach and atomistic approach. Nucleation and growth theories of vapour to liquid, liquid to solid, and solid to solid transformations, Partitionless solidification

Homogeneous and heterogeneous strain energy effect during nucleation; Thermodynamics of solidification, evolution of microstructures in pure metals and binary alloys.

Precipitation from solid solution: types of precipitation reactions, crystallographic description of precipitates, precipitation sequence and age hardening, Precipitate coarsening, spinodal decomposition.

Iron-carbon system: Thermodynamics of peritectic, eutectic, and eutectoid transformations. nucleation and growth of equilibrium phases and non-equilibrium transformations. Diffusion less transformation.

Interface-controlled growth and diffusion-controlled growth;Kolmogorov-Johnson-Mehl-Avrami (KJMA) kinetics, TTT and CCT diagrams, precipitate coarsening

References

1. Porter, D.A, Easterling, K.E., and Sherif, M.A., Phase transformations in metals and alloys, 3rd Ed, CRC press, 2017.
2. Reza Abbaschian, Robert E. Reed-Hill, Physical Metallurgy Principles, Cengage Learning, 2008
3. Lakhtin Y., 'Engineering Physical Metallurgy', 2nd Edition, University Press of the Pacific, 2000
4. Prabhu Dev K. H., 'Handbook of Heat Treatment of Steel', McGraw Hill Education, 2003

5. Avner S.H., 'Introduction to Physical Metallurgy', 2nd edition, Tata McGraw Hill, 1984

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	To understand the nucleation and growth theories relevant to phase transformation
CO2	To understand the evolution of microstructures in pure metals and binary alloys.
CO3	To understand the different mechanisms of phase transformation (diffusion, diffusionless, massive, spinodal decomposition).
CO4	To apply the TTT and CCT diagrams to design a heat treatment cycle for a given alloy.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT674	Phase Transformations	CO 1	To understand the nucleation and growth theories relevant to phase transformation	H	L	M
		CO 2	To understand the evolution of microstructures in pure metals and binary alloys.	H	L	H
		CO 3	To understand the different mechanisms of phase transformation (diffusion, diffusionless, massive, spinodal decomposition).	H	L	H
		CO 4	To apply the TTT and CCT diagrams to design a heat treatment cycle for a given alloy.	H	H	L

Course Code	**:**	MT675
Course Title	**:**	**Crystallography**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To become familiar with basics of crystal systems and lattices.
CLO2	To get adapted with various crystallographic symmetries, point groups and space groups and also understand the correlation between symmetry and properties
CLO3	To get acquainted with different types of solid solutions and other compounds
CLO4	To become familiar with crystallographic defects and their interactions and understand how defects determine the properties

Course Content

Motif, lattices, lattice points, lattice parameter, Crystal systems, 14 Bravais lattices, Coordination number, number of atoms per unit cell, packing factor, Miller indices of planes directions, repeat distance, linear density packing factor along a direction, planar density, planar packing fraction

Symmetry and crystallography. Symmetry in crystals. Rotational symmetry, stereographic projections. Crystallographic point groups, micro translations, symmetry of reciprocal lattice, systematic absences, space groups special position.

Radius ration for coordination number 2,4,6,8. Interstitial solid solution, Interstitial compounds. AX, AX2, AB03 A 2B04 crystal structures.

Frenkel- Schottky ionic defects, Ionic defect concentration, solute incorporation, electronic defect electronic defect concentration

Band Gap, density of states, defects. Defects and chemical reaction.

References

1. Christopher Hammond, The Basics of Crystallography and Diffraction, Oxford Science Publications, third edition, 2009
2. Donald R. Askeland and Pradeep phule, The science and Engineering Materials.Thmson,2003
3. Cullity B.D., Elements of X-ray diffraction, Addison-Wesley Publishing company 1956

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	To distinguish different crystal structure and their characteristics
CO2	To understand the different symmetry in the crystal systems and their importance
CO3	To identify and characterize the various ionic and electronic defects in crystal structure
CO4	To demonstrate the importance of band gap and density of states in material properties.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT675	Crystallography	CO 1	To distinguish different crystal structure and their characteristics	H	L	H
		CO 2	To understand the different symmetry in the crystal systems and their importance	H	L	H
		CO 3	To identify and characterize the various ionic and electronic defects in crystal structure	H	H	L
		CO 4	To demonstrate the importance of band gap and density of states in material properties.	H	M	M

Course Code	**:**	MT676
Course Title	**:**	**Particulate Technology**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the importance non-conventional processing routes for different materials and its importance for advanced materials manufacturing.

Course Content

Introduction to particulate /powder processing: Historical development, merits, and limitations of this process over other conventional manufacturing methods and applications of particulate processing. Stages of powder metallurgy process in design and manufacturing of full shape components

Attributes of powders: Chemical purity, microstructure, size & distribution, shape, surface area, bulk properties (powder density: apparent density, tap density, flow rate, compressibility, Standards for powder characterizations, procedure, and analysis of powder characteristics, Relate the powder attributes in components manufacturing

Particulates / powders fabrication methods: Mechanical methods, Chemical methods, and Physical methods., Customizing process parameters to tailor the powders, Advances in powder manufacturing methods. Powders for specific engineering applications such as additive manufacturing, automobile, magnetic materials, etc.

Shaping and Compaction: Binder assisted pressure less compaction (Slip & slurry casting, extrusion, and injection moulding), precursor preparation and mould design.

Pressure assisted compaction: Selection of press and die design, pressure selection upon density, selection of lubrications (both internal and externals) Understanding compaction mechanism and measure the green density and strength, relate green density with pressure and strength. Compaction methods: Die compaction, high velocity compaction, warm compaction, powder rolling, Alternative new pressing technologies, Pressure, and temperature assisted powder consolidation: Hot pressing, spark plasma sintering, etc.

Sintering: Fundamental, Sintering theory, sintering diagrams, Effect of compaction on sintering, Sintering types and variables, Solid state sintering, Liquid phase sintering, Sintering equipment and practical sintering operations, Full density methods, Spray forming methods

Finishing operation / post-sintering processes: Repressing, machining, heat treatment, etc. Inspection methods and characterization of sintered components (microstructure, porosity, density, mechanical properties, etc.)

Applications: Structural components, Friction materials, Wear resistant materials, Magnetic materials, etc.

New development in particulate technology.

References

1. German R.M., 'Powder Metallurgy Science', Metal Powder Industries Federation, New Jersey, 1994
2. Kuhn H. A. and Alan Lawley, 'Powder Metallurgy Processing - New Techniques and Analysis', Oxford IBH, Delhi, 1978.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs.
CO2	Characterize the various powders (materials) based on the engineering applications Differentiate the processing routes for various powders (materials) and associated technology.
CO3	Define modern day processing routes and apply them successfully to materials processing.
CO4	Apply the powder metallurgy concepts to design new materials for advanced engineering materials.
CO5	Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce other techniques.

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT676	Particulate Technology	CO1	Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs.	H	L	H
		CO2	Characterize the various powders (materials) based on the engineering applications Differentiate the processing routes for various powders (materials) and associated technology.	H	H	M
		CO3	Define modern day processing routes and apply them successfully to materials processing.	H	M	H
		CO4	Apply the powder metallurgy concepts to design new materials for advanced engineering materials.	M	L	H
		CO5	Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce other techniques.	M	L	H

Course Code	**:**	MT677
Course Title	**:**	**Process Modeling**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To provide an understanding of the basic principles of modelingand use those methods to analyze and solve metallurgical Processes

Course Content

Mathematical modeling, physical simulation, advantages and limitations; process control, instrumentation and data acquisition systems

Review of transport phenomena, differential equations & numerical methods; concept ofphysical domain and computational domain, assumptions and limitations in numerical solutions, introduction to FEM & FDM, examples

Introduction to software packages– useful websites and generic information about different products - ANSYS, Thermocalc, CFD; usage of expert systems, artificial intelligence and robotics; demonstration of some software packages

Physical modeling – cold and hot models; case studies of water models, use of computers for the construction of phase diagrams, alloy design, crystallography, phase transformations and thermo chemical calculations.

Case studies from literature – pertaining to modeling of solidification / heat transfer, fluidflow, casting, welding and liquid metal treatment

References

1. Szekely J., Themelis N. J., 'Rate Phenomena in Process Metallurgy', Wiley, 1971
2. P.S. Ghosh Dastidar, "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill, New Delhi, 1998

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the capabilities provided by various modeling methods
CO2	Analysis methods and apply the appropriate ones to solve real problems

CO3	Gain hands-on experience in using software packages.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT677	Process Modeling	CO1	Understand the capabilities provided by various modeling methods	H	L	M
		CO2	Analysis methods and apply the appropriate ones to solve real problems	H	M	H
		CO3	Gain hands-on experience in using software packages.	M	L	H

Course Code	**:**	MT678
Course Title	**:**	**Advanced Material Characterization Techniques**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To become familiar with advanced microscopy techniques
CLO2	To understand application of various advanced microscopy techniques in materials engineering
CLO3	To understand the post processing of results from various advanced characterization techniques

Course Content

Electron back scattered diffraction –working principle, imaging, post-processing and orientation analysis, application

Transmission kikuchi diffraction -working principle, imaging, post-processing analysis, application, TKD vs EBSD, TKD vs TEM, TKD vs APT

Aberration-corrected Transmission electron microscopy –basic principle, construction and operation, high resolution imaging, applications

X-ray microscopy -principle, construction and operation, sample preparation, application and limitations, X-ray tomography

Atom probe tomography –principle, construction and operation, sample preparation, IVAS software, post processing and 3D construction, application and limitations

References

1.	Micheal K Miller Richard G. Forbes, Atom probe tomography: The local electrode atom probe, Springer New York, 2014.
2.	Chris Jacobsen, X ray Microscopy, Cambridge University Press, 2019
3.	Adam J. Schwartz, Brent L. Adams, Mukul Kumar, Electron Back Scattered diffraction in Material Science, 2nd Edition, Springer 2010
4.	Glenn C. Sneddon, Patrick W. Trimby, Julie M. Cairney, Transmission Kikuchi diffraction in a scanning electron microscope: A review, Material Science and Engineering R: Reports, 2016
5.	C. Barry Carter and David B Williams, Transmission Electron Microscopy: Diffraction, Imaging and spectrometry, Springer 2016

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand the working principle of various advanced characterization techniques
CO2	To choose a characterization technique to analyze various features of materials at sub-micro scale
CO3	To interpret results of advanced characterization techniques

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT678	Advanced Material Characterization Techniques	CO1	To understand the working principle of various advanced characterization techniques	H	L	H
		CO2	To choose a characterization technique to analyze various features of materials at sub-micro scale	H	L	H
		CO3	To interpret results of advanced characterization techniques	H	L	H

Course Code	**:**	MT679
Course Title	**:**	**Non-Destructive Testing**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To impart the knowledge in Non Destructive Testing with case studies.

Course Content

Visual Inspection- tools, applications and limitations. Liquid Penetrant Inspection - principles, types and properties of penetrants and developers. Advantages and limitations of various methods of LPI. Magnetic particle inspection- principles, instrumentation, applications, advantages and limitations.

Ultra sonic testing(UT) - Nature of sound waves, wave propagation - modes of sound wave generation - Various methods of ultrasonic wave generation, types of UT, Principles, instrumentation, applications, advantages, limitations, A, B and C scan - Time of Flight Diffraction (TOFD).

Radiography testing (RT) – Principles, instrumentation, applications, advantages and limitations of RT. Types and characteristics of X ray and gamma radiation sources, Principles and applications of Fluoroscopy/Real-time radioscopy - advantages and limitations - recent advances.

Eddy current testing - Principles, types, instrumentation, applications, advantages and limitations of eddy current testing.

Acoustic emission testing - Principles, instrumentation, types of signals and noises, applications, advantages and limitations of acoustic emission testing.

Thermography - Principles, types, applications, advantages and limitations. Optical & Acoustical holography- Principles, types, applications, advantages and limitations. Case studies: weld, cast and formed components.

Application of Industrial Internet of Things (IIoT) on NDT inspections.

References

1. Practical Non – Destructive Testing, Baldev raj, Narosa Publishing House(1997).

2. Non-Destructive Testing, B.Hull and V.John, Macmillan (1988)
3. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, 3rd edition, New York, Springer-Verlag (1983).

Course Outcomes (CO)
At the end of the course, students will be able to

CO1	Understand the basics of Non destructive testing
CO2	Describe the overview of Non destructive testing methods
CO3	Understand the recent developments, modifications, and applications in Non destructive testing and apply them in real time problems associated with failure analysis and regular quality testing for industries

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT764	Non-Destructive Testing	CO 1	Understand the basics of Non destructive testing	H	L	H
		CO 2	Describe the overview of Non destructive testing methods	H	H	L
		CO 3	Understand the recent developments, modifications, and applications in Non destructive testing and apply them in real time problems associated with failure analysis and regular quality testing for industries	H	M	H

Course Code	**:**	MT721
Course Title	**:**	**High-Temperature Materials**
Type of Course	**:**	PE/OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To study the high temperature sustainability of various materials in critical high temperature applications.

Course Content

Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate

Design of transient creep, time hardening, strain hardening, expressions for rupture life for creep, ductile and brittle materials, Monkman - Grant relationship

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage, ductile fracture due to microvoid coalescence - diffusion controlled void growth; fracture maps for different alloys and oxides

Oxidation, Pilling-Bedworth ratio, kinetic laws of oxidation - defect structure and control of oxidation by alloy additions - sulphation, hot gas corrosion deposit, modified hot gas corrosion, effect of alloying elements on hot corrosion, Borides, silicides and High temperature coatings.

Iron base, nickel base and cobalt base superalloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase - embrittlement, solidification of single crystals

References

1. Raj R, 'Flow and Fracture at Elevated Temperatures', American Society for Metals, 1985
2. Hertzberg R. W, 'Deformation and Fracture Mechanics of Engineering Materials', 4th Edition, John Wiley, 1996
3. Courtney T.H, 'Mechanical Behaviour of Materials', McGraw Hill, 1990

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Describe the basic mechanism of high temperature deformation and Understand the details of creep deformation mechanisms
CO2	Analyze the fracture phenomenon in various materials in high temperature failures Study the high temperature behaviour of superalloys
CO3	Apply basic understanding of high temperature phenomenon like oxidation and hot corrosion in identifying suitable materials for specific high temperature applications
CO5	Design new materials for high temperature applications

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT721	High-Temperature Materials	CO1	Describe the basic mechanism of high temperature deformation and Understand the details of creep deformation mechanisms	H	M	H
		CO2	Analyze the fracture phenomenon in various materials in high temperature failures Study the high temperature behaviour of superalloys	H	M	L
		CO3	Apply basic understanding of high temperature phenomenon like oxidation and hot corrosion in identifying suitable materials for specific high temperature applications	H	L	H
		CO4	Design new materials for high temperature applications	M	M	H

Course Code	**:**	MT722
Course Title	**:**	**Biomaterials**
Type of Course	**:**	PE/OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To provide a fundamental understanding of various materials, including metallic, ceramic, polymeric, composite, and biological materials, and their characteristics in both in-vitro and in-vivo..
CLO2	Students will learn to critically analyze and evaluate different biomaterials' in-vitro and in-vivo properties, including their application in biomedical contexts.
CLO3	This course aims to equip students with a foundational knowledge of bone biology and tissue engineering, providing a basis for understanding how these principles apply to developing and using biomaterials.
CLO4	The course will introduce students to the ethical considerations in biomaterials research, helping them understand and navigate the complex ethical landscape of developing and using biomaterials.

Course Content

Introduction to biomaterials; need for biomaterials; Salient properties of important material classes; Property requirement of biomaterials; Metallic implant materials, ceramic implant materials, polymeric implant materials, composites as biomaterials; Orthopedic, dental and other applications.

Biomaterials preparation and characterization; Processing and properties of different bioceramic materials; Mechanical and physical properties evaluation of biomaterials; New and novel materials for biomedical applications. Design concept of developing new materials for bio-implant applications; Nanomaterials and nanocomposites for medical applications;

Concept of biocompatibility; cell-material interactions and foreign body response; assessment of biocompatibility of biomaterials; In-vitro and In-vivo evaluation; Dissolution study, cytotoxicity test, cell adhesion test; Antibacterial assessment: Kirby– Bauer disc diffusion method or antibiotic sensitivity test and spread plate method.

Biomaterials for drug delivery, timed release materials; biodegradable polymers; Blood compatible materials; Biomimetics; Bone biology: bone architecture, collagen, osteoblasts, osteoclasts, etc; Protein mediated cell adhesion;

Introduction to tissue engineering; Applications of tissue engineering; Biomaterials world wide market, technology transfer and ethical issues; Standards for biomaterials and devices.

References

1. Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005.
2. Hench L. Larry, & Wilson J., (Editors), An Introduction to Bioceramics, World Scientific, 1994.
3. Publised Literature: Highly cited research and review papers and recently published papers in high impact factor journals

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the synthesis and processing methods for producing the different biomaterials and their properties.
CO2	Know the advantages and disadvantages of different biomaterials and select materials for different applications.
CO3	Characterize the biomaterials for their physicochemical properties and analyze the cell-material interactions
CO4	Design new biomaterials for different biomedical applications.

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT722	Biomaterials	CO1	Understand the synthesis and processing methods for producing the different biomaterials and their properties.	H	L	H
		CO2	Know the advantages and disadvantages of different biomaterials and select materials for different applications.	H	L	H
		CO3	Characterize the biomaterials for their physicochemical properties and analyze the cell-material interactions	M	M	M
		CO4	Design new biomaterials for different biomedical applications.	H	M	H

Course Code	**:**	MT723
Course Title	**:**	**Severe Plastic Deformation**
Type of Course	**:**	PE/OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To know the concepts of Severe Plastic Deformation and methods. Applying them to the conventional and advanced materials to achieve nano/ultrafine grain structure for various structural applications.

Course Content

Basics of plastic deformation – Mohr's circle – yield theories – plastic stress – strain relationship – plastic work – constitute relationships – mechanical working – work hardening.

Analysis – slab analysis – upper and lower bound theorem – exact solutions – slip line field theory and its solution – numerical methods and FEM.

Severe plastic deformation by ECAP – types – microstructural variation with different processing routes – multichannel ECAP – strain distribution and texturing.
SPD by ARB, HPT, Multiaxialnforging, CBS, cryo rolling – process – types – microstructural variation with stress – strain distribution.

SPD by mechanical alloying – introduction – types of equipment – compaction – sintering – HIP, SIS – mechanism of sintering.

References

1. Hosford W.F. and Caddell R.M. "Metal forming mechanics and metallurgy", Printice Hall 1983.
2. Altan T, Metal forming: Fundamentals and Applications (ASM Series in Metal processing)
3. Dieter, "Mechanical Metallurgy", Mc Graw Hill Publishers, NY,2002
4. Aliofkhazraei (Ed), "Handbook of Mechanical nanostructuring" Contributed by .B.Ravisankar, Wiley- VCH Publishers, Germany, 2015.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Apply the concept of plastic deformation for metals and alloys

CO2	Differentiate the various methods of severe plastic deformation and choose the appropriate one for required engineering applications
CO3	Analyze various operational and materials parameters influencing the final structure and properties of the materials

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT723	SEVERE PLASTIC DEFORMATION	CO1	Apply the concept of plastic deformation for metals and alloys	H	M	L
		CO2	Differentiate the various methods of severe plastic deformation and choose the appropriate one for required engineering applications	H	L	H
		CO3	Analyze various operational and materials parameters influencing the final structure and properties of the materials	M	H	M

Course Code	**:**	MT724
Course Title	**:**	**Nuclear Materials**
Type of Course	**:**	PE/OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the concepts of nuclear materials and their properties, applications and safety precautions.

Course Content

Introduction to nuclear energy / reactors – comparison of different modes of energy generation – ecological and environmental aspects

Nuclear reactions – concept of half life, nuclear minerals – related exploration and processing

Material requirements – structural materials,rare earth materials coolants, shielding materials and fuel rods – fabrication requirements

Nuclear irradiation effects on structural materials – safe guards, safety and health protection Strategic issues – current status and major needs, overview of nuclear scenario in India, nuclear scenario at international level.

References

1. Benjamin M. M., Van Nostrand "Nuclear Reactor Materials and Applications", Reinhold Company Inc, 1983
2. Henley E.J., & Herbert Kouts, "Advances in Nuclear Science and Technology".

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Learn different types of materials used to produce nuclear energy
CO2	Understand properties of nuclear materials and applications
CO3	Learn and understand the safety precautions of nuclear radiation and protection

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT724	Nuclear Materials	CO1	Learn different types of materials used to produce nuclear energy	H	L	M
		CO2	Understand properties of nuclear materials and applications	H	L	H
		CO3	Learn and understand the safety precautions of nuclear radiation and protection	H	L	M

Course Code	**:**	MT725
Course Title	**:**	**Manufacturing Processes**
Type of Course	**:**	PE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To know the fundamental concepts of various manufacturing processes and its applications and limitations with respect to industries

Course Content

Introduction to manufacturing processes – different approaches – technical and economic considerations – significance of material properties with respect to selection of manufacturing process

Conventional casting processes – advantages and limitations – melting practices – design of castings – special casting processes

Conventional material joining processes – concept of weldability – need for dissimilar joints - machining processes – concept of machinability – material examples – developments in machining processes

Rolling – forging – extrusion – drawing - sheet metal forming – classification, advantages and limitations

Introduction to powder metallurgy – recent developments esp. in forging and mechanical alloying - concept of near net shape processing - concept and applications of rapid prototyping – emerging technologies for nano – processing

References

1. Rao, P.N, 'Manufacturing Technology', Tata McGraw Hill, 1996.
2. Kalpakjian, S, 'Manufacturing Engineering and Technology', 3rd Edition, Addison-Wesly, 1995.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Know the fundamental concepts of metal casting, melting techniques and its limitations
CO2	Know the concepts of various metal forming techniques and its applications and limitations regarding the manufacture of various wrought products

CO3	Develop an overall knowledge of the selection of suitable manufacturing technique to produce a product
CO4	Know the basic concepts of rapid prototyping and near-net-shape processing

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT725	Manufacturing Processes	CO1	Know the fundamental concepts of metal casting, melting techniques and its limitations	H	L	M
		CO2	Know the concepts of various metal forming techniques and its applications and limitations regarding the manufacture of various wrought products	H	L	M
		CO3	Develop an overall knowledge of the selection of suitable manufacturing technique to produce a product	H	M	H
		CO4	Know the basic concepts of rapid prototyping and near-net-shape processing	M	L	M

Course Code	**:**	MT726
Course Title	**:**	**Structure-Property Relations in Nonferrous Metals**
Type of Course	**:**	PE / OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To have a basic understanding of the physical metallurgy of nonferrous alloys.
CLO2	To gain knowledge on the role of alloying elements, microstructure/property relationships
CLO3	To learn novel processing methods and production of fine-scale microstructures
CLO4	To provide knowledge on Nonferrous superalloys and Intermetallics

Course Content

Properties of pure Al, Al alloy designations, properties and applications of wrought and cast Al Alloys, principles of age hardening, crystal structures in liquid Al, dispersoids in Al, oxide Inclusions in Al. Mg alloy designations and tempers, Cast Mg Alloys, Wrought Mg alloys, development of creep-resistant Mg alloys, and Metastable Mg solid solutions of several transition metals.

Alloys of Ti: Alpha-Ti Alloys, Beta-Ti Alloys Alpha–Beta Ti Alloys, Nitinol Shape Memory Alloy, Bauschinger Effect, Zr Alloys for Nuclear Reactor Core Components Structure-Property Relations in Zr, Radiation damage in Zr alloys, hydride formation in zircaloy tubing. Electronic and dental uses of gold.

Cu alloys: Brasses, Bronzes, Marine alloys; Cu Matrix Deformation Processed Metal–Metal Composites, Stacking-Fault Energy and Mechanical Properties, Nanocrystalline Strengthening & Inverse Hall–Petch Relationship, Properties and applications of silver and silver alloys, Electronic and dental uses of gold.

Zinc: physical properties, alloying behaviour; coatings on steel, alloying addition to other metals, die casting alloys; superplastic Zn-Al system; physical properties and applications of tin and lead, Sn-based bearing alloys, phase transformation in Tin, Pb-Sn solders, Sn whisker Formation in Electronic Circuits, Effect of Atmosphere on Fatigue Life of Pb.

High-temperature Co alloys; Applications of Co: speciality alloys, cermets, magnetic alloys, protective coatings, additions to steel and Ni superalloys. Ni additions to stainless and alloy steels, Ni–Cu alloys, Ni-Cr-Fe alloys, Ni-based superalloys, annealing twins in Ni, and Single-crystal Ni superalloy turbine blades.

Novel materials and processing methods, rapid solidification processing, amorphous alloys, mechanical alloying, physical vapour deposition, and nanophase alloys.
Intermetallics: oxidation resistance of different compounds, stoichiometric and

nonstoichiometric intermetallics, grain boundary strength of intermetallics, the effect of third-element additions, and multiple ductilizing strategies.

References

1.	Polmear I. J., Light Alloys: From Traditional Alloys to Nanocrystals, 4th Edition, Butterworth Heinemann, 2006
2.	Alan Russell and, Kok Loong Lee ., Structure-Property Relations in Nonferrous Metals, WileyInterscience, 2005.
3.	ASM Handbook: Properties and Selection: Nonferrous Alloys and Special-Purpose Material, 10th Edition, ASM International, 1990
4.	Joseph R. Davis, Alloying: Understanding the Basics, ASM International, 2001
5.	Angelo P C and Ravisankar B: “Nonferrous Alloys: Structures, Properties and Engineering Applications”, Cengage publishers, 2018

Course Outcomes (CO)

At the end of the course student will be able.

CO1	Understand the structure-properties relation in nonferrous metals and alloys.
CO2	Design and select different alloy systems for engineering applications.
CO3	Gain knowledge on developing novel materials and processing methods.
CO4	Know the developments in superalloys and intermetallics.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
		CO1	Understand the structure-properties relation in nonferrous metals and alloys.	H	L	M
		CO2	Design and select different alloy systems for engineering applications.	H	M	H
		CO3	Gain knowledge on developing novel materials and processing methods.	H	L	H
		CO4	Know the developments in superalloys and intermetallics.	H	L	M

Course Code	**:**	MT727
Course Title	**:**	**Polymer Processing**
Type of Course	**:**	PE/OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the basics of polymers and its various processing techniques towards technological applications

Course Content

General features of single screw extrusion, Feed zone, compression zone and metering zone, Mechanism of flow, Analysis of flow in extruder, Extruder volumetric efficiency, and General features of twin screw extruders

Granule production and compounding, Profile production, Film blowing, Blow moulding, Extrusion blow moulding. Extrusion stretch blow moulding. Extrusion coating processes. Recent developments in extrusion technology

Screws. Nozzles. Moulds- runners, sprues, venting, mould temperature controls. Insulated runner moulds. Structural foam injection moulding. Sandwich moulding. Reaction injection moulding. Injection moulding of thermosetting materials.

Thermoforming, Calendering, Rotational Moulding, Compression Moulding, Vacuum forming, pressure forming, analysis of thermoforming. Calendaring and analysis of calendaring. Rotational moulding. Compression moulding. Transfer moulding.

Filament, Fabric, cloth, Mat, chopped fibres, Manufacturing methods. Semi-Automatic processing methods- cold press moulding, Automatic Process- Filament winding, centrifugal casting, pultursion and injection moulding.

References

1. Crawford R.J., "Plastics Engineering", Pergamon Press, 2nd Edition, 1987.
2. Billmeyer, "Text Book Of Polymer Science", John Wiley & Sons(Asia) Pvt Ltd,1994

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the structure and properties of polymers

CO2	Learn different types of processing techniques of polymers
CO3	Choose a processing technique for the given polymer for a particular application

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT727	Polymer Processing	CO1	Understand the structure and properties of polymers	H	L	H
		CO2	Learn different types of processing techniques of polymers	H	L	M
		CO3	Choose a processing technique for the given polymer for a particular application.	H	M	H

Course Code	**:**	MT761
Course Title	**:**	**Design and Selection of Materials**
Type of Course	**:**	OE
Prerequisites	**:**	NiL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To know different Principles of selecting materials and processes for engineering applications and methodologies for designing new materials and conceiving hybrid solutions.

Course Content

Engineering materials and their properties - Technologically important properties of materials - Physical, chemical, mechanical,thermal, optical, environmental and electrical properties of materials.

Material property charts - Modulus – density, strength-density, fracture toughness-strength, etc.

Strategy for materials selection - Types of design, Design tools and materials data. Materials selection without shape, Materials selection involving multiple constraints and/or conflicting objectives, Methodology for selection of materials – Collection of data on availability, requirements and non-functional things- its importance to the situations – case studies

Selection of material and shape - Materials and shape – microscopicand micro structural shape factors – limit to shape efficiency Comparison of structural sections and material indices – case studies

Material processes and process selection - Classifying process- -systematic selection of process – Selection charts - Ranking of processes – case studies - Influence of manufacturing aspects and processing routeon properties of materials and its influence on selection of materials – case studies.

References

1. Michael F. Ashby, Materials Selection in Mechanical Design, 4th Edition, Butterworth-Heinemann, 2011.
2. Joseph Datsko, Materials Selection for Design and Manufacturing: Theory and Practice, 2nd Edition, CRC Press, 1997.

3. Mahmoud M. Farag, Materials and Process Selection for Engineering Design, 2nd Edn, CRC Press, 2007.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Approach to the selection of metals, ceramics, polymers, and composites required for mechanical design.
CO2	Construct and use material property charts to identify a small set of materials meeting mechanical, physical, and cost requirements
CO3	Construct a translation table for problems involving either multiple constraints or conflicting objectives, and systematically identify candidate materials.
CO4	Use material processing charts to select suitable fabrication processes

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT761	Design and Selection of Materials	CO1	Approach to the selection of metals, ceramics, polymers, and composites required for mechanical design.	L	M	H
		CO2	Construct and use material property charts to identify a small set of materials meeting mechanical, physical, and cost requirements	M	H	L
		CO3	Construct a translation table for problems involving either multiple constraints or conflicting objectives, and systematically identify candidate materials.	L	H	M
		CO4	Use material processing charts to select suitable fabrication processes s	H	M	L

Course Code	**:**	MT762
Course Title	**:**	**Statistical Quality Control and Management**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the concepts of quality control and quality management and their applications related to the manufacture of metallurgical products.

Course Content

Quality – philosophy; cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; quality loss function; PDCA cycle; quality control; quality assurance; quality audit; vendor quality assurance.

Quality organization; quality management; quality system; total quality management; quality awards; quality certification; typical procedure for ISO 9000, ISO 14000, QS 9000.

Review of some calculation procedures involving statistics and probability; exposure to some applications of statistics and probability; distribution functions; normal distribution curve.

Variations; analysis of variance – statistical tools – statistical quality control; control charts; process capability analysis; statistical process control; introduction to six sigma

Inspection; inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans; statistical design of experiments.

References

1. Hansen B.L., P.M. Ghare, 'Quality Control and Application', PHI – EEE, 1997.
2. Juran J.M., and F.M.Gryna, 'Quality Planning and Analysis', McGraw Hill, New York, 2nd Edition, 1980

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the basic concepts in quality control and management
CO2	Learn the statistics and probability and distribution functions related to quality management
CO3	Understand the process of inspection, sampling and their statistical approach in quality management in industry

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT762	Statistical Quality Control and Management	CO1	Understand the basic concepts in quality control and management	H	L	L
		CO2	Learn the statistics and probability and distribution functions related to quality management	H	L	H
		CO3	Understand the process of inspection, sampling and their statistical approach in quality management in industry	H	L	M

Course Code	**:**	MT763
Course Title	**:**	**Intellectual Property Rights**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To impart the knowledge in IPR and related areas withcase studies.

Course Content

Introduction to Intellectual Property Law – The Evolutionary Past - The IPR Tool KitPara -Legal Tasks in Intellectual Property Law – Ethical obligations in Para Legal Tasks in Intellectual Property Law - Introduction to Cyber Law – Innovations and Inventions Trade related Intellectual Property Right.

Introduction to Trade mark – Trade mark Registration Process – Post registration Procedures – Trade mark maintenance - Transfer of Rights - Inter partes Proceeding – Infringement - Dilution Ownership of Trade mark – Likelihood of confusion - Trademarks claims – Trademarks Litigations – International Trade mark Law

Introduction to Copyrights – Principles of Copyright Principles -The subjects Matter of Copy right – The Rights Afforded by Copyright Law – Copy right Ownership, Transfer and duration – Right to prepare Derivative works – Rights of Distribution – Rights of Perform the work Publicity Copyright Formalities and Registrations - Limitions - Copyright disputes and International Copyright Law – Semiconductor Chip Protection Act

Introduction to Trade Secret – Maintaining Trade Secret – Physical Secrurity – Employee Limitation - Employee confidentiality agreement - Trade Secret Law - Unfair Competation – Trade Secret Letigation – Breach of Contract – Applying State Law. Geographic indication

Managing intellectual property in a knowledge-based society. IPR and technology transfer, case studies.

References

1. Debirag E.Bouchoux: “Intellectual Property”. Cengage learning , New Delhi
2. M.Ashok Kumar and Mohd.Iqbal Ali: "Intellectual Property Right" Serials Pub.
3. Cyber Law. Texts & Cases, South-Western's Special Topics Collections
4. Prabhuddha Ganguli: 'Intellectual Property Rights" Tata Mc-Graw –Hill, New Delhi

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the different types of IPR
CO2	Study the fundamentals of IPR laws
CO3	Understand scope of patent, copy right, geographic indication and trade secrete

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT763	Intellectual Property Rights	CO1	Understand the different types of IPR	H	L	M
		CO2	Study the fundamentals of IPR laws	H	L	H
		CO3	Understand scope of patent, copy right, geographic indication and trade secrete	H	L	L

Course Code	**:**	MT764
Course Title	**:**	**INNOVATION AND PRODUCT DEVELOPMENT**
Type of Course	**:**	OE
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand customer needs and demand for new products.
CLO2	To train for design thinking for new products
CLO3	To know various IPR issues in new product development.

Course Content

Understanding Customer Needs, Organizing Product Development, and New Product Strategy and Six Sigma in new product development, Creating Demand for New Products.

Quantitative Methods for material selection and Cost–Benefit Analysis.

Design for Manufacturing (DFM); role of DFM in product specification and standardization.

Introduction to Intellectual Property and IPR issues in new Product Development
Case studies and a minor project.

References

1.	Drew Boyd & Jacob Goldenberg (2013) Inside the Box: The Creative Method that Works for Everyone
2.	Joseph V. Sinfield, Edward Calder, Bernard McConnell and Steve Colson (2012) How to Identify New Business Models, MIT Sloan Management Review Vol. 53, No.2.
3.	Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang (2020) Product Design and Development, 7th Edition
4.	ASTM Design Handbook.

Course Outcomes (CO)

At the end of the course, student will be able.

CO1	Understand the customer expectations and requirements for new products
CO2	Understand the methods of materials selection for new products

CO3	Solve social problems by new products development
CO4	Understand IPR and various IPR issues in new product development

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT764	INNOVATION AND PRODUCT DEVELOPMENT	CO1	Understand the customer expectations and requirements for new products	M	L	L
		CO2	Understand the methods of materials selection for new products	L	M	L
		CO3	Solve social problems by new products development	M	L	L
		CO4	Understand IPR and various IPR issues in new product development	L	L	M

Course Code	**:**	MT765
Course Title	**:**	**Energy Storage Systems**
Type of Course	**:**	OE
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To become familiarize with energy demands
CLO2	Acquire insights on various energy storage systems
CLO3	Study mateirals used in various energy storage systems
CLO4	Gain insights on futuristic technologies viable for commercialization

Course Content

Energy Storage Systems: Introduction - Energy Demand in India and Sources - Renewable Energy Sources - Power Density Vs. Energy Density –Energy Storage Systems Including Batteries, Supercapacitors, Fuel Cells and Hydrogen Storage

Batteries: Primary And Secondary Batteries (Lithium-Ion, Sodium-Ion, Metal-Air/O2/Co2 Batteries) Working Mechanisms - Battery Components (Cathode, Anode, Electrolyte, Casing Materials) - Nanostructured Materials for Batteries (Carbon-Based and Metal Oxide/Metal Sulfide/MOFs/COFs/MXenes)

Supercapacitors - Electrical Double Layer Model - Principles & Design For EDLC And Pseudocapacitors - Material Prospects - Status & Future Trends. Fuel Cells - Principles For Different Fuel Cells and Materials - Issues & Challenges in Fuel Cells. Hydrogen Storage Methods and Materials- Production and Energy Conversion

Prospects - Discussing Viable Technologies for Commercialization with Emphasis on Environmental Impact, Cost, Efficiency, Advantages, Disadvantages, and Applicability - Integration in Electric Vehicle and Smart Grids.

References

1. Braun, A. Electrochemical energy systems: foundations, energy storage and conversion. Walter de Gruyter GmbH & Co KG. (2018)
2. Paul, Rajib, Vinodkumar Etacheri, Yan Wang, and Cheng-Te Lin, eds. Carbon based nanomaterials for advanced thermal and electrochemical energy storage and conversion. Elsevier, (2019).
3. Hirose, Katsuhiko. Handbook of hydrogen storage: new materials for future energy storage. John Wiley & Sons, (2010).

4. Allen J.Bard and Larry R. Faulkner, Electrochemical methods: Fundamentals and Applications, 2ndEdition John Wiley & Sons. Inc (2004)
5. San Ping Jiang, Qingfeng Li, Introduction to Fuel Cells Electrochemistry and Materials, Springer Singapore (2021)

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Learn about energy demands and various energy storage systems.
CO2	Understand various battery chemistries and their future prospects.
CO3	Select and design materials for energy storage systems.
CO4	Understand Hydrogen production and materials used for hydrogen storage

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT675	Energy Storage Systems	CO1	Learn about energy demands and various energy storage systems	H	L	M
		CO2	Understand various battery chemistries and their future prospects	H	M	L
		CO3	Select and design materials for energy storage systems	H	M	H
		CO4	Understand Hydrogen poduction and materials used for hydroegen storage	H	M	L

Course Code	**:**	MT766
Course Title	**:**	**Artificial Intelligence in Materials Engineering**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To explore the scope of artificial intelligence (AI) in materials engineering and research.

Course Content

Considering that AI in Materials Engineering and Research is an emerging field, the following syllabus is intended to provide an outline for the instructor. This syllabus can be suitably navigated to accommodate the recent and relevant advancements.)

Basics of AI – Mathematical Foundation, History and Evolution; Need for AI in Materials Engineering and Research – Data Analysis, Factor Analysis, Image Analysis, Material Discovery

Machine Learning as a subset of AI – Introduction, Types of Data; Supervised Learning – Basics, Regression, Linear and Non-Linear Regression, Gradient Descent, Logistic Regression; Unsupervised Learning – Clustering; Reinforced Learning

Deep Learning – Introduction; Neural Networks – Feedforward, Backpropagation and Parameters; Types – Convolutional and Recurrent Neural Networks; Autoencoders
Quantitative Microstructure Analysis – Computer Vision, Segmentation, Classification**,**

References

1. Artificial Intelligence - A Modern Approach, Stuart Russell, Pearson Publication, 3rd Edition, 2015.
2. Basics of Artificial Intelligence and Machine Learning, Deeraj Mehrotra, Notion Press, 2019.
3. Artificial Intelligence by Example, Dennis Rothman, Packt Publishing, 2020

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Understand the mathematical foundation, history, and evolution of AI, and grasp its necessity in materials engineering for tasks such as data analysis, factor analysis, image analysis, and material discovery.
CO2	Gain knowledge of supervised learning, including regression techniques, gradient descent, and logistic regression, as well as unsupervised learning methods like clustering, and understand the basics of reinforced learning, applying these techniques to analyze and interpret data relevant to materials engineering.

CO3	Introduce neural networks, including feedforward and backpropagation, learn about convolutional and recurrent neural networks, and autoencoders, and apply deep learning methods to tasks such as computer vision, segmentation, classification, object detection, and counting.
CO4	Understand the significance and relevance of Industry 4.0 in the context of AI in materials engineering, learn various data visualization techniques to effectively present and interpret data, and be equipped to use AI-driven approaches to enhance materials engineering practices

Course Code	**Course Title**	**CO**	**Course outcomes At the end of the course, students will be able**	**PO1**	**PO2**	**PO3**
MT766	Artificial Intelligence in Materials Engineering	CO1	Understand the mathematical foundation, history, and evolution of AI, and grasp its necessity in materials engineering for tasks such as data analysis, factor analysis, image analysis, and material discovery.	H	L	M
		CO2	Gain knowledge of supervised learning, including regression techniques, gradient descent, and logistic regression, as well as unsupervised learning methods like clustering, and understand the basics of reinforced learning, applying these techniques to analyze and interpret data relevant to materials engineering.	H	L	M
		CO3	Introduce neural networks, including feedforward and backpropagation, learn about convolutional and recurrent neural networks, and autoencoders, and apply deep learning methods to tasks such as computer vision, segmentation, classification, object detection, and counting.	H	M	M
		CO4	Understand the significance and relevance of Industry 4.0 in the context of AI in materials engineering, learn various data visualization techniques to effectively present and interpret data, and be equipped to use AI-driven approaches to enhance materials engineering practices	H	L	H

Course Code	**:**	MT767
Course Title	**:**	**Molecular Modeling of Materials**
Type of Course	**:**	OE
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous and End Assessment

Course Learning Objectives (CLO)

CLO1	To become familiar with the basic concepts electronic scale and atomic scale modeling techniques useful in materials research.

Course Content

Quantum Mechanics – Basic concepts, Schrödinger wave equation, assumptions and approximations, brief introduction to first principle/ab initio methods, applications in materials research

Density functional theory – Electron density, energy terms, exchange correlation functionals, Generalized gradient approximation (GGA), Pseudopotential, DFT exercises

Molecular dynamics - Introduction - Classical mechanics, molecular statics, molecular dynamics; interatomic potentials, Solution for Newton's equations of motion – different algorithms.

Molecular dynamics - Initialization and Integration, energy minimization, estimation of thermodynamic properties, structural properties, thermal properties, MD simulations using LAMMPS

Monte Carlo methods - Introduction, ensembles, algorithms, monte carlo for atomic systems, Modified monte carlo methods-Kinetic Monte Carlo method, Applications of Monte Carlo simulations in different material systems, nucleation and grain growth.

References

1. Lesar, R., Introduction to computational materials science: Fundamentals to applications, Cambridge University Press, UK, 2013.
2. Lee, J.G., Computational Materials Science: An Introduction, CRC Press, Boca Raton, 2017
3. Ohno K, Esfarjani k, Kawazoe Y, Computational materials science: From ab-initio to monte carlo methods, 2nd Ed, Springer-Verlag GmbH Germany, 2018

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	To perform density functional theory simulations to obtain various material properties
CO2	To understand the principles of molecular dynamics simulations and their fundamentals
CO3	To perform molecular dynamics simulations for obtaining thermodynamic, structural and thermal properties of different materials.
CO4	To apply the Monte Carlo simulation methods in materials research.

Course Code	Course Title	CO	Course outcomes At the end of the course, students will be able	PO1	PO2	PO3
MT767	Molecular Modeling of Materials	CO1	To perform density functional theory simulations to obtain various material properties	M	M	M
		CO2	To understand the principles of molecular dynamics simulations and their fundamentals	H	L	H
		CO3	To perform molecular dynamics simulations for obtaining thermodynamic, structural and thermal properties of different materials.	H	M	H
		CO4	To apply the Monte Carlo simulation methods in materials research.	M	M	M