Department of Materials and Metallurgical Engineering

Curriculum of the UG programme B.Tech. in Materials Engineering

Background:

1. At the 35th Senate Meeting, it is proposed to introduce a new undergraduate programme B.Tech. in Materials Engineering at the Indian Institute of Technology Palakkad for the academic year 2026-2027, with an intake of 30 students. The Senate discussed the proposal in detail and approved it.

2. The UG (B.Tech.) program in Materials Engineering is designed to meet the growing demand for advanced materials expertise in sectors such as energy, aerospace, defence, healthcare, and transport. The proposed program is recommended to be designed as a modern, industry-oriented curriculum that addresses the nation's long-term needs, with due emphasis on the core engineering disciplines.

3. The course is designed to have a total of 144 credits as per the Senate guidelines, with the split as follows

Category	Credits	Remarks
Institute Core (IC)	42	Mandatory foundational courses
Professional Major	63	Includes a minimum of 15 credits of Professional Major Electives (PME)
Humanities & Social Sciences Electives (HSE)	9	Elective courses
Science & Mathematics Electives (SME)	6	Elective courses
Open Electives (OE)	15	Interdisciplinary/open choice courses
Project (BTP and/or OELP)	9	Final year/capstone project
Total Credits	**144**	

Detailed Curriculum (Appendix 1)
List of Professional Major Courses (Appendix 2)
List of Professional Electives Courses (Appendix 3)
Detailed Syllabus Professional Major (Appendix 4)

4. It is proposed that students to develop a strong foundation through fundamental courses, then progress to core and elective subjects across the key streams, with greater emphasis on computational materials engineering, followed by functional and structural materials. The curriculum particularly highlights emerging areas such as energy, biomedical, transportation, and advanced structural materials.

5. The program will offer an option for the design and development of materials, processing and manufacturing techniques, characterisation and performance evaluation, and metallurgical extraction and refining processes.

6. Industry-oriented courses will be offered as a Professional Major through a collaborative teaching model involving industry experts. In addition, a one-credit industry lecture series featuring invited talks by leading practitioners from industries will be introduced in the later semesters.

Appendix 1

Detailed Curriculum

S. No	Sem	Course Code	Course Name	Category	Credits
1	I	PH1030	Physics	Institute Core	2-1-0-3
2	I	MA1011	Linear Algebra and Series	Institute Core	3-1-0-4
3	I	ME1130	Engineering Drawing	Institute Core	1-0-3-3
4	I	ID1010	Ecology and Environment	Institute Core	2-0-0-2
5	I	ID1050A	Engineering Design	Institute Core	1-0-3-3
6	I	ME1150	Mechanical Workshop	Institute Core	0-0-3-2
7	I	PH1130/CY1140	Physics/Chemistry Lab	Institute Core	0-0-3-2
Total					19
S. No	**Sem**	**Course Code**	**Course Name**	**Category**	**Credits**
1	II	MA1021	Multivariable Calculus	Institute Core	3-1-0-4
2	II	CY1040	Basic Chemistry for Engineers	Institute Core	2-1-0-3
3	II	HS1010	Technology and Society	Institute Core	2-0-0-2
4	II	CE1020	Engineering Mechanics	Institute Core	3-1-0-4
5	II	ID1110	Introduction to Programming	Institute Core	2-0-3-4
6	II	EE1110	Electrical Workshop	Institute Core	0-0-3-2
7	II	CY1140/PH1130	Chemistry/Physics Lab	Institute Core	0-0-3-2
Total					21
S. No	**Sem**	**Course Code**	**Course Name**	**Category**	**Credits**
1	III	MM2XXX	Principles of Physical Metallurgy	PMC	3-0-2-4
2	III	MM2XXX	Thermodynamics of Materials	PMC	3-0-0-3
3	III	MM2XXX	Fundamentals of Polymers, Composites and Ceramics	PMC	3-0-0-3
4	III	MM2XXX	Mechanics of Materials	PMC	3-0-0-3
5	III	BT2010	Life Sciences	Institute Core	2-0-0-2
6	III		Science and Mathematics Elective 1	SME	3
7	III		Humanities and Social Sciences Elective 1	HSE	3
Total					21
S. No	**Sem**	**Course Code**	**Course Name**	**Category**	**Credits**
1	IV	MM2XXX	Transport Phenomena and Kinetic Processes	PMC	3-0-0-3
2	IV	MM2XXX	Electrochemical and Corrosion Engineering	PMC	3-0-0-3
3	IV	MM2XXX	Mechanical Behaviour of Engineering Materials	PMC	3-0-2-4
4	IV	MM2XXX	Materials Characterisation Techniques	PMC	3-0-2-4
6	IV		Science and Mathematics Elective 2	SME	3
	IV		Humanities and Social Sciences Elective 2	HSE	3
Total					20

S. No	Sem	Course Code	Course Name	Category	Credits
1	V	MM3XXX	Materials Selection in Engineering Applications	PMC	3-0-0-3
2	V	MM3XXX	Ferrous and Nonferrous Extractive Metallurgy	PMC	3-0-0-3
3	V	MM3XXX	Machine Learning for Materials	PMC	3-0-0-3
4	V	MM3XXX	Electronic, Optical and Magnetic Materials	PMC	3-0-2-4
5	V		Program Major Elective 1	PME	3
6	V		Open Elective 1	OE	3
Total					19
S. No	**Sem**	**Course Code**	**Course Name**	**Category**	**Credits**
1	VI	MM4XXX	Computational Materials Engineering	PMC	2-0-2-3
2	VI	MM4XXX	Material Processing Techniques	PMC	3-0-2-4
3	VI	MM4XXX	Industrial Lecture Series	PMC	1 (Pass/Fail)
4	VI		Program Major Elective 2	PME	3
5	VI		Program Major Elective 3	PME	3
6	VI		Humanities and Social Sciences Elective 3	HSE	3
7	VI		Open Elective 2/Project I	OE/Project	3
Total					20
S. No	**Sem**	**Course Code**	**Course Name**	**Category**	**Credits**
1	VII		Program Major Elective 4	PME	3
2	VII		Program Major Elective 5	PME	3
3	VII		Project I/Open Elective 2	Project/OE	3
4	VII		Open Elective 3/Project II	OE/Project	3
5	VII		Open Elective 4/Open Elective 3	OE	3
6	VII		Program Major Elective* (for Honours)	PME*	3
7	VII		Program Major Elective* (for Honours)	PME*	3
Total					15/21
S. No	**Sem**	**Course Code**	**Course Name**	**Category**	**Credits**
1	VIII		Project II/Open Elective 4	Project/OE	3
2	VIII		Project III/Project I	Project	3
3	VIII		Open Elective 5	OE	3
4	VIII		Program Major Elective* (for Honours)	PME*	3
5	VIII		Program Major Elective* (for Honours)	PME*	3
Total					09/15

Options for Courses under Project Category (Project-based courses and B.Tech. Project)

	Semester VI	Semester VII	Semester VIII
Option 1	Project I (3 credits)	Project II (3 credits)	Project III (3 credits)
Option 2	Project I (3 credits)	-	BTP (6 credits)
Option 3	-	Project I (3 credits)	BTP (6 credits)
Option 4	-	BTP (6 credits)	Project I (3 credits)

Category-Wise Credits Count

Total credits (144)	
Institute Core (IC)	42
Program Major Core (PMC)	48
Program Major Elective (PME)	15
Humanities and Social Sciences Elective (HSE)	9
Sciences and Mathematics Elective (SME)	6
Open Elective (OE)	15
Project	9

Appendix 2

List of Professional Major Courses (PMC)

Sl. No.	Course Name	Credit	Syllabus
1	Principles of Physical Metallurgy	4	Proposed
2	Thermodynamics of Materials	3	Proposed
3	Fundamentals of Polymers, Composites and Ceramics	3	Proposed
4	Mechanics of Materials	3	Proposed
5	Transport Phenomena and Kinetic Processes	3	Proposed
6	Electrochemical and Corrosion Engineering	3	Proposed
7	Mechanical Behaviour of Engineering Materials	4	Proposed
8	Materials Characterisation Techniques	4	Proposed
9	Materials Selection in Engineering Applications	3	Proposed
10	Ferrous and Nonferrous Extractive Metallurgy	3	Proposed
11	Machine Learning for Materials	3	Proposed
12	Electronic, Optical and Magnetic Materials	4	Proposed
13	Computational Materials Engineering	3	Proposed
14	Material Processing Techniques	4	Proposed
15	Industrial Lecture Series	1	Proposed

Appendix 3

List of Professional Major Electives Courses

S. No	Course Name	Syllabus
1	Principle and design of MEMS	EE5526
2	Solid State Devices	EE3010A
3	Additive Manufacturing	ME5618
4	Mechanics of Composites	ME5635
5	Advanced Engineering Materials	ME5007
6	Introduction to Nanoscience & Nanotechnology	CY4003
7	Surface Degradation and Surface Engineering Processes	ME5611
8	Industrial Tribology	ME3503
9	Mechanics of Metal Forming and Tool Design	Senate Approved
10	Fatigue and Fracture of Metals	Senate Approved
11	Modern Manufacturing Process	Senate Approved
12	Advanced Cast Irons and Foundry Management	Senate Approved
13	Soft Computing	Senate Approved
14	Fundamentals of Light Microscopy and Image Processing	Under Proposal
15	Digital Twins for Manufacturing	Under Proposal
16	Device Fabrication	Under Proposal
17	Biomaterials	Under Proposal
18	Porous and Soft Materials	Under Proposal
19	Powder Metallurgy	Under Proposal
20	High Entropy Alloys and Materials	Under Proposal
21	Iron and Steel Making	Under Proposal
22	Semiconductor Technology and Fabrication	Under Proposal
23	Energy Materials	Under Proposal

<u>**Appendix 4**</u>

Detailed Syllabus for Professional Major

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Principles of Physical Metallurgy
Course Code	: MM2XXX
Credit	: 3-0-2-4 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Nil
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D

Course Content:

Atomic structure and crystallography: Atomic bonding, crystal structures of metals and alloys, Miller indices, crystal orientations, and basic stereographic projection. Crystal defects and strengthening: Vacancies, dislocations, stacking faults, grain boundaries; slip and twinning; strengthening mechanisms (solid-solution, grain-boundary, dislocation, precipitation strengthening). [10L]
Phase diagrams and transformations: Binary and ternary phase diagrams; Fe-C system; phase equilibria, lever rule, tie-lines; concepts of diffusion and phase transformations. [8L]
Solidification and microstructure: Nucleation and growth, solidification modes, microsegregation, dendritic structures, ingot and cast-alloy microstructures. [8L]
Recovery, recrystallization, and grain growth: Effects of cold work, recovery, recrystallization, and grain growth; annealing behaviour and its impact on microstructure and properties. [8L]
Heat treatment and transformations: TTT/CCT diagrams, pearlite, bainite, martensite, and tempering; age-hardening in alloys (e.g., Al–Cu-type systems) and associated case studies. [8L]

Laboratory Experiments: [24 hr]

1. Study of microstructures of common metals and alloys such as mild steel, cast iron, brass, bronze, and aluminium alloys.
2. Determination of grain size of metals using the ASTM Grain Size Number method.
3. Hardness measurement of metals using the Brinell Hardness Test, the Rockwell Hardness Test, and the Vickers Hardness Test.
4. Heat treatment of steels, including annealing, normalising, hardening, and tempering, and an examination of their effects on hardness and microstructure. Identification of steel microstructures such as Ferrite, Pearlite, Austenite, and Martensite.
5. Study of the effects of cold working and annealing, including concepts of Work Hardening and Recrystallization.

Learning Outcomes:

1. Explain crystal structures, crystal defects, and bonding in metals and alloys.
2. Interpret binary phase diagrams and phase transformations in metallic systems.
3. Relate microstructure to mechanical properties of metals and alloys.
4. Describe diffusion and its role in phase transformations and heat treatment.
5. Apply strengthening mechanisms and heat treatment principles to engineering materials.

Text Books:

1. Sidney H. Avner, *Introduction to Physical Metallurgy*. McGraw-Hill, 2nd Ed., 1974, ISBN-10: 0070024985, ISBN-13: 978-0070024984.
2. Robert E. Reed-Hill & Reza Abbaschian, *Physical Metallurgy Principles*. PWS Publishing / Cengage Learning, 3rd Ed., ISBN-10: 0534921734, ISBN-13: 978-0534921736.
3. V. Raghavan, *Physical Metallurgy: Principles and Practice*. PHI Learning Pvt. Ltd. (New Delhi), 3rd Ed., 2015, ISBN-10: 8120351703, ISBN-13: 978-8120351707.

Reference Books:

1. William D. Callister Jr. & David Rethwisch, *Materials Science and Engineering: An Introduction*. John Wiley & Sons, ISBN-10: 1118324576, ISBN-13: 978-1118324578.
2. V. Raghavan, *Materials Science and Engineering: A First Course*. PHI Learning (Prentice Hall of India), ISBN-10: 8120334051, ISBN-13: 978-8120334052.
3. Kenneth G. Budinski & Michael K. Budinski, *Engineering Materials: Properties and Selection*. Prentice Hall, ISBN-10: 0130910295, ISBN-13: 978-0130910295.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Thermodynamics of Materials
Course Code	: MM2XXX
Credit	: 3-0-0-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: CY1040: Basic Chemistry for Engineers
Date of proposal	:
Date of approval	:
Proposing faculty	: Prof. T. Sundararajan and Dr. Samarjeet Chanda

Course Content:

Continuum and macroscopic properties of pressure and temperature, open and closed systems, state and process, definitions of heat and work, different forms of work, First law of thermodynamics for cyclic and non-cyclic processes, energy-related properties of internal energy and enthalpy, First law for open systems, criterion for material stability. [8L]

Properties of ideal gases, phase change substances, Mixture of ideal gases, Dalton's law of partial pressures, concept of partial volumes. [4L]

First law applications for closed and open systems, steady flow energy equation and its application to adiabatic and heat exchange devices; First law application to unsteady processes. [6L]

Second law of thermodynamics and its application to heat engines and heat pumps, concept of entropy, reversibility, isentropic efficiency, Gibbs and Helmholz free energies, equilibrium and free energy minimum principle, spontaneous reactions, reversible reactions and equilibrium concentrations, effect of system pressure and temperature on chemical equilibrium, activity and chemical potential, fugacity. [12]

Homogeneous and heterogeneous equilibria, Gibbs phase rule. Properties of solutions and concepts of partial molar properties. Thermodynamics of mixing and solution thermodynamics, Binary, ternary and alloy phase diagrams. [12]

Note: ME1020: Engineering Thermodynamics is a similar course. Students who have registered for this course are not allowed to register for a similar course.

Learning Outcomes:

1. Understand and apply the laws of thermodynamics in a material context.
2. Learn about the fundamentals of phase stability and phase diagrams.
3. Appreciate the role of thermodynamics in mixtures, solutions, chemical reactions and environmental stability.
4. Learn about the thermodynamic aspects of synthesis and processing of materials.

Text Books:

1. D. R. Gaskell, *Introduction to the Thermodynamics of Materials*. Taylor & Francis (New York), 4th Ed., 2003, ISBN-10: 1560329920, ISBN-13: 978-1560329923.
2. Robert T. DeHoff, *Thermodynamics in Materials Science*. McGraw-Hill (New York), 1993, ISBN-10: 0070168938, ISBN-13: 978-0070168930.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Fundamentals of Polymers, Composites and Ceramics
Course Code	: MM2XXX
Credit	: 3-0-0-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Nil
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D, Dr. Nelson Muthu, Dr. Chaitanya Paramatmuni

Course Content:

Fundamentals of Materials Selection: Introduction to materials selection; performance indices; strength, stiffness, toughness, and durability considerations; cost and manufacturability; case study of a torsionally stressed cylindrical shaft. [9L]

Polymers: Structure and bonding in polymers; polymerization, molecular weight, structure, and configurations; thermoplastics and thermosets; copolymers; crystallinity and glass transition; mechanical and viscoelastic behaviour; polymer additives and processing techniques. [9L]

Ceramics: Crystal structures and bonding; silicates and advanced ceramics; defects and diffusion; phase diagrams; mechanical behaviour and brittle fracture; types of ceramics (glasses, refractories, cements, advanced ceramics); powder processing, forming, and sintering. [12L]

Composites: Classification of composites; particle and fibre reinforced composites; matrix (PMC, CMC and MMC) and reinforcement phases; rule of mixtures; interface and load transfer; polymer, metal, and ceramic-matrix composites; processing methods and engineering applications. [12L]

Learning Outcomes:

1. Explain the structure, classification, and properties of polymers, ceramics, and composite materials.
2. Describe the processing techniques used for polymers, ceramics, and composites.
3. Analyze the relationship between structure, processing, and properties of these materials.
4. Compare the mechanical, thermal, and chemical properties of polymers, ceramics, and composites.
5. Select suitable advanced materials for specific engineering applications.

Text Books:

1. Materials Science and Engineering: An Introduction, William D. Callister & David G. Rethwisch, Publisher: Wiley, 2018, 10th Ed. ISBN-13: 978-1118324578

2. Materials Science and Engineering: A First Course, V. Raghavan, Publisher: Prentice Hall / Pearson, 2004, ISBN-13: 978-0132701946

Reference Books:

1. Polymer Science and Technology, Robert O. Ebewele, ISBN-13: 978-0849318555
2. Ceramic Materials: Science and Engineering, C. Barry Carter & M. Grant Norton, ISBN-13: 978-0387755899
3. Daniel Gay, Suong V. Hoa & Stephen W. Tsai, Composite Materials: Design and Applications. CRC Press, ISBN-10: 1420056856, ISBN-13: 978-1420056853.
4. K. K. Chawla, Composite Materials: Science and Engineering. Springer, ISBN-10: 0387984097, ISBN-13: 978-0387984094.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Mechanics of Materials
Course Code	: MM2XXX
Credit	: 3-0-0-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Nil
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Nelson Muthu

Course Content:

Introduction to Mechanics of Solids – Concept of deformable bodies, continuum assumption, types of loads, stress and strain, normal and shear stresses, stress–strain relations, elastic constants and their interrelationships. [4L]

Uniaxial Loading and Material Deformation – Stress-strain behaviour under uniaxial loading, elastic and inelastic deformation, bars of uniform and varying cross-section, statically determinate and indeterminate systems, Thermal stresses and constrained thermal deformation, residual stress due to temperature change. [5L]

Torsional Deformation – Pure torsion theory, shear stress distribution, angle of twist, torsional strain energy, application to material characterization. [4L]

Stress Analysis in Bending – Pure bending concept, Stress distribution under bending, Moment–curvature relationship, Flexural rigidity, Bending of homogeneous and composite sections. [4L]

Transverse Shear Stress – Shear stress distribution in sections, shear flow concept, relevance to structural and functional materials. [4L]

Deformation and Strain Energy Methods – Beam deflection methods, strain energy in elastic solids, energy approach to stiffness evaluation. [7L]

Multiaxial Stress States and Failure Criteria – Principal stresses and strains, Mohr’s circle, stress variants, yielding under multiaxial loading, ductile vs brittle material response, theories of failure including Maximum Principal Stress theory, MaximumShear Stress (Tresca) theory, Distortion Energy (von Mises) theory, and brittle material criteria such as Mohr–Coulomb and Modified Mohr failure theories applicable to ceramics and polymers. [8L]

Thin Cylinders and Pressure Vessels – Thin cylindrical and spherical pressure vessels, hoop and longitudinal stresses, volumetric strain, Applications [4L]

Note: ME2012: Mechanics of Solids: Theory and Practice and CE2010: Strength of Materials are similar courses. Students who have registered for this course are not allowed to register for a similar course.

Learning Outcomes:

1. Analyze stress-strain behaviour of materials under axial, shear, torsional, and bending loads.
2. Evaluate stresses and deformations in solids subjected to mechanical and thermal loading.
3. Predict elastic deformation using analytical and energy-based methods.
4. Assess the yielding and failure of materials under multiaxial stress states using failure theories.

Textbooks

1. E. P. Popov, *Engineering Mechanics of Solids*. Prentice Hall, 1998, ISBN-10: 0132792583, ISBN-13: 978-0132792585.
2. F. P. Beer, E. R. Johnston Jr. & J. T. DeWolf, *Mechanics of Materials*. Tata McGraw-Hill, 5th Ed., 2005, ISBN-10: 0071247289, ISBN-13: 978-0071247283.

Reference Books

1. S. H. Crandall, N. C. Dahl & T. J. Lardner, *An Introduction to the Mechanics of Solids*. Tata McGraw-Hill, 2nd Ed., 2008, ISBN-10: 0071247203, ISBN-13: 978-0071247207.
2. S. P. Timoshenko, *Strength of Materials, Volumes 1 & 2*. CBS Publishers & Distributors, 1986, ISBN-10: 812390892X, ISBN-13: 978-8123908922.
3. Irving H. Shames & James M. Pitarresi, *Introduction to Solid Mechanics*. Prentice Hall of India, 3rd Ed., 2003, ISBN-10: 812032451X, ISBN-13: 978-8120324510.
4. James M. Gere, *Mechanics of Materials*. Thomson Brooks/Cole, 6th Ed., 2006, ISBN-10: 0534417939, ISBN-13: 978-0534417932.
5. Norman E. Dowling, *Mechanical Behavior of Materials*. Pearson Education, 4th Ed., 2017, ISBN-10: 0134572130, ISBN-13: 978-0134572130.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title : Transport Phenomena and Kinetic Processes
Course Code : MM2XXX
Credit : 3-0-0-3 (L-T-P-C)
Category : Core
Target Programme : UG
Target Discipline : BTech (Materials Engineering)
Prerequisite (if any) : Thermodynamics of Materials
Date of proposal :
Date of approval :
Proposing faculty : Prof. T. Sundararajan and Samarjeet Chanda

Course Content:

Introduction: continuum hypothesis, Newton's law of viscosity, Newtonian and non-Newtonian fluids, fluid statics, material derivative and Reynolds transport theorem, mass and momentum conservation laws, Bernoulli's equation and its applications, integral form of momentum equation and its applications. [8L]

Buckingham Pi-Theorem and dimensionless numbers, 1-D flows in channels and circular pipes, ideal fluid flow over cylinders and spheres, concept of boundary layer flow for a flat plate and bluff bodies, flow separation, drag and lift forces, Reynolds number and transition to turbulence, friction factor and Moody's chart, creeping flow and Stokes law. [8L]

Basic modes of heat transfer, steady 1D heat conduction in plane, cylindrical and spherical geometries, concept of conduction and convection resistances, lumped system transient model, 1D transient heat conduction and Heissler charts, Nusselt and Biot numbers, internal & external flow heat transfer, heat transfer correlations for forced and natural convection. [8L]

Radiation heat transfer: Basic laws, black body radiation, properties of surfaces, view factors, network method, and enclosure analysis for grey-diffuse enclosures. [8L]

Fick's law of diffusion, mass-based and mole-based species fluxes, similarity of mass, momentum and species transport processes, mass transfer correlations, homogeneous and heterogeneous reactions, diffusion and kinetic resistances, combined heat and mass transfer processes. [10]

Note: This course is similar to ME2020: Fluid Mechanics Theory and Practice and ME3050A: Heat and Mass Transfer. Hence students who have taken those courses are not allowed to register for this course.

Learning Outcomes:

1. Fundamental understanding of flow, heat and mass transfer processes.
2. Appreciation of the analogy between the diffusion and convection of momentum, energy and species.

3. Apply the mass, momentum, energy, and species conservation principles and obtain the velocity, temperature and concentration solutions in different applications
4. Study the flow and transport processes in reacting and non-reacting systems and understand the aspects of rate-controlling phenomena.
5. Understand the roles played by various dimensionless numbers and their effects on transport phenomena.

Text Books:

1. R. B. Bird, W. E. Stewart & E. N. Lightfoot, *Transport Phenomena*. John Wiley & Sons, 2nd Ed., 2002 (Wiley India Reprint 2005), ISBN-10: 0471410776, ISBN-13: 978-0471410775.
2. Frank P. Incropera & David P. DeWitt, *Fundamentals of Heat and Mass Transfer*. John Wiley & Sons, 5th Ed., 2002 (Wiley India Edition 2006), ISBN-10: 0471386506, ISBN-13: 978-0471386506.

3. James R. Welty, Charles E. Wicks, Robert E. Wilson & Gregory L. Rorrer, *Fundamentals of Momentum, Heat, and Mass Transfer*. John Wiley & Sons, 5th Ed., 2007, ISBN-10: 0470128686, ISBN-13: 978-0470128688.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Electrochemical and Corrosion Engineering
Course Code	: MM2XXX
Credit	: 3-0-0-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	:
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Yugender Goud Kotagiri

Course Content:

Introduction to Electrochemistry: Introduction: Importance of electrochemistry in materials science; types of conductors (electronic vs. ionic); Redox Reactions; Electromotive Force (EMF): Concept of cell potential and the Galvanic series vs. EMF series; IUPAC Conventions: Standard state definitions and sign conventions for electrode potentials; Thermodynamics of Cells; The Nernst Equation. [8L]

Module II: The Electrode-Electrolyte Interface: Faraday's Laws: Quantitative electrolysis and current efficiency in industrial plating; Faradaic vs. Non-Faradaic processes; Electrical Double Layer (EDL): The Helmholtz model, The Gouy-Chapman theory and its limitations; The Stern Model; Adsorption: Specific vs. non-specific adsorption of ions; Mass Transport: Diffusion, Migration, and Convection; Overpotential: Introduction to Activation, Concentration, and Resistance polarization. [11L]

Electro-Analytical Techniques: The 3-Electrode System: Working (WE), Reference (RE), and Counter (CE) electrode functions; Reference Electrodes: Construction, Types and storage; The Glass pH electrode and ion-selective electrodes; Voltammetry Principles: Linear sweep and Cyclic Voltammetry (CV); Randles-Sevcik Equation: Understanding the peak current in relation to scan rate and diffusivity; Polarography: Dropping Mercury Electrode (DME) and the Ilkovic equation; Industrial Electrolysers: 2-electrode systems. [11L]

Module IV: Corrosion Science and Engineering: Introduction to Corrosion; Kinetics of Corrosion: Mixed Potential Theory and Evans Diagrams; Forms of Corrosion I: Uniform, Galvanic (Area effect), and Crevice corrosion; Forms of Corrosion II: Pitting (Critical Pitting Temperature), Intergranular corrosion (Sensitization of SS); Environmental Cracking: Stress Corrosion Cracking; Factors Affecting Corrosion: pH, dissolved oxygen, temperature, and fluid velocity; Cathodic Protection: Sacrificial Anodes (Mg, Zn, Al) and Impressed Current (ICCP); Coatings and Inhibitors: Organic coatings, galvanizing, and anodic/cathodic inhibitors; [12L]

Learning Outcomes:

1. The learners should be able to write equations representing electrochemical cells and explain the various overpotentials involved in cell operation.
2. Understanding the basic principles of stationary and dynamic electroanalytical methods
3. Calculate electrochemical cell parameters, electrochemical active surface area, current, and overpotential under the given conditions
4. Plot potential vs current, surface coverage vs. potential, potential vs. pH, concentration profile vs. distance from the electrode
5. Explain electrochemical theory of corrosion.
6. Apply various corrosion-preventing techniques on metals depending on the conditions

Textbooks:

1. Electrochemical methods: Fundamentals and applications, Allen J Bard and Larry R Faulkner, John Wiley, 3 rd Edn., 2022, ISBN: 9781119334064.
2. Electrochemistry and Corrosion Science, Nestor Perez, Springer. ISBN-13: 978-3319248455
3. Corrosion Engineering, Mars G. Fontana and Norbert D. Greene ISBN-13: 978-0070607446

Reference Books:

1. Fundamentals of Electroanalytical Chemistry, P M S Monk, John Wiley, 2003, ISBN 0-471-88140-6
2. J. Newman and K. E. Thomas-Alyea, Electrochemical Systems, 3rd Edition, Wiley Interscience, 2004, ISBN:0471477567.
3. E. Gileadi, Physical Electrochemistry, Fundamental, Techniques and Applications, 2 nd edition, Wiley-VCH, 2018, ISBN: 978-3-527-34139-9
4. Atkins' Physical Chemistry 11 th Edition, Peter Atkins, Oxford University Press, ISBN 978–0–19–108255–9
5. Analytical Electrochemistry, Joseph Wang, John Wiley, 4th Edn., 2023. ISBN-978-1-119-78769-3
6. Electroanalytical methods: Guide to experiments and applications, Fritz Scholz, Springer, 2nd Edn., 2010. ISBN 978-3-642-02914-1

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Mechanical Behaviour of Engineering Materials
Course Code	: MM2XXX
Credit	: 3-0-2-4 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Mechanics of Materials or Mechanics of Solids: Theory and Practice or Strength of Materials
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D and Dr. Chaitanya Paramatmuni

Course Content:

Elasticity: Stress concepts; two-dimensional and three-dimensional states of stress; stress–strain relationships; failure theories. [4L]

Microplasticity and Plasticity: Slip systems; resolved shear stress, tensile testing; strain hardening; flow curves (stress-strain behaviour). [5L]

Strengthening Mechanisms: Precipitation strengthening; dispersion strengthening; solid-solution strengthening; grain-boundary strengthening; fibre strengthening. [5L]

Dislocation Theory: Dislocation geometry and energy; dislocation motion, interactions, and reactions. [8L]

Fracture and Fracture Mechanics: Stress concentration; notch effects; cohesive strength; ductile and brittle fracture; ductile-to-brittle transition temperature (DBTT). [10L]

Fatigue: Stress cycles; S–N curves; low-cycle and high-cycle fatigue; structural features; design for fatigue. Creep: Creep curves; deformation mechanism maps; stress rupture tests; life prediction. [10L]

Laboratory Experiments: [24hr]

1. Uniaxial tensile and compressive deformation behaviour of metals
2. Effect of strain rate on the mechanical response of materials
3. Impact testing
4. High temperature deformation of metals – Creep
5. Fatigue response of materials

Learning Outcomes:

1. Explain the fundamental concepts of stress, strain, and elastic–plastic deformation in materials.
2. Describe the mechanisms of strengthening and deformation in metals and alloys.

3. Analyze mechanical properties such as hardness, toughness, fatigue, and creep.
4. Interpret stress–strain behavior and failure mechanisms of engineering materials.
5. Evaluate the mechanical performance of materials for engineering applications.

Text books:

1. George E. Dieter, Mechanical Metallurgy, Tata McGraw-Hill Publishing Company Pvt. Ltd., ISBN 0071004068. 2.
2. Thomas H Courtney, Mechanical Behaviour of Materials, Tata McGraw-Hill Publishing Company Pvt. Ltd., ISBN-10: 1259027511.

Reference Books:

1. William F. Hosford, Mechanical Behavior of Materials, Cambridge University Press, 2nd edition, ISBN-10: 0521195691.
2. Norman E. Dowling, Mechanical Behavior of Materials, Engineering Methods for Deformation, Fracture, and Fatigue, Pearson; 2nd edition, ISBN-10: 9780139057205.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Material Characterization Techniques
Course Code	: MM2XXX
Credit	: 3-0-2-4 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Principles of Physical Metallurgy or ME2080A: Materials Science and Engineering
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D

Course Content:

Fundamentals of Microscopy: Introduction to microscopy, Principles of image formation, Resolution, magnification, depth of field, depth of focus, Optical microscopy and contrast development, Components: light source, specimen stage, lenses, optical train, etc. [5L]

Optical Microscopy Techniques: Bright-field (transmission and reflection modes), Dark-field microscopy, Polarised light microscopy, Interference contrast microscopy, Fluorescence microscopy. [5L]

Electron Microscopy: Principles, Fundamentals of electron microscopy, construction and operation of a SEM. Electron gun and electromagnetic lenses, Lens aberrations and correction methods, Electron-material interactions (elastic/inelastic, coherent/incoherent scattering). Scanning Electron Microscopy (SEM): Working principle and scanning mode, Signal generation (SE, BSE, Auger electrons, characteristic X-rays), Detectors and instrumentation, SEM optics and resolution factors. [11L]

Transmission Electron Microscopy (TEM): Construction and operation of a TEM, Image formation and contrast (mass–thickness, atomic number, diffraction contrast), TEM modes: BF, DF, HAADF, STEM, Electron diffraction and Bragg's law, Zone axis and diffraction order. Electron Diffraction: Reciprocal lattice and Ewald sphere, Diffraction from finite crystals, SAED patterns (single crystal and polycrystalline), Indexing of diffraction patterns, Applications: phase identification, dislocation analysis. Chemical Analysis in Electron Microscopy: EDS and WDS techniques, Topographic and compositional imaging, Quantitative and qualitative analysis. [11L]

X-ray Production and Diffraction: X-ray generation (continuous and characteristic spectra), X-ray absorption and filters, Scattering theory (Thomson and Compton scattering), Atomic scattering factor, Structure factor, multiplicity, and temperature factor. X-ray Diffraction Analysis: Diffraction peak profile analysis, FWHM and line broadening, Crystallite size (Scherrer equation), Strain analysis, Amorphous vs. crystalline materials. [10L]

Laboratory Experiments: [24hr]

1. Preparation of metallographic specimens and observation of microstructures of metals and alloys using an optical microscope.
2. Examination of surface morphology and microstructure using Scanning Electron Microscopy (SEM) in secondary electron (SE) and backscattered electron (BSE) modes.
3. Qualitative and semi-quantitative elemental analysis and mapping using Energy Dispersive X-ray Spectroscopy (EDS).
4. Recording and analysis of powder X-ray diffraction (XRD) patterns for phase identification of crystalline materials.
5. Structural characterization of crystalline materials using X-ray diffraction (XRD) followed by Rietveld Refinement to determine lattice parameters, phase composition, and crystal structure.

Learning Outcomes:

1. Explain the principles of various material characterization techniques used to analyze structure and properties.
2. Describe the working principles of microscopy techniques such as optical microscopy and electron microscopy.
3. Interpret data obtained from characterization tools such as XRD, SEM, and spectroscopy methods.
4. Analyze the relationship between microstructure, composition, and material properties using characterization results.
5. Select appropriate characterization techniques for investigating engineering materials.

Text Books:

1. B. D. Cullity & S. R. Stock, *Elements of X-Ray Diffraction*. Prentice Hall (Pearson Education), 3rd Ed., 2001, ISBN-10: 0201610914, ISBN-13: 978-0201610918.
2. David B. Williams & C. Barry Carter, *Transmission Electron Microscopy: A Textbook for Materials Science*. Springer, 2nd Ed., 2009, ISBN-10: 038776500X, ISBN-13: 978-0387765006.
3. Joseph I. Goldstein, Dale E. Newbury, David C. Joy, Charles E. Lyman, Patrick Echlin, Eric Lifshin, Linda Sawyer & Joseph R. Michael, *Scanning Electron Microscopy and X-Ray Microanalysis*. Springer, 3rd Ed., 2003, ISBN-10: 0306472929, ISBN-13: 978-0306472923.

Reference Books:

1. Sam Zhang, Lin Li & Ashok Kumar, *Materials Characterization Techniques*. CRC Press, 1st Ed., 2008, ISBN-10: 0849389003, ISBN-13: 978-0849389009.
2. H. P. Klug & L. E. Alexander, *X-Ray Diffraction Procedures for Polycrystalline and Amorphous Materials*. John Wiley & Sons, 2nd Ed., ISBN-10: 0471493698, ISBN-13: 978-0471493693

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Material Selection in Engineering Applications
Course Code	: MM3XXX
Credit	: 3-0-0-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Fundamentals of Polymers, Ceramics and Composites
Date of proposal	:
Date of approval	:
Proposing faculty	: Prof. Mayank Tiwari and Dr. Chaitanya Paramatmuni

Course Content:

Introduction of engineering materials: Survey of engineering materials such as metals, metal alloys, ceramics, polymers, semi-conductors, nano-materials and different types of composites, Introduction to design concepts. classroom video/case discussion. [3]

Materials for stiffness-based designs: Revisiting concepts of stiffness of materials. Examples of stiff materials and their applications in engineering designs, a case study on stiffness-based design, and selection criteria for stiffness-based design [4]

Materials for strength-based designs: Revisiting strength of materials. Ashby Charts: Strength vs. stiffness. Criterion for strength critical design, Survey of the strength of materials, Case study – material for pressure vessels, Material selection chart: Tensile strength vs. compressive strength, Ceramics, polymers and metals, [5]

Materials for damage-tolerant designs: Revisiting concepts of material damage. Ashby Charts: Toughness vs. fracture toughness, Case studies of design of damage-tolerant materials. [4]

Materials and fatigue-based designs: Revisiting fatigue failure of materials, Case study – Failure of lifting eye, Fatigue behaviour for materials with existing cracks, Material design for fatigue resistance – avoiding fatigue failure, Fatigue design criteria. [4]

Materials and design against corrosion and environmental degradation: Revisiting Corrosion in Metals, Design considerations for corrosion control, design and selection criteria for Corrosion-resistant materials, [4]

Materials for wear critical applications: Wear critical applications, What is wear, Types of wear, Wear resistance of materials, Wear mechanisms and wear maps, Prevention of wear, Liquid and solid lubricants, Factors affecting wear, Wear resistant materials, coatings and surface engineering for wear resistance. [4]

Materials and Design for High Temperatures: Limiting Factors, Mechanisms, and Materials Selection for Creep-Resistant Designs. [5]

Introduction to Materials for biomedical applications: Defining biomaterials, biocompatibility and biostability. Important medical use of biomaterials, Selection criteria for biomaterials, Biomaterial classes, Polymers as biomaterials, Metals as biomaterials, BioCeramics, Current research trends in biomaterials. [3]

Case Studies/Mini-project [6]

Learning outcome:

1. Describe important mechanical properties (strength, toughness, fatigue, wear resistance, corrosion resistance etc) and attributes (e.g. cost, processability) of engineering materials that are important for engineering design.
2. Explain the mechanisms underlying different mechanical properties of materials such as strength, fatigue, wear, friction, corrosion, thermal etc.
3. Use mathematical (materials and performance indices) and mapping tools (Ashby's map) for selecting the right material for a given design situation.
4. Explain the requirements of simple engineering design such as stress, stiffness, environment, stress concentration and then "predict" performances of given materials using analytical tools.
5. Outline important engineering materials for mechanical design and assess their performances based on various properties and processing. Materials include metals, alloys, plastics, composites and ceramics.
6. Devise a plan for materials selection for a given mechanical design using various materials properties, design requirements and performance indicators.

Text Book:

1. Engineering Materials in Mechanical Design by S. K. Sinha, 2nd Edition, 2014, Research Publishing, ISBN 978981082314-6
2. Engineering Materials 1: An Introduction to their properties & Applications by M. F. Ashby and D. R. H. Jones, 2nd Edition, 2000, Butterworth-Heineman, ISBN 9780750630818
3. Engineering Materials 2: An Introduction to materials and processing by M. F. Ashby and D. R. H. Jones, 2nd Edition, 2000, Butterworth-Heineman, ISBN 9780080966687

Reference Books:

1. Engineering Materials: Properties and Selection by K. G. Budinski and M. K. Budinski, 7th Edition, 2002, Prentice Hall
2. Engineering Design by G. E. Dieter, 3rd Edition, 2000, McGraw-Hill International Editions
3. Mechanical Behavior of Materials by N. E. Dowling, 2nd Edition, 1999, Prentice Hall International
4. Materials Selection in Mechanical Design by M. F. Ashby, 2nd Edition, Butterworth Heinemann, ISBN: 0750643579

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Ferrous and Nonferrous Extractive Metallurgy
Course Code	: MM3XXX
Credit	: 3-0-0-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Thermodynamics of Materials and Transport Phenomena & Kinetic Processes
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D, Dr. Buchibabu Vicharapu, Dr. Soham Manni

Course Content:

Fundamentals of Extractive Metallurgy: Overview of mineral resources and ore beneficiation techniques. Pyrometallurgy, hydrometallurgy, and electrometallurgy principles. [4L]

Thermodynamic basis of extraction: Ellingham diagrams, slag–metal reactions. Kinetics of metallurgical reactions; mass and heat transfer considerations. Environmental aspects and sustainability in metallurgy. [4L]

Ferrous Metallurgy: Ironmaking: raw materials, blast furnace operation, direct reduction processes. Steelmaking: basic oxygen furnace (BOF), electric arc furnace (EAF), secondary steel refining. Slag chemistry and inclusion control. Casting and solidification of steel; continuous casting. Classification of steels: plain carbon steels, alloy steels, stainless steels, and tool steels. Heat Treatment and Microstructure Control in Steels. Recent advances: clean steel technology, advanced high-strength steels (AHSS). [12L]

Nonferrous Extractive Metallurgy: Extraction and refining of major nonferrous metals: Aluminium (Bayer process, Hall–Héroult process), Copper (matte smelting, converting, electrorefining), Zinc and Lead (roasting, reduction, electro-winning), Magnesium and Titanium (Pidgeon process, Kroll process), Hydrometallurgical routes and solvent extraction. Recycling of nonferrous metals. [12L]

Processing and Applications of Nonferrous Alloys: Alloy systems and phase relations in Al, Cu, Mg, Ti, and Ni alloys. Solidification and casting processes. Mechanical working and heat treatment. Corrosion behavior and protection. Applications in aerospace, automotive, energy, and electronics sectors. [10L]

Learning Outcomes:

1. Understand the principles of extractive metallurgy and apply thermodynamic and kinetic concepts in the extraction of ferrous and non-ferrous metals from their ores.
2. Explain and analyse the major industrial processes involved in ferrous metallurgy and the extraction of important non-ferrous metals.

3. Evaluate different metallurgical extraction routes (pyrometallurgy, hydrometallurgy, and electrometallurgy) with consideration of process efficiency, industrial practice, and environmental aspects.

Text Books:

1. Daniel A. Brandt & J. C. Warner, Metallurgy Fundamentals: Ferrous and Nonferrous. GGoodheart-Willcox (Tinley Park, IL), ISBN-10: 1635638747, ISBN-13: 978-1635638745
2. Frank K. Crundwell, Michael S. Moats, Venkoba Ramachandran, Timothy G. Robinson & W. G. Davenport, *Extractive Metallurgy of Nickel, Cobalt and Platinum Group Metals,* Elsevier, ISBN-10: 0080968090, ISBN-13: 978-0080968094.

Reference Books:

1. W. G. Davenport, M. King, M. Schlesinger & A. K. Biswas, *Extractive Metallurgy of Copper*. Elsevier, ISBN-10: 0080967894, ISBN-13: 978-0080967899.
2. A. K. Biswas, *Principles of Blast Furnace Ironmaking: Theory and Practice*. Cootha Publishing House (Brisbane), ISBN-10: 0977564602, ISBN-13: 978-0977564606.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Machine Learning for Materials
Course Code	: MM3XXX
Credit	: 2-0-2-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Introduction to Programming (ID1110); Principles of Physical Metallurgy or Materials Science and Engineering (ME2080A)
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Chaitanya Paramatmuni, Dr. Nelson Muthu, Prof. Mayank Tiwari

Course Content:

Introduction: Data in materials engineering: Source, Classification (composition, microstructure images, process parameters, etc.) and mining of data, Role of data analytics in materials engineering, Introduction to programming in Matlab/Python. [4L]

Handling Materials Data: Data types and interpretation, cleaning, understanding features, noise and bias in experimental data, uncertainty in materials data. [4L]

Mathematical fundamentals: Probability theory, Random variables, Conditional probability and Bayes theorem, Linear algebra, Curve fitting, Covariance and correlation, Regression, Different measures of errors. [4L]

Machining learning in Materials Science: Introduction to ML models: Unsupervised and supervised learning, applications, advantages and limitations in their applications to materials engineering, feature engineering in materials, sanity checks in ML (feature importance, physical consistency checks, uncertainty estimation), materials property prediction models [7L]

Material Knowledge Improvement: Dimensionality Reduction: Dimensionality of data, Need for dimensionality reduction, Approaches for dimensionality reduction, Principal component analysis (PCA): Methodology, Application and reconstruction of data using reduced components, Applications to Materials Engineering data. [6L]

Clustering: Why clustering, mathematical and geometric intuition, data processing, interpretation, finding trends in data, and K-means clustering algorithms. [6L]

Introduction to neural networks and artificial neural networks: Advantages over machine learning models, Artificial Neurons and Multi-layer networks, Training neural networks, Advantages and limitations of neural networks. [4L]

Case studies/Mini-project: Process-structure-property correlations, microstructure fingerprinting, process optimization based on target mechanical property/microstructure, alloy design etc. [7L]

Learning Outcomes:

1. Understand the noise and uncertainty in materials data
2. Identify different types in manifestations of materials response in experimental data and their suitability for developing appropriate ML models
3. Employ the basics of statistics and probability to train basic ML models to predict material properties
4. Understand the importance of dimensionality in materials data for machine learning

Text Books:

1. S. R. Kalidindi, Hierarchical Materials Informatics: Novel Analytics for Materials Data. Elsevier (Butterworth-Heinemann), ISBN-10: 0128178360, ISBN-13: 978-0128178362.
2. Krishna Rajan, Informatics for Materials Science and Engineering: Data-Driven Discovery for Accelerated Experimentation and Application. Butterworth-Heinemann (Elsevier), ISBN-10: 0123943999, ISBN-13: 978-0123943996.
3. András Sobester, Alexander I. J. Forrester & Andy J. Keane, Engineering Design via Surrogate Modelling: A Practical Guide. John Wiley & Sons, ISBN-10: 047074431X, ISBN-13: 978-0470744314.

References

1. Jake VanderPlas, Python Data Science Handbook: Essential Tools for Working with Data. O'Reilly Media, ISBN-10: 1491912057, ISBN-13: 978-1491912058.
2. Oliver Theobald, Machine Learning for Absolute Beginners, Scatterplot Press, ISBN-10: 1549617214, ISBN-13: 978-1549617218.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title : Electronic, Optical and Magnetic Materials
Course Code : MM3XXX
Credit : 3-0-2-4 (L-T-P-C)
Category : Core
Target Programme : UG
Target Discipline : BTech (Materials Engineering)
Prerequisite (if any) : PH1030 - Physics
Date of proposal :
Date of approval :
Proposing faculty : Dr. Aswathi R Nair, Dr. Arvind Ajoy, Dr. Soham Manni, Dr. Jayakumar Balakrishnan.

Course Content:

Free electron theory, Brillouin zones, Energy bands. Classification of electronic materials (metal, semiconductor, insulator). Local electric field of an atom, dielectric constant and polarizability. Ferroelectric crystals. [16L]

Origin of magnetism-Diamagnetism, Paramagnetism, Ferromagnetism, Antiferromagnetism, and Ferrimagnetism. Soft and Hard Magnetic materials. Superconductors- Type I and II, Meissner Effect. Basics of spectroscopy- Fluorescence, Photoluminescence, Raman, Infrared spectroscopy [14L]

Preparation of bulk polycrystalline, single crystalline and amorphous materials; thin films and nanomaterials. [12L]

Laboratory Experiments: [24 hr]

1. Four-probe, sheet resistance
2. Hall Effect in a semiconductor
3. Electrical characterisation of semiconductor: temperature-dependent V vs I
4. Dielectric constant measurement and Ferroelectric characterisation PE loop (2 Lab).
5. Raman spectroscopy and PL.
6. FTIR and Optical Emission Spectroscopy
7. Photoresponse measurements
8. MH loop measurement and data analysis of temperature-dependent magnetisation.

Learning Outcomes: At the end of the course, the students

i. Understand and analyze the basic theories explaining the energy bands and the classification of materials and their behaviour in external fields.
ii. should be able to differentiate different kinds of magnetism in materials and their origin;
iii. develop skills for the preparation and characterization of materials

Text Books:

1. Introduction to Solid State Physics; Charles Kittel; John Wiley and Sons. Inc. ISBN:9788126578436 9788126578436

Reference Books:

1. Handbook of Crystal Growth. Bulk Crystal Growth: Growth Mechanisms and Dynamics Volume II.

Proforma for proposing course (New)

Course Title	: Computational Materials Engineering
Course Code	: MM4XXX
Credit	: 2-0-2-3 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Introduction to Programming (ID1110) and Principles of Physical Metallurgy
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D and Dr Chaitanya Paramatmuni

Course Content:

Review of programming in high-level languages such as Python or Octave or SageMath or Sympy or C / C++ [4L]

Fitting and visualization of multidimensional data; Quantification of experimental microstructures using programs as well as software tools; Application of linear algebra towards the solution to a system of linear and nonlinear equations. [10L]

Numerical integration; Numerical solution of the diffusion equation. [10L]

Computational techniques such as the phase field method and Monte Carlo towards the evolution of microstructure; synthetic microstructures; [10L]

Evaluation of properties from the computed microstructures using mean field and full field approaches; data analytics using principal component analysis; ICME approach. [8L]

Learning Outcomes:

1. Students will be able to select appropriate computational tools to solve a given metallurgical and materials problem.
2. Visualize, plot, analyse and employ the experimental measurements in appropriate computational tool
3. Understand the underlying physical processes that drive structure-property correlations

Text Books:

1. Introduction to Computational Materials Science – Richard LeSar, Cambridge University Press (2013). ISBN: 9781316614877.

Reference Books:

1. Mathematical Methods for Physics and Engineering, 3 rd Edition – R.F. Riley, M.P. Hobson, S.J. Bence, Cambridge University Press (2012). ISBN: 9780521139878.
2. Integrated Computational Materials Engineering (ICME) for Metals – Mark F. Horstemeyer, TMS (2012). ISBN: 9781118022528.
3. Integrative Computational Materials Engineering: Concepts and Applications of a Modular Simulation Platform – Georg J. Schmitz and Ulrich Prahl, Wiley-VCH Verlag GmbH & Co (2012). ISBN: 9783527330812.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Material Processing Techniques
Course Code	: MM4XXX
Credit	: 3-0-2-4 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Fundamentals of Polymers, Composites, and Ceramics
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D, Dr. Afzaal Ahmed, Dr. Dinesh Setti

Course Content:

Metal Forming Principles: Plasticity related to metal forming; cold, warm, and hot working; dynamic recovery and recrystallisation. Basic metal forming processes such as rolling, forging, extrusion, wire drawing, and sheet metal working. [8L]

Metal Casting Principles: Casting processes; thermodynamics of solidification; nucleation and growth; undercooling; dendritic growth; structure of castings and ingots; heat transfer during solidification; types of casting processes. [8L]

Metal Joining Principles: Welding processes; welding metallurgy; TTT and CCT diagrams; carbon equivalent; welding of ferrous and non-ferrous alloys; joining of dissimilar metals; low-energy and high-energy welding processes. [8L]

Additive Manufacturing Principles: AM process sequence; design for additive manufacturing (DfAM); AM processing methods; comparison and process selection guidelines. [10L]

Ceramics and Glass Processing: Structure of ceramics and glassy materials; ceramic powder preparation; forming and consolidation processes; comparison of processing methods and applications of different materials. [10L]

Laboratory Experiments: [24hr]

1. Metal forming
2. Casting
3. Welding
4. Additive manufacturing
5. Ceramics and glass processing
6. Machining
7. Alloy formation by arc/induction melting.

Learning Outcomes:

1. Explain the principles of various material processing techniques used for metals and alloys.
2. Describe casting, forming, machining, and joining processes used in manufacturing.

3. Analyze the influence of processing parameters on material properties and product quality.
4. Select suitable processing methods for different engineering materials and applications.
5. Evaluate defects and limitations associated with different material processing techniques.

Text Books:

1. Lorraine F. Francis, *Materials Processing: A Unified Approach to Processing of Metals, Ceramics and Polymers*. Academic Press (Elsevier), 2016, ISBN-10: 0123859718, ISBN-13: 978-0123859716.
2. Serope Kalpakjian & Steven R. Schmid, *Manufacturing Engineering and Technology*. Pearson, 7th Ed., ISBN-10: 0133128741, ISBN-13: 978-0133128741.
3. Mikell P. Groover, *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*. John Wiley & Sons, ISBN-10: 111912869X, ISBN-13: 978-1119128694.

Reference Books:

1. Ian Gibson, David W. Rosen & Brent Stucker, *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*. Springer, ISBN-10: 1493921126, ISBN-13: 978-1493921126.
2. E. Paul DeGarmo, J. T. Black & Ronald A. Kohser, *Materials and Processes in Manufacturing*. Wiley, ISBN-10: 0470055123, ISBN-13: 978-0470055120.

INDIAN INSTITUTE OF TECHNOLOGY PALAKKAD

Proforma for proposing course (New)

Course Title	: Industry Lecture Series
Course Code	: MM4XXX
Credit	: 1-0-0-1 (L-T-P-C)
Category	: Core
Target Programme	: UG
Target Discipline	: BTech (Materials Engineering)
Prerequisite (if any)	: Materials Selection in Engineering Applications
Date of proposal	:
Date of approval	:
Proposing faculty	: Dr. Kesavan D, Dr. Nelson, Dr. Chaitanya Paramatmuni, Dr. Kali Prasad, Prof. Mayank Tiwari

Course Content:

The Industry Lecture Series will consist of 10–12 lectures delivered by eminent practitioners from leading industries. The invited talks focusing on industry practices, emerging technologies, and applications oriented to Materials Engineering, Metallurgy, etc. Attendance for these lectures is mandatory for students. The course will be evaluated on a Pass/Fail basis.