NATIONAL INSTITUTE OF TECHNOLOGY
ANDHRA PRADESH

COURSE STRUCTURE

B.Tech. – Metallurgical and Materials Engineering

Effective from 2024-25

I – Year: I – Semester

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	HS1011	English for Engineers - I	2	0	0	2	HSC
2	MA1071	Differential and Integral Calculus	3	0	0	3	BSC
3	PH1011	Engineering Physics	2	0	0	2	BSC
4	ME1031	Engineering Mechanics	2	0	0	2	ESC
5	MM1011	Introduction to Metallurgical & Materials Engineering	3	0	0	3	PCC
6	CS1011	Problem Solving through Computer Programming	3	0	0	3	ESC
7	CS1012	Problem Solving through Computer Programming Lab	0	0	2	2	ESC
8	PH1012	Engineering Physics Lab	0	0	2	1	BSC
9	HS1022	Physical Education	0	0	2	1	HSC
Total						**19**	

I – Year: II – Semester

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA1081	Matrix Algebra and Differential Equations	3	0	0	3	BSC
2	ME1011	Engineering Drawing with CAD	2	0	2	3	ESC
3	CY1011	Engineering Chemistry	2	0	0	2	BSC
4	EE1601	Basic Electrical & Electronics Engineering	2	0	0	2	ESC
5	MM1511	Ores & Mineral Processing	2	0	0	2	PCC
6	MM1521	Engineering Thermodynamics	2	0	0	2	PCC
7	ME1062	Fabrication Laboratory	0	0	2	1	ESC
8	CY1042	Chemistry Laboratory - I	0	0	2	1	BSC
9	HS1032	Health Education	0	0	2	1	HSC
Total						**17**	

II – Year: I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA2071	Transform Techniques and Numerical Methods	3	0	0	3	BSC
2	ME2111	Strength of Materials	2	0	0	2	ESC
3	MM2011	Physical Metallurgy	3	0	0	3	PCC
4	MM2021	Principles of Extractive Metallurgy	3	0	0	3	PCC
5	MM2031	Metallurgical Thermodynamics and Kinetics	2	0	0	2	PCC
6	MM2041	Transport Phenomena	3	0	0	3	PCC
7	MM2052	Physical Metallurgy and Metallography Laboratory	0	0	2	1	PCC
8	MM2062	Extractive Metallurgy Laboratory	0	0	3	2	PCC
9	HS2011	Personality Development	1	0	0	1	HSC
10	HS2022	Yoga	0	0	2	1	HSC
		Total				**21**	

II – Year: II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.) - I	3	0	0	3	OEC
2	MM2511	Iron Making	3	0	0	3	PCC
3	MM2521	Casting and Solidification	3	0	0	3	PCC
4	MM2531	Mechanical Behaviour of Materials	3	0	0	3	PCC
5	MM2541	Principles of Heat Treatment	2	0	0	2	PCC
6		Department Elective – 1	3	0	0	3	DEC
7		Department Elective – 2	3	0	0	3	DEC
8	MM2552	Heat Treatment Laboratory	0	0	2	1	PCC
9	MM2562	Mechanical Behaviour of Materials Laboratory	0	0	2	1	PCC
10	HS1052	Social Service	0	0	2	1	HSC
		Total				**23**	

III – Year: I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.) - II	3	0	0	3	OEC
2	MM3011	Powder Metallurgy	2	0	0	2	PCC
3	MM3021	Steel Making	2	0	0	2	PCC
4	MM3031	Metal Joining	2	0	0	2	PCC
5	MM3041	Non-Ferrous Extractive Metallurgy	3	0	0	3	PCC
6		Department Elective – 3	3	0	0	3	DEC
7		Department Elective – 4	3	0	0	3	DEC
8	MM3052	Powder Metallurgy Laboratory	0	0	2	1	PCC
9	MM3062	Casting and Welding Laboratory	0	0	3	2	PCC
10	SM3011	Introduction to Entrepreneurship (for BTE, CHEM, CE, ME, MME Depts)				1	HSC
		Total				**22**	

III – Year: II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.) - III	3	0	0	3	OEC
2	MM3511	Corrosion Engineering	2	0	0	2	PCC
3	MM3521	Metal Forming	2	0	0	2	PCC
4		Department Elective – 5	3	0	0	3	DEC
5		Department Elective – 6	3	0	0	3	DEC
6	MM3531	Materials Characterization Techniques	3	0	0	3	PCC
7	MM3542	Corrosion Engineering Laboratory	0	0	2	1	PCC
8	MM3552	Metal Forming Laboratory	0	0	2	1	PCC
9	HS3011	Liberal Arts/Creative Arts Courses – I or English for Engineers - II				3	HSC

10	SM3021	Introduction to Design Thinking (for BTE, CHEM, CE, ME, MME Depts)				1	HSC
11	MM3040	Mini Project	0	0	1	0	PRC
		Total				**22**	

IV – Year: I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.) - IV	3	0	0	3	OEC
2		Open Elective /DAC approved Free Electives (NPTEL, MOOCs, etc.) - V	3	0	0	3	OEC
3	MM4034	Professional Major Work	0	0	12	6	PRC
4	MM4011	Computational Materials Engineering	2	0	0	2	PCC
5	MM4023	Industrial lectures & Industrial Visits	1	0	1	2	PCC
6	MM4032	Computational Materials Engineering Laboratory	0	0	2	1	PCC
7	HSXXXX	Liberal Arts/Creative Arts Courses – II				3	HSC
		Total				**20**	

IV – Year: II – Semester

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MM4024	Semester-Long Internship (SLI) /Additional Project at the institute/Additional department elective courses for 6 credits	0	0	12	6	
		Total				**6**	

Note:

BSC: Basic Science Courses; ESC: Engineering Science Courses;

PCC: Professional Major Core Courses; DEC: Professional Major Elective Courses;

OEC: Open Elective Courses; HSC: Humanities and Social Science Courses

Basket – 1: Departmental Elective Courses:

Semester	Course Code	Course Title
Departmental Elective Courses 1		
IV	MM2601	Fuels, Furnaces and Refractories
	MM2611	Theory of Metallurgical Processes
	MM2621	Non Destructive Testing
	MM2631	Electronic, Optical and Magnetic Materials
Departmental Elective Courses 2		
IV	MM2641	Ferroalloy Technology
	MM2651	Extractive Metallurgy of Refractory Metals
	MM2661	Metallurgical Waste Recycling
	MM2671	Introduction to Nano Science and Technology
Departmental Elective Courses 3		
V	MM3101	Materials for Renewable Energy
	MM3111	Diffusion in Solids
	MM3121	Physical Metallurgy of Non-Ferrous Metals and Alloys
	MM3131	Advanced Manufacturing Processes
Departmental Elective Courses 4		
V	MM3141	Thin Films and Coatings
	MM3151	Surface Engineering
	MM3161	Stainless Steels and Advanced Ferrous Alloys
	MM3171	Metallurgical Failure Analysis
Departmental Elective Courses 5		
VI	MM3601	Materials Selection and Design
	MM3611	Materials for High Temperature Applications
	MM3621	Materials for Automotive Applications
	MM3631	Energy Materials
Departmental Elective Courses 6		
VI	MM3641	Ceramics, Polymers, and Composites
	MM3651	Smart and Bio Materials
	MM3661	Secondary Steel Making
	MM3871	X-Ray Diffraction & Applications

Basket – 2: Open Elective Courses (offered to other departments):

Semester	Elective Number	Course Code	Course Title
IV	I	MM2701	Materials Science and Engineering Basics
V	II	MM3201	Fundamentals of Materials Processing Technology
VI	III	MM3701	Materials Testing and Evaluation
VII	IV	MM4201	Techniques for Materials Characterization
VII	V	MM4701	Selection of Materials

Basket – 3: Engineering Science Courses (offered to Biotechnology Dept.):

Semester	Course Code	Course Title
I	MM1601	Introduction to Materials Science and Engineering

Basket – 4: Engineering Science Courses (offered to Mechanical Engg Dept.):

Semester	Course Code	Course Title
III	MM2061	Materials Science and Metallurgy

Minor/Double Major programs

- Each engineering department should identify the list of courses for the minor & Double Major degree programmes. These identified courses will be offered to the Minor/Double Major degree students in every branch.
- To get Minor degree in any engineering branch, a student has to earn 12 Credits (6 Core credits + 6 Elective Credits) prescribed for the programme.
- To get Double Major degree in any engineering branch, a student has to earn 24 Credits (12 Core credits + 12 Elective Credits) prescribed for the programme.
- The Minor & Double Major choices start from the beginning of 3rd Semester.
- The students of Minor & Double Major courses will sit with regular students in the class.
- There will be separate time table slots for Minor & Double Major courses identified by each department to enable the students to register for these courses. Courses other than Minor & Double Major courses will not be offered during these slots.
- A student is permitted to do one Minor and one Double Major at max.
- Each department will choose a CGPA cut off (based on II Sem CGPA) such that the total of Minor and Double Major students in any branch do not cross a maximum of 30 seats.

Minor program Course Distribution

S. No.	Course Code	Course Title	Credits	Offered Sem
1	MM2011	Physical Metallurgy	03	III
2	MM2531	Mechanical Behaviour of Materials	03	IV
3	MMXXXX	Department Elective – 3	03	V
4	MMXXXX	Department Elective – 5	03	VI
		TOTAL (6 Core credits + 6 Elective Credits)	**12**	

Double Major program Course Distribution

S. No.	Course Code	Course Title	Credits	Offered Sem
1	MM2011	Physical Metallurgy	03	III
2	MM2031	Metallurgical Thermodynamics and Kinetics	03	III
3	MM2531	Mechanical Behaviour of Materials	03	IV
4	MM2521	Casting and Solidification	03	IV
5	MMXXXX	Department Elective – 3	03	V
6	MMXXXX	Department Elective – 4	03	V
7	MMXXXX	Department Elective – 5	03	VI
8	MMXXXX	Department Elective – 6	03	VI
		TOTAL (12 Core credits + 12 Elective Credits)	**24**	

DETAILED SYLLABUS

I – Year: I – Semester

HS1011	English for Engineers - I	ESC	2-0-0	2 Credits

Pre-requisites: None

Syllabus:

Module 1

Basics of Language: Tense, Concord, Error detection, Reading Comprehension.

Module 2

Writing: Paragraphs, Precis writing, Formal letters, and Email etiquette.

Module 3

Interpretation and Critical Thinking: Cross cultural communication, Identifying biases, Interpretation of visual data and information, and Logical reasoning.

Module 4

Understanding Audience/Profiling Readers, Introduction to workplace communication, Group Contract/Team Contract, Presentation skills, and Techniques to enhance listening skills.

Text Books:

1. Anderson, Marilyn, Pramod K. Nayar, and Madhu Chanda Sen. Critical Thinking, Academic Writing and Presentation Skills. Pearson Education, 2008.
2. Emden, Joan van. Effective Communication for Science and Technology. Macmillan Education UK, 2001.
3. Murphy, Raymond. Intermediate English Grammar. Cambridge University Press, 2014.
4. Narayanaswami, V. R. Strengthen Your Writing. Orient Longman Private Limited, 2005.
5. Sharma, Sangeetha and Binoth Mishra. Communication Skills for Engineers and Scientists. PHI, 2023.

Reference Books:

1. Aarts, Bas. Oxford Modern English Grammar. Oxford University Press, 2011.
2. Blake, Gary. The Elements of Technical Writing. Pearson, 2000.
3. Carlisle, Joanne and Melinda S. Rice. Improving Reading Comprehension Research-based Principles and Practices. York Press, 2002.
4. Carter, Ronald and Michael McCarthy. Cambridge Grammar of English: A Comprehensive Guide. Cambridge University Press, 2006.
5. Carter, Ronald, Rebecca Hughes, and Michael McCarthy. Exploring Grammar in Context: Upper-intermediate and Advanced. Cambridge University Press, 2000.
6. Dobelli, Rolf. The Art of Thinking Clearly: Better Thinking, Better Decisions. Sceptre, 2013.
7. Eastwood, John. Oxford Guide to English Grammar. Oxford University Press, 1994.
8. Rolf, Dobelli. https://learnenglish.britishcouncil.org/.

MA1071	Differential and Integral Calculus	BSC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand the concepts of limit, continuity, and differentiability.
CO2	Understand the concepts of partial derivative, chain rule, and total differentiation.
CO3	Find the maxima and minima of multivariable functions.
CO4	Evaluate multiple integrals in various coordinate systems.
CO5	Apply the concepts of gradient, divergence, and curl to formulate engineering problems.
CO6	Convert line integrals into area integrals and surface integrals into volume integrals.

Syllabus:

Differential Calculus of functions of several variable: Review of Limit, continuity (sequential verification) and differentiability, Partial differentiation; Total differentiation; Euler's theorem and generalization; Change of variables- Jacobians; Maxima and minima of functions of several variables (2 and 3 variables); Lagrange's method of multipliers.

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals (including convergence); Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals.

Vector Calculus: Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stokes' theorem; Gauss Divergence theorem.

Text Books:

1. Joel R. Hass, Maurice D. Weir, George B. Thomas, Thomas' Calculus, 12th edition, Pearson, 2010.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", Eighth Edition, John Wiley and Sons, 2015.
3. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publications, 2015.
4. R. K. Jain and S. R. K. Iyengar, "Advanced Engineering Mathematics", Fifth Edition, Narosa Publishing House, 2016.

Reference Books:

1. T. M. Apostol, Calculus, Volumes 1 and 2 (2nd Edition), Wiley Eastern, 1980.

PH1011	Engineering Physics	BSC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Solve engineering problems using the concepts of wave and particle nature of radiant energy.
CO2	Understand the use of lasers as light sources for low and high energy applications.
CO3	Construct quantum mechanical model to explain the behaviour of a system at microscopic level.
CO4	Apply the concepts of energy harvesting and understand the mechanisms of photo-voltaic cells.
CO5	Understand the nature and characterization of magnetic and nano-materials for applications.

Syllabus:

UNIT I: WAVE OPTICS

Interference: Superposition principle, coherence of light, methods to produce coherent light: division of amplitude and wave front division, Young's double slit experiment: concept, working principle, and applications, Newton's ring: concept, working principle, and applications.

Diffraction: Fraunhofer's single-slit diffraction, diffraction grating, and resolving power of a grating.

Polarization: Types of optical polarization, various methods to produce polarized light, working and applications of retarder plates, and half-shade polarimeter: construction and working principle.

UNIT II: LASERS

Basic theory of LASER, Einstein's coefficients and their relations, concept of population inversion, components of lasers, three and four level lasing systems, construction and working principle of various types of lasers: Nd-YAG, Helium-Neon and semiconductor lasers and their applications.

UNIT III: QUANTUM PHYSICS

Origin of quantum theory and related experiments: Black-Body radiation and photo-electric effect. Heisenberg's uncertainty principle, de- Broglie's wave concept, wave function, and its properties, operators, Schrödinger's time-dependent and time-independent equations (Quantitative), particle in one-dimensional, infinite potential well, quantum tunneling phenomena and their applications in alpha decay, and scanning tunnelling microscopy (STM). Introduction to Quantum Technology (Q-switching, interaction of radiation with matter).

UNIT IV: PHOTOVOLTAICS

Introduction to semiconductors, Solar spectrum, photovoltaic (PV) effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, and applications.

UNIT V: MAGNETIC and NANO MATERIALS

Magnetic Materials:

Introduction to Weiss theory of ferromagnetism, concepts of magnetic domains, spontaneous magnetization, Curie transition, hard and soft magnetic materials and their applications.

Nano Materials:

Introduction, classification, and properties of nanomaterials, various methods of synthesizing nanomaterials: top-down (ball milling) and bottom-up (sol-gel) approaches.

Text Books:

1. A Textbook of Engineering Physics, M. N. Avadhanulu, P. G. Kshirsagar, S. Chand and Company (2015).
2. Concepts of Modern Physics, Beiser A., Mc. Graw Hill Publishers (2003).
3. Optics, Ajoy Ghatak, Tata Mc Graw Hill (2012).
4. Lasers- Fundamentals and Applications, Ajoy Ghatak and K. Thyagarajan, 2 nd Edition, Laxmi Publications (2019).

Reference Books:

5. Materials Science and Engineering: An Introduction (Tenth edition), William D. Callister, John Wiley & Sons (2018).
6. Introduction to Solid State Physics, 8 th Edition, Charles Kittel, Wiley Publishers (2012).

ME1031	Engineering Mechanics	ESC	2-0-0	2 Credits

Pre-requisites: None

Syllabus:

Introduction: Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space,

Equilibrium of force system: Degrees **of** freedom – Equilibrium Equations, Degree of Constraints – Free body diagrams.

Coplanar Force Systems: Introduction – Equilibrium equations – All systems, Problems**,** Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of members.

Friction in rigid bodies: Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Centroid & Moment of Inertia: Centroid and M.I. – Arial – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles: Introduction to kinematics- Equations of rectilinear motion, D'Alembert's principle -Simple problems- Introduction to kinetics- Work and Energy.

Text Books:

1. J.L.Meriam, L.G. Kraige, Engineering Mechanics, Statics, John Wiley &Sons,7th Edition, 2012.
2. A.K. Tayal, Engineering Mechanics, Umesh Publications, 14th Edition, 2010.
3. S S Bhavikatti and K G Rajashekarappa, Engineering Mechanics, New Age International Publication, 4th Edition.

Reference Books:

1. Dietmar Gross, Werner Hauger, Jorg Schroder, Wolfgang A. Wall, Nimal Rajapakse, Engineering Mechanics 1, Statics, Springer, 2nd Edition, 2013.
2. S. Timoshenko, D.H. Young, Pati Sukumar, J V Rao, Engineering Mechanics, Mc-Graw Hill, 5th Edition.

MM1011	Introduction to Metallurgical and Materials Engineering	PCC	3-0-0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Classify materials and explain the materials paradigm.
CO2	Describe structure and crystal imperfections in materials.
CO3	Explain thermal, mechanical, and electronic material properties.
CO4	Discuss metallurgy basics and applications of engineering materials.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	–	–	L	L	–	–	L	–	M	M	–	–	–
CO2	S	S	M	M	–	–	–	–	–	–	–	M	S	S	–	S
CO3	S	S	M	M	–	–	–	–	–	–	–	M	M	S	–	–
CO4	S	M	M	M	–	L	–	–	–	–	–	M	S	S	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Classes of Materials: Metals and alloys, ceramics, polymers, and composites. Materials paradigm – relation between processing, structure, properties, and applications of materials.

Structure of Materials: Atomic structure and interatomic bonding; different levels of structure in materials; polycrystalline, amorphous, and single-crystalline materials; partial crystallinity. Texture and crystallographic orientation of materials, isotropy and anisotropy. Crystal structures of metals, alloys, ceramics, and polymers. Crystal defects and imperfections in materials. Phase diagrams, allotropy, polymorphism, and polytypism.

Properties of Materials:

Thermal Properties: Heat capacity, thermal expansion, thermal conductivity.

Mechanical Properties: Elastic and plastic deformation, stress-strain behavior, tension, compression, shear force, hardness, rigidity, strength, ductility, malleability, fatigue, creep, fracture, and failure of materials.

Electronic Materials: Basics of electronic properties, conductivity, semiconductors, insulators, and superconductors.

Introduction to Extractive Metallurgy: History of metallurgy, fundamentals of ore processing and metal extraction.

Iron and Steel Metallurgy: Iron–Iron carbide phase diagram, critical temperatures, phase transformations in steels.

Applications of Materials: Structural, functional, and biomedical applications.

Text Books:

1. W.J. Callister, Materials Science and Engineering: An Introduction, Wiley, 2010.

Reference Books:

2. V Raghavan, Materials Science and Engineering – A first course, PHI Publications, 2011.

CS1011	Problem Solving through Computer Programming	ESC	3–0–0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Construct solutions to problems using computer with an understanding of the components of computing systems (apply)
CO2	Construct algorithms for mathematical and scientific problems (apply)
CO3	Construct modular programs using control structures and suitable data types (apply)
CO4	Compare alternate algorithmic approaches for problem solving and construct efficient algorithms (analyze)
CO5	Construct modular programs with an understanding of efficient memory access and usage (apply)

Detailed Syllabus:

Fundamentals of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.
Problem solving techniques – Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.
Number systems and data representation, Basics of C, Basic data types, Operators, Precedence and Associativity, Storage Classes, Dynamic Memory Allocation, Preprocessor Macros, Numbers, Digit separation, Reverse order, writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.
Factoring Methods: Finding the square root, Finding the smallest divisor of an integer, finding the greatest common divisor using Euclid's algorithm, Computing the prime factors of an integer, generating prime numbers, Raising a number to a large power, Computation of the nth Fibonacci number.
Functions – Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.
Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions.
Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays, String processing, File operations
Structures and Unions - Declaration, member variables, Problems on Complex numbers, Date, Time, Large Numbers.

Reading list:

1. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.

2. Brian W.Kernighan, Dennis Ritchie, “The C Programming Language”, 2nd edition, Person Education India, 2015.
3. Behrauz, A. Forouzan, “Computer Science: A Structured Programming Approach Using C”, 3rd edition, Cengage.
4. Hanly J R & Koffman E.B, “Problem Solving and Programm design in C”, 7th edition, Pearson Education.
5. Randal E. Bryant, David R. O’Hallaron, “Computer Systems. A Programmer’s Perspective”, 2nd Edition, Prentice Hall.
6. Ron white and Timothy Edward Downs, “How Computers work: The evolution of Technology” 10th Edition BPB Publications.

CS1012	Problem Solving through Computer Programming Lab	ESC	0 – 0 – 2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Construct, debug, test and run efficient programs by leveraging suitable flow of control constructs and syntactic units of the programming language.
CO2	Construct efficient programs by constructing and translating algorithms for solving problems using sorting, searching, selection and / or arithmetic computations.
CO3	Implement, refactor, test and debug functional programs in a shell-based runtime environment.
CO4	Construct efficient programs by demonstrating problem-solving skills and out-of-the-box algorithmic thinking.

Introduction to fundamentals of Ubuntu, Operators, Storage classes, Dynamic memory allocation, Conditional statements, Iterative statements, Factoring methods, Functions, Pointers, Single and Multidimensional Arrays, Searching and Sorting algorithms, String operations, File operations, Structures and Union.

Reading list:

1. R.G. Dromey, "How to solve it by Computer", Pearson, 2008.
2. Brian W.Kernighan, Dennis Ritchie, “The C Programming Language”, 2nd edition, Person Education India, 2015.
3. Behrauz, A. Forouzan, “Computer Science: A Structured Programming Approach Using C”, 3rd edition, Cengage
4. Hanly J R & Koffman E.B, “Problem Solving and Programm design in C”, 7th edition, Pearson Education.
5. Randal E. Bryant, David R. O’Hallaron, “Computer Systems. A Programmer’s Perspective”, 2nd Edition, Prentice Hall.
6. Ron white and Timothy Edward Downs, “How Computers work: The evolution of Technology” 10th Edition BPB Publications.

PH1012	Engineering Physics Lab	BSC	0-0-2	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand the basic properties of light by performing experiments on interference, diffraction and polarization.
CO2	Acquire the experimental knowledge by performing the experiment using light-emitting diode (LED) for energy conversion applications.
CO3	Understand the nature and characteristics of ferromagnetic and dielectric materials for memory device and sensor applications.
CO4	Apply the knowledge of Solar/ PV cells for choice of materials in efficient alternate energy generation.
CO5	Apply the concepts of wave propagation through optical fibres and communication systems.

List of experiments (any eight of the following):

S. No	Name of the experiment
1	Determination of radius of curvature of plano-convex lens using Newton's ring experiment.
2	Determination of the width of narrow-slit by diffraction method.
3	Determination of wavelength of spectral lines of Mercury light by normal incidence method using diffraction grating.
4	Determination of Planck's constant using light emitting diode.
5	Study the B-H loop hysteresis and find the coercivity and retentivity of magnetic materials.
6	Studying current-voltage characteristics of a photovoltaic material using solar cell.
7	Determination of wavelength of diode laser using diffraction by metal scale.
8	Determination of dielectric constant of various dielectric materials.
9	Determination of numerical aperture of an optical fibre.
10	Determination of specific rotation of an optically active material-using Laurent's half-shade polarimeter.

Exposure to virtual lab (any three of the following):

1. B-H Loop tracer
2. Planck's Constant
3. Numerical aperture of Optical Fibre
4. Newton's ring

Reference Books:

1. Physics Laboratory Manual, 2024, Department of Physics, School of Sciences, National Institute of Technology Andhra Pradesh, Tadepalligudem.
2. Arora, CL, 2012, B.Sc. Practical Physics, S Chand and Company Ltd., New Delhi.
3. A Textbook of Engineering Physics, M. N. Avadhanulu, P. G. Kshirsagar, S. Chand and Company (2015).
4. A Course of Experiments with He-Ne Lasers by R.S. Sirohi, New Age International (P) Ltd., (2009)

HS1022	Physical Education	HSC	0-0-2	1 Credit

Pre-requisites: None

Syllabus:

Introduction to Physical Education & EAA (Sports and Games): Meaning & Definition of Physical Education, Aims & Objectives of Physical Education, Importance of Physical Education.

Physical Fitness & Wellness Lifestyle: Meaning & Importance of Physical Fitness, Components of Physical Fitness (Cardiovascular Endurance, Strength Endurance Muscular Endurance, Flexibility, Body Composition), Components of Motor Fitness (Agility, Balance, Power, Speed, Coordination), Development of Fitness Components.

Training Methods in Physical Education: Circuit Training (Circuit Training), Continues Training (Endurance), Interval Training (Speed & Endurance), Fartlek Training (Speed Endurance), Weight Training (Maximum Strength), Plyometric Training (Power), Flexibility Training**.**

Test & Measurements: Measurements: Height, Weight, Age, Calculation of BMI, Motor Fitness and Physical Fitness Tests (Pre - Test & Post-Test), Cardiovascular Endurance - 9/12 Minute Run or Walk, Muscular Endurance – Sit Ups for abdominal strength, Strength Endurance – Flexed arm hang for girls / Pull ups for boys, (Speed – 50m Dash or 30mts Fly Start, Strength – Broad Jump, Vertical Jump for Lower Body, Medicine Ball Put for Shoulder Strength, Endurance - 800mts, Flexibility - Bend and Reach, Agility (Coordination)) – Shuttle Run and Box Run **.**

Formal Activities: Calisthenics (free hand exercises), Dumbbells, Woops, Wands, Laziums (Rhythmic activities), Aerobic Dance and Marching.

Sports / Games: Following subtopics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc., Teaching & Coaching of the Game/Sport, Latest General Rules of the Game/Sport.

- Specifications of Play Grounds and Related Sports Equipment.

I – Year: II – Semester

MA1081	**Matrix Algebra and Differential Equations**	**BSC**	**3-0-0**	**3 Credits**

Pre-requisites: Differential and Integral Calculus (MA1071)

Course Outcomes: At the end of the course, student will be able to:

CO1	Solve the consistent system of linear equations
CO2	Apply orthogonal transformations to a quadratic form
CO3	Solve higher-order linear differential equations with constant coefficients
CO4	Apply the concepts in solving physical problems arising in engineering
CO5	Apply Laplace transforms to solve initial value problems

Syllabus:

Matrix Theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigenvalues and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.

Ordinary Differential Equations of Higher Order: Review of First-order Ordinary Differential Equations, applications of first-order order linear differential equations, Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations, applications in physical problems - forced oscillations.

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem, Solving certain initial value problems, Solving system of linear differential equations, applications.

Text Books:

1. E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015.
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Fifth Edition, Narosa Publishing House, 2016.

Reference Books:

1. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole India, 2006.
2. T. M. Apostol, Calculus, Volume 2 (2nd Edition), Wiley Eastern, 1980.
3. G. F. Simmons, Differential equations with applications and historical notes. CRC Press, 2016.

ME1011	Engineering Drawing with CAD	ESC	2-0-2	3 Credits

Note: 50% of the Practice through manual drawing and
50% of the Practice through a Computer Aided Drafting Package.

Syllabus:

Introduction: Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Construction of Polygons, Scales. Introduction to Computer Aided Drafting (CAD), DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES, etc.

Orthographic Projection: Principles of Orthographic Projection, Four Systems of Orthographic Projections.

Projection of Points: Projections of points when they are situated in different quadrants.

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces.

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.

Sections of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

Isometric Views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views - simple objects.

Reference Books:

1. N.D. Bhatt and V.M. Panchal, Engineering Graphics, Charotar Publishers, 2013.
2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23 rd Edition, 201.

CY1011	Engineering Chemistry	BSC	2-0-0	2 Credits

Pre-requisites: None

Syllabus:

Basic Organic Chemistry

Reaction intermediates: carbocations, carbanions, free radicals and carbenes. Classification of organic reactions, examples and their mechanisms: substitution, addition, elimination and rearrangement reactions. Reimer–Tiemann reaction, Kolbe-Schmidt reaction, Cannizzaro reaction. Pinacol-Pinacolone, Hofmann and Beckmann rearrangements. Diels-Alder reaction.

Spectroscopic Techniques for Chemical Analysis

Introduction of spectroscopy, Quantum aspects of electronic, vibrational and nuclear energy levels. UV-Visible spectroscopy: Principle, Instrumentation, Beer-Lambert's law, Effect of conjugation, Woodward-Fieser empirical rules for acyclic/cyclic dienes. IR spectroscopy: Principle, Factors that affect vibrational frequencies and functional group detection. Proton NMR spectroscopy: Principle, Instrumentation, Chemical equivalency, Chemical shift and spin-spin splitting. Applications of UV-Vis, IR and proton-NMR spectroscopy in determining the structure of small organic molecules.

Coordination Chemistry

Introduction of coordination chemistry, Valence bond (VB) theory and shapes of Inorganic Compounds, Spectrochemical series, Crystal Field theory (CFT): octahedral and tetrahedral complexes, Crystal field splitting energy (CFSE); Molecular Orbital (MO) Theory: Molecular orbital diagrams for octahedral complexes (strong and weak ligand fields).

Electrochemistry

Electrodes, Electrochemical Cells, Electrochemical series and Nernst equation; Conductometry and Potentiometry; Batteries: Types of batteries, Ni-Cd and Lithium (Li)-ion batteries; Fuel Cells: Hydrogen-Oxygen, Methanol-Oxygen fuel cells; Corrosion - Theories of corrosion, Wet corrosion, Types of wet corrosion, Factors affecting the rate of corrosion, Corrosion control methods: Sacrificial anode method and Impressed current method.

Engineering Materials and Applications

Polymers: Introduction, Types of polymerization, Functionality in polymers, Number and Weight average molecular weight, Polydispersity index, Biodegradable polymers; Conductive polymers: classification, examples and applications; Organic light emitting diode (OLED): structure, principle and applications; Optical fibres: principle and Applications.

Reference Books:

1. Organic Chemistry, Clayden, Greaves, Warren and Wothers, Oxford University Press, 2014.
2. Organic Spectroscopy, William Kemp, 2nd edition, Macmillan publishers, 2019.
3. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo and Manfred Bochmann, 6th Edition, 1988.
4. Physical Chemistry, P. Atkins and Julio de Paula, 8th Edition, Freeman & Co. 2017.
5. A Textbook of Engineering Chemistry, Shashi Chawla, 2017.

EE1601	Basic Electrical & Electronics Engineering	ESC	2-0-0	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Analyze DC & AC circuits and determine power & power factor.
CO2	Understand the principle and operation of transformers
CO3	Identify the type of electrical machines for a given application
CO4	Acquire the knowledge on electrical safety
CO5	Analyze basic electronic circuits.

Syllabus:

DC Circuits: Kirchoff's voltage and current laws, superposition theorem, star delta transformations.

AC Circuits: Complex representation of impedance, phasor diagrams, power & power factor, solution of 1-phase series & parallel circuits.

Single Phase Transformers: Principle of operation of a single-phase transformer, emf equation, phasor diagram, equivalent circuit of a 1-phase transformer, voltage regulation & efficiency.

Electrical Machines: DC Machines- principle of operation, classification, emf and torque equations, characteristics of DC generators and motors. 3-Phase induction motor- principle of operation, torque – speed characteristics & applications.

Electrical Safety: Electrical shock and precautions, concept of fuses, and application; concept of earthing.

Electronic Devices & Circuits: P-N junction diode, I-V characteristics, bipolar junction transistor operation and characteristics.

Text Books:

1. Engineering Circuit Analysis, William H. Hayt Jr., Jack E. Kemmerly, Steven M. Durbin, Tata McGraw Hill, 2020, 9th Edition.
2. 2. Fundamentals of Electrical Circuits by Charles k. Alexander, Mattew N.O. Sadiku, Tata McGraw Hill, 2022, 7th Edition.
3. V.N.Mittle, Basic Electrical Engineering, 2nd edition, MC Graw Hill Education, 1 July 2017.
4. Ravish R Singh, Basic Electrical Engineering, MC Graw Hill Education, 3rd edition, 2018.
5. R. Boylested and L. Nashelsky, "Electronics Devices and Circuits", Prentice Hall India, 2009.

Reference Books:

1. J. A. Edminister, Electric Circuit Theory, Schaum's Outline series: 5th edition, McGraw Hill, 2017.
2. D. P. Kothari & I.J. Nagrath, Basic Electrical Engineering, 4th edition, MC Graw Hill Education, 2019.

MM1511	Ores & Minerals Processing	ESC	2-0-0	2 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain sampling methods and comminution fundamentals.
CO2	Apply sizing and classification methods to mineral particles.
CO3	Analyze concentration techniques used in mineral processing.
CO4	Evaluate separation techniques for ore beneficiation applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	M	M	L	–	–	L	L	–	M	S	M	–	–
CO2	S	S	M	S	S	–	–	–	L	L	L	S	S	S	–	–
CO3	S	S	M	S	S	–	–	–	L	M	L	S	S	S	–	–
CO4	S	S	M	S	S	M	M	L	L	M	M	S	S	S	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of mineral processing and its importance in extractive metallurgy. Ore sampling methods – hand and mechanical sampling; sampling errors.

Comminution of Minerals: Mineral liberation theory. Crushing – primary, secondary, and special crushers (jaw, gyratory, cone, rolls, toothed rolls). Grinding – batch and continuous, dry and wet, open and closed-circuit grinding. Grinding Mills – ball, rod, and tube mills; theory of ball mill operation. Laws of comminution – Kick's, Rittinger's, and Bond's theories.

Sizing and Classification of Minerals:
Industrial sizing units – screen surfaces, grizzlies, trommels, vibrating and shaking screens. Movement of solids in fluids – Stokes' and Newton's laws, terminal velocity, time and distance relations. Settling ratios – equal settling, free and hindered settling. Classification – types of classifiers: settling cones, rake, spiral classifiers, cyclones.

Concentration of Minerals: Heavy Media Separation – principles, flowchart, media used; separation with heavy liquids/suspensions; washability curves. Jigging – theory, jigging machines (Harz, Hancock), design considerations. Tabling – stratification, shaking tables (Wilfley), theory of flowing film concentration. Flotation – principles, physical and chemical aspects, influencing factors; collectors, frothers, regulators; flotation of copper, lead, zinc ores. Magnetic and Electrostatic Separation – principles and applications.

Text Books:
1. Barry Wills and James Finch, Mineral Processing Technology, Elsevier, 2016.

Reference Books:
2. S. K. Jain, Mineral Processing, CBS publishers, 2005.
3. S K Haldar - Mineral Exploration: Principles and Applications, Elsevier, 2019.

MM1521	**Engineering Thermodynamics**	**PCC**	**2-0-0**	2 **Credits**

Pre-requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Define thermodynamic systems, processes, and laws.
CO2	Apply the first law in thermodynamic calculations and processes.
CO3	Analyze entropy, free energy, and thermodynamic equations.
CO4	Apply phase rule and third law to chemical equilibrium.

Course Articulation Matrix:

PO/PSO → CO ↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	S	M	–	–	–	–	–	–	–	–	–	M	S	–	–	–
CO2	S	S	M	M	–	–	L	–	–	–	–	M	S	M	–	–
CO3	S	S	M	S	–	–	L	–	–	–	–	S	S	S	–	–
CO4	S	S	M	S	–	–	M	–	–	–	–	S	S	S	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Fundamentals: Basic concepts and definitions-Thermodynamic systems, thermodynamic variables, thermodynamic processes, cycle and equilibrium, reversible and irreversible processes, zeroth law of thermodynamics.

First Law of Thermodynamics: Internal energy, Enthalpy, Constant volume and constant pressure process; Isothermal and adiabatic process. Heat capacity, Enthalpy of physical transformations and chemical reactions, Hess's law and Kirchhoff's law and applications, Thermochemistry.

Second Law of Thermodynamics: Entropy and disorder, Configurational entropy and thermal entropy; calculation of entropy change from heat capacities, variation of entropy with temperature, Principle of increase in entropy, Combined statement of I and II laws, Thermodynamic equation of state, Applications of thermodynamic equations of state. Free energy functions, Properties of the Gibbs energy, Calculation of Gibbs free energy, Variation of Gibbs energy with temperature and pressure. Maxwell's relations, Gibbs- Helmholtz equation.

Third Law of Thermodynamics: Clausius-Clapeyron equation and its uses. Fugacity, Activity and Equilibrium constant, variation of equilibrium constant with temperature. Concept of chemical potential, Gibbs phase rule and its derivative, Applications of Gibbs phase rule.

Text Books:

1. P.K. Nag, Engineering Thermodynamics, McGraw-Hill Education, 2017.

Reference Books:

2. A. Venkatesh, Basic Engineering Thermodynamics, Universities Press, 2007.
3. D. R. Gaskell, Introduction to Thermodynamics of Materials, Taylor & Francis, 2018.
4. R. T. DeHoff, Thermodynamics in Materials Science, McGraw Hill, 1993.

ME1062	Fabrication Laboratory	ESC	0-0-2	2 Credits

Pre-requisites: None

Syllabus:

1. **Fitting Shop:** Preparation of T-Shape Work piece as per the given specifications, Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding, and Practice marking operations.
2. **Machine shop:** Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaping operation. Demonstration of the working of CNC and 3D Printing Machines.
3. **Power Tools:** Study of different hand operated power tools, uses and their demonstration and Practice of Power tools.
4. **Carpentry:** Study of Carpentry Tools, Equipment and different joints, Practice of Cross Half lap joint, half lap Dovetail joint and Mortise Tenon Joint.
5. **Welding:** Study of welding tools and welding equipment, Arc Welding Practice (Lap and Butt joint).

CY1042	Chemistry Laboratory - 1	BSC	0-0-2	2 Credits

Pre-requisites: None

Syllabus:

List of experiments (any eight of the following):

Exp. No	Name of the experiment
1	Standardization of $KmnO_4$ solution
2	Determination of Iron in Haematite
3	Determination of Hardness of Water
4	Determination of available chlorine in bleaching powder and of iodine in Iodized salt
5	Ph-metric titration of an acid vs a base
6	Conductometric titration of an acid vs a base
7	Potentiometric titration of Fe^{2+} against $K_2Cr_2O_7$
8	Colorimetric determination of Potassium Permanganate
9	Determination of rate of Corrosion of mild steel in acidic environment in the absence of presence of an inhibitor
10	Determination of Chlorophyll in Olive oil by using UV and Fluorescence spectroscopic techniques
11	Functional group analysis of organic compounds by using IR spectroscopic technique
12	Organic solvent evaporation by using rotary-evaporation technique

Virtual labs

1. Determination of unknown concentration of analyte by using the Beer-Lambert's law.
2. Identification of unknown components using spectroscopic techniques.
3. Nuclear magnetic resonance spectroscopy and evolution of simple ^1H NMR spectra of organic compounds
4. Study of kinetics of a reaction by using spectrophotometric methods.

References:

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 1st Edition, 2006.

HS1032	Health Education	HSC	0-0-2	2 Credits

Pre-requisites: None

Syllabus:

Health Education & Personal Hygiene: Introduction & Meaning of Health Education, Definition of Health Education, Principles of Health Education, Importance of Health Education, Meaning of Personal Hygiene, Importance of Personal Hygiene, Personal cleanliness (teeth, ears, eyes, nose & throat, nails & fingers, skin, cloths, and hair).

Nutrition: Introduction of Nutrition, Balanced Diet, Daily Energy Requirements, Nutrient Balance, Nutritional Intake, Eating and Competition, Ideal Weight

First Aid & Injury Management: Introduction, Types and Principles of First Aid, Functions of First Aider, Reasons for Sports Injuries, The First Aid and Emergency Treatment in Various cases (drowning, dislocation & fractures, burns, electric shock, animal bite, snake bite, poison, etc.

Human Posture: Introduction, Meaning of Posture, types of Good Posture, causes of Poor Posture, preventive and Remedial Poor Posture, common Postural Deformities, Body Types, Advantages of Good Posture

Yoga: Introduction, Meaning & Importance of Yoga, Elements of Yoga, Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas, Yoga for concentration & related Asanas (standing asanas, sitting asanas, supine and prone postures.), Relaxation Techniques for improving concentration – Yoga – Nidra, Pranayama.

Sports / Games: Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc., Teaching & Coaching of the Game/Sport., Latest General Rules of the Game/Sport, Specifications of Play Grounds and Related Sports Equipment.

II – Year: I – Semester

MA2071	**Transform Techniques and Numerical Methods**	**BSC**	**3-0-0**	**3 Credits**

Pre-Requisites: Differential & Integral Calculus (MM1071), Matrix Algebra & Differential Equations (MM1081)

Course Outcomes: At the end of the course, student will be able to:

CO1	Obtain the Fourier series for a given function
CO2	Find the Fourier transform of a function and Z- transform of a sequence
CO3	Determine the solution of a PDE by variable separable method
CO4	Interpret an experimental data using interpolation / curve fitting
CO5	Solve numerically algebraic/transcendental and ordinary differential equations

Syllabus:

Fourier Series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions.

Fourier Transforms: Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Partial Differential Equations: Classification of Second order linear Partial Differential Equations, D'alembert's solution of wave equation, Method of separation of variables - Solution of one dimensional wave equation, one dimensional heat conduction equation and two dimensional steady state heat conduction equation with illustrations.

Numerical Methods: Numerical solution of algebraic and transcendental equations by Regula- Falsi method and Newton-Raphson’s method, Gauss-Seidal iteration method to solve a system of linear equations,Newton-Raphson’s method to solve a system of nonlinear equations - Lagrange interpolation, Forward and backward differences, Newton’s forward and backward interpolation formulae - Numerical differentiation with forward and backward differences - Numerical Integration with Trapezoidal rule, Simpson’s 1/3 rule and Simpson’s 3/8 rule - Taylor series method, Euler’s method, modified Euler’s method, 4th order Runge-Kutta method for solving first order ordinary differential equations.

Text Books:

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Pub. House,Fifth edtion, 2016.
2. 2. E. Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8 th Edition, 2008.
3. 3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 44th edition, 2017.
4. 4. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.

Reference Books:

1. K. S. Rao, Introduction to partial differential equations. PHI Learning Pvt. Ltd., 2010.
2. S. S. Sastry, Introductory methods of numerical analysis. PHI Learning Pvt. Ltd., 2012.

ME2111	Strength of Materials	ESC	2-0-0	2 Credits

Pre-requisites: Engineering Mechanics

Course Outcomes: At the end of the course, student will be able to:

CO1	Identify material behavior through testing and characterization.
CO2	Analyze stress, strain, and deformation in materials.
CO3	Calculate shear force, bending moment, and stresses in beams.
CO4	Evaluate torsion, principal stresses, and failure theories.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	--	M	S	--	--	--	--	--	--	M	S	S	M	S
CO2	S	S	M	M	M	--	L	--	--	--	--	M	M	S	--	S
CO3	S	S	S	S	M	--	--	--	L	--	--	M	M	S	--	M
CO4	M	S	S	S	M	--	L	--	--	--	L	M	M	S	--	M

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Material Testing and Characterization: Basic assumptions, destructive and non-destructive testing methods – tensile, compression, hardness, impact, fatigue, creep; characterization technique – TEM, XRD, SEM.

Stress and Deformation: Resistance and deformation concepts, determinate and indeterminate problems, thermal stresses, pure shear, elastic constants, stress-strain behavior for ductile and brittle materials, working stress, strain energy, and impact loading.

Thin Cylinders: Analysis of thin cylinders and spherical shells under internal pressure, wire-wound and compound cylinders, shrink fit.

Shear Force and Bending Moment: Types of supports, beams, and loads; SFD and BMD for various loading conditions.

Bending and Shear Stress: Bending theory, stress in beams, composite beams, shear stress distribution in beam cross sections.

Shear Stress Distribution: Flexural shear stress distribution in different cross sections of beams.

Torsion: Torsion in circular shafts, power transmission, combined bending and torsion analysis.

Principal Stresses and Strains: Biaxial stress analysis, Mohr's Circle.

Theories of failure: Maximum stress, strain, shear, strain energy, and distortion energy theories.

Text Books:

1. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw Hill, New York, 1986.

Reference Books:

2. Goodno, Barry J., and James Gere. Statics and Mechanics of Materials. Cengage Learning, 2018.
3. Shames, I. H., & Pitarresi, J. M. Introduction to Solid Mechanics, 2000.

MM2011	Physical Metallurgy	PCC	3-0-0	3 Credits

Pre-Requisites: Engineering Physics, Engineering Chemistry

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain the crystal structures and defects in crystals.
CO2	Describe the concepts of constitution of alloys.
CO3	Interpret important binary and ternary phase diagrams.
CO4	Apply diffusion theory to phase transformations and microstructural evolution.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	M	L	–	–	–	–	–	–	M	M	S	–	S
CO2	S	S	M	M	M	–	–	–	–	–	–	M	S	S	M	M
CO3	S	S	M	S	M	–	L	–	–	–	–	M	S	S	–	M
CO4	M	S	M	S	S	–	–	–	–	–	L	M	M	M	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Crystal Structure and Defects: Crystal systems, Bravais lattices, packing factor, Miller indices, stacking sequence in cubic and HCP structures, voids. Point, line, and planar defects; dislocations and slip system.

Alloys and Phase Diagrams: Solid solutions, Hume-Rothery rules, intermediate phases. Phase rule, single, binary and ternary phase diagrams, invariant reactions. Key systems: Cu–Zn, Cu–Sn, Al–Cu, Al–Si.

Iron and Carbon system: Fe-C and Fe-F3C phase diagrams, phase transformations in steels: iso-thermal transformations and non iso-thermal transformations; Cast irons: White, gray, malleable, nodular cast irons, their microstructures and properties

Microstructure Characterization Techniques: Optical and electron microscopy; microstructural analysis and interpretation.

Case Studies/Applications: Microstructure-property relationships, and alloy selection using phase diagrams.

Text Books:

1. V. Raghavan, Physical Metallurgy: Principles and Practice, PHI Learning, 2004.

Reference Books:

2. S. H. Avner, Introduction of Physical Metallurgy, Mc Graw Hill, 1987.
3. R E Reed Hill, Physical Metallurgy Principles, PWS Publishing, 2008.

MM2021	Principles of Extractive Metallurgy	PCC	3-0-0	3 Credits

Pre-Requisites: Ores & Mineral Processing

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain basic unit operations in mineral/ore processing for metal extraction.
CO2	Apply Ellingham diagrams and thermodynamic principles in metal extraction.
CO3	Describe unit processes in pyro-, hydro-, and electrometallurgy.
CO4	Analyze kinetics, heat/material balance, and process flow in metal extraction.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	M	S	–	–	–	–	–	–	M	S	–	M	–
CO2	S	S	M	M	M	–	L	–	–	–	–	M	S	S	–	–
CO3	S	S	M	S	M	–	M	–	–	–	–	M	S	S	–	M
CO4	M	S	S	S	S	–	S	–	–	–	L	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Scope of extractive metallurgy, occurrence and classification of ores and minerals, basics of mineral processing, theories of comminution, crushing and grinding equipment, solid-fluid separation, settling laws, classifiers, and introduction to fuels and refractories.

Pyrometallurgy: Drying, calcination, roasting (with Kellogg's diagram), Ellingham diagrams for reduction processes, smelting, converting, slag chemistry, and fire refining techniques (liquation, distillation, and zone refining).

Hydrometallurgy: LPrinciples of leaching (acidic, basic, and bioleaching), Pourbaix diagrams, purification (solvent extraction, ion exchange), and metal recovery from solutions (precipitation, cementation, and crystallization).

Electrometallurgy: Fundamentals of electrolysis, electrochemical cell design, electro-winning, electro-refining, electrodeposition, and current efficiency.

Process Advancements and Recent Practices: Modern trends in extraction processes, sustainable and energy-efficient techniques.

Text Books:

1. 1. H.S. Ray and A. Ghosh, Principles of Extractive Metallurgy, New Age International, 1991.

Reference Books:

2. S.K. Dutta, A.B. Lele, Y.B. Chokshi, Extractive Metallurgy: Processes and Applications, PHI Learning, 2018.

MM2031	Metallurgical Thermodynamics and Kinetics	PCC	2-0-0	2 Credits

Pre-Requisites: Engineering Thermodynamics

Course Outcomes: At the end of the course, student will be able to:

CO1	Apply laws of gases to metallurgical systems.
CO2	Analyze thermodynamics of metallurgical solutions.
CO3	Evaluate reaction kinetics in heterogeneous systems.
CO4	Interpret rate expressions and thermal analysis data.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	M	L	–	–	–	–	–	–	M	S	M	–	–
CO2	S	S	M	M	M	–	–	–	–	–	–	M	M	S	–	M
CO3	S	S	S	S	M	–	L	–	–	–	–	M	M	S	–	S
CO4	M	S	M	S	M	–	–	–	–	–	L	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, “–”: No correlation

Syllabus:

Pure Substances: Concepts of mole, molarity, and molality; Avogadro’s law, Boyle’s law, and their applications in metallurgical systems.

Solution Thermodynamics: Composition and partial molal quantities, Gibbs-Duhem equation and its integration, thermodynamic properties of binary solutions—ideal, non-ideal, and regular solutions; Raoult’s, Henry’s, and Sievert’s laws; activity and activity coefficients; excess functions.

Metallurgical Kinetics: Kinetics of heterogeneous reactions (gas-solid, solid-liquid, liquid-liquid, solid-solid), empirical and semi-empirical rate expressions, Johnson-Mehl equation, and basics of thermal analysis.

Text Books:

1. D. R. Gaskell, Introduction to Thermodynamics of Materials, Taylor & Francis, 2018.

Reference Books:

2. R. T. DeHoff, Thermodynamics in Materials Science, McGraw Hill, 1993.
3. G.S.Upadhyaya & R.S.Dube, Problems in Metallurgical Thermodynamics and Kinetics, Pergamon, 1977.

MM2041	Transport Phenomena	PCC	3-0-0	3 Credits

Pre-Requisites: Engineering Physics, Engineering Thermodynamics

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand fluid flow behavior in metallurgical systems.
CO2	Analyze heat transfer under various operating conditions.
CO3	Evaluate steady and unsteady-state mass transfer.
CO4	Integrate momentum, heat, and mass transfer principles.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	S	M	–	–	–	–	–	–	M	S	S	–	–
CO2	S	S	M	S	M	–	L	–	–	–	–	M	M	S	–	S
CO3	S	S	M	S	M	–	M	–	–	–	–	M	M	S	–	M
CO4	M	S	S	S	S	–	M	–	–	–	L	S	M	S	M	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of unit operations in chemical metallurgy and engineering fundamentals of unit processes..

Momentum Transfer: Fluid flow properties, viscosity, types of flow, Reynolds experiment, continuity and motion equations, momentum balance, velocity profiles, Navier-Stokes equation, fluid flow in packed beds, Bernoulli's equation, friction in pipes, pumps, blowers, and compressors.

Heat Transfer: Fourier's law of heat conduction, steady and unsteady-state conduction, natural and forced convection, heat transfer coefficients, thermal boundary layer, radiation heat transfer, phase change heat transfer, solidification heat transfer, ablation, and heat transfer in packed/fluid beds.

Mass Transfer: Diffusivity, steady-state diffusion, Darken's equation, Kirkendall effect, unsteady-state mass transfer, mass transfer coefficients, concentration boundary layers, inter-phase mass transfer theories, simultaneous mass and heat transfer, classification of diffusional operations, model and pilot plant studies, and similarities in momentum, mass, and energy transfer.

Text Books:

1. G. H. Geiger, D. R. Poirier, Transport phenomena in Materials Processing, John Wiley& Sons, 2010.

Reference Books:

2. David R Gaskell, An Introduction to Transport Phenomena in Materials Engineering, Momentum Press, 2013.
3. R. B. Bird, W.E. Stewart, E.N. Lightfoot, Transport phenomena, Wiley- India, 2011.
4. G. S. Upadhyaya and R. K Dube, Problems in Metallurgical Thermodynamics and Kinetics, Pergamon, NewYork, 1982.

MM2052	Physical Metallurgy and Metallography Laboratory	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Perform sample preparation for metallographic analysis.
CO2	Apply etching techniques for microstructure revelation.
CO3	Analyze microstructures and quantify metallurgical phases.
CO4	Use software for grain size and phase analysis.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	M	M	S	–	–	M	–	M	M	S	M	–	S
CO2	M	M	M	S	M	M	–	–	M	–	L	M	S	M	–	S
CO3	S	S	M	S	M	–	–	–	M	–	–	S	M	S	–	S
CO4	M	S	S	M	S	–	–	–	M	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

List of experiments:

1. To prepare an alloy (Steel / Al / Cu) sample for Microstructural Analysis: Sample preparation for metallography: sandpaper polishing, cloth polishing, electropolishing .
2. To etch the polished sample. Etching of polished samples - ferrous and nonferrous specimens.
3. Quantitative metallography and image analysis.
4. To measure the Grain size using line intercept method and ImageJ software.
5. To calculate volume fraction of phases.
6. Introduction to Safety Practices.

Reference Books:

1. Physical Metallurgy and Metallography Laboratory manual.

MM2062	Extractive Metallurgy Laboratory	PCC	0-0-3	2 Credits

Pre-Requisites: None

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Perform calcination and reduction processes experimentally.
CO2	Conduct leaching and cementation for metal recovery.
CO3	Execute anodizing and electroplating of metals.
CO4	Analyze deposition uniformity and process efficiency.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	S	M	L	–	–	M	–	M	M	S	S	–	–
CO2	S	S	M	S	M	L	–	–	M	–	L	M	S	S	–	M
CO3	M	M	S	S	S	L	–	–	M	M	M	S	M	S	–	S
CO4	M	S	M	S	S	–	–	–	M	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

List of experiments:

1. Calcination of the given sample of limestone and report the degree of calcinations.
2. Reduction of cupric oxide carbo-thermically and calculate percentage of reduction.
3. Study the effect of time on the amount of copper deposited on steel plates during cementation.
4. Leaching of metal oxide ores to extract corresponding metal.
5. Anodize the given aluminium sample and colour the sample with a dye and seal the pores.
6. Electroplating of copper coating on a given electrode through reduction of Cu ions.
7. Electroplating of nickel coating on a given electrode through reduction Ni ions.
8. Study the throwing power of a given electrolytic bath to deposit metal of uniform thickness.

Reference Books:

1. Extractive Metallurgy Laboratory manual

HS2011	Personality Development	HSC	2-0-0	1 Credits

Pre-Requisites: None

CO1	Students will develop a deeper self-awareness, gaining insights into their strengths, weaknesses, values, and emotional triggers.
CO2	Students will enhance their communication skills, enabling them to express themselves more clearly and engage effectively with others.
CO3	Students will improve their emotional intelligence and cultivate a growth mindset, equipping them to navigate challenges with resilience and adaptability.
CO4	Students will strengthen their abilities in conflict management, adaptability, and networking, preparing them for successful interactions in personal and professional contexts.

Syllabus:

Module 1: Introduction to personality development - self assessment- SWOT - personal values statement - (punctuality, attitude, responsibility, ethics, integrity, values, and trust, and self-confidence) - imposter syndrome, communication skills (verbal and non-verbal, body language and posture, avoiding miscommunication) - techniques for persuasive communication - key principles to increase clarity of communication.

Module 2: Emotional Intelligence - ways to improve emotional intelligence - application of emotional intelligence - identifying emotional triggers - Building rapport and maintaining positive interactions - Fixed and growth mindset - emotions in personal and professional relationships, strategies for effective networking - social and dining etiquette - greetings - dress code.

References:

1. Mitra, Barun K. Personality Development and Soft Skills. 2nd ed. Oxford Higher Education, 2016.
2. Sharma, Prashant. Soft Skills: Personality Development for Life Success. 3rd ed. BPB Publications, India, 2022.
3. Goleman, D. (1995). Emotional intelligence: Why it can matter more than IQ. Bantam Books.
4. Carnegie, D. (2020). How to win friends and influence people. Srishti Publishers and Distributors.
5. Khera, S. (2014). You can win: A step-by-step tool for top achievers. Bloomsbury India.

HS2022	Yoga	HSC	0-0-2	1 Credits

II – Year: II – Semester

MM2511	Iron Making	PCC	3-0-0	3 **Credits**

Pre-Requisites: Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain preparation and testing of burden materials.
CO2	Analyze blast furnace operations and impurity removal.
CO3	Compare alternative and conventional iron making routes.
CO4	Evaluate sustainability and new trends in iron making.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	M	M	–	–	–	–	–	–	M	S	S	–	–
CO2	S	S	M	S	M	–	–	–	–	–	–	M	S	S	–	M
CO3	M	S	S	M	M	–	M	–	–	–	–	M	S	M	–	M
CO4	M	S	M	M	M	M	S	M	–	–	M	S	M	M	–	M

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Iron Making: Preparation of burden materials (coal, coke, limestone, dolomite), sintering and pelletization of iron ore, testing of burden materials.

Blast Furnace Operations: Blast furnace structure and accessories, operational procedures, thermal, physical, and chemical processes in the blast furnace, slag formation and control, hot metal composition control, removal of impurities (phosphorus, sulfur, and silicon), control of irregularities, performance evaluation over the years, modern trends in blast furnace design and practice.

Alternate Routes of Iron Making: Sponge iron production, direct reduction, smelting-reduction, comparative analysis with blast furnace route.

Recent Advancements in Iron Making: Technological developments, energy efficiency, environmental impact reduction, sustainability in iron production.

Text Books:

1. Ahindra Ghosh and Amit Chatterjjee, Ironmaking making: Theory and practice, PHI learning private limited, 2008.

Reference Books:

2. S.K. Dutta, Y. B. Chokshi, Basic Concepts of Iron Making, Springer, 2020.
3. R. J. Fruehan (ed.), The making, shaping and treating of steel, AISE, 1998.
4. R. H. Tupkary and V. R. Tupkary, Production of Steel: Theory and Practice, Tupkary Publication, 2021.

MM2521	Casting and Solidification	PCC	3-0-0	3 Credits

Pre-Requisites: Physical Metallurgy, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Describe casting steps and pattern/mold design.
CO2	Differentiate casting processes and their applications.
CO3	Identify casting defects and apply quality controls.
CO4	Explain solidification mechanisms and structure control.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	–	–	–	–	–	–	–	M	S	M	–	–
CO2	S	S	M	M	–	M	–	–	–	–	L	S	S	S	–	–
CO3	S	S	M	M	–	M	M	–	–	–	L	S	S	S	–	–
CO4	S	M	M	M	–	M	S	L	–	M	M	S	M	S	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Casting: Steps in casting, pattern making, mold/core making, riser and gate design, melting equipment, fluidity, solidification time (Chvorinov's rule), pattern allowances (shrinkage, draft, machining, shake/rapping, distortion).

Types of Casting Processes: Sand, Investment, Die, Low-pressure, Centrifugal, Gravity die, Vacuum die, Squeezing die casting, Ingot casting, Continuous casting of steels.

Defects in Casting: Defects in castings, quality control, fettling, repair, and heat treatment.

Solidification: Pure metal/alloy solidification, thermal undercooling, nucleation, growth kinetics, solute diffusion, constitutional undercooling, solid-liquid interface nature (planar, cellular, dendritic), micro/macro segregation, shrinkage, zones in cast structure, polyphase solidification (eutectic, peritectic, monotectic), directional solidification, single crystal growth, rapid solidification.

Recent advances: 3D printing in the casting industry.

Text Books:

1. R. Heine, C. Loper, P. Rosenthal, Principles of Metal Casting McGraw Hill, 2017.
2. W. Kurz & D.J. Fisher, Fundamentals of solidification, Trans Tech publications, 1998.

Reference Books:

3. M.C. Fleming, Solidification Processing, McGraw Hill, 1974.
4. Doru Stefanescu, Science and Engineering of Casting Solidification, Springer, 2009.

MM2531	Mechanical Behaviour of Materials	PCC	3-0-0	3 Credits

Pre-Requisites: Physical Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand elastic, plastic behavior, and stress-strain relations.
CO2	Explain dislocation theory and deformation mechanisms.
CO3	Apply strengthening mechanisms in engineering materials.
CO4	Interpret mechanical testing methods and failure modes.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	–	–	–	–	–	–	M	S	S	–	–
CO2	S	S	M	M	M	–	–	–	–	–	–	M	S	S	–	M
CO3	S	S	M	M	M	–	–	–	–	–	–	S	M	S	–	M
CO4	S	S	M	S	S	–	L	–	–	–	L	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:
Introduction: Elastic and plastic behavior, stress and strain, key mechanical properties..
Dislocation Theory: Imperfections in solids, dislocations (edge, screw, mixed), Burger vector, dislocation movement, glide, climb, Peierls and Nabarro stress, energy of dislocations, dislocation-precipitate interactions, Frank-Read source, twinning, jogs, kinks, dislocation pileups, geometrically necessary dislocations.
Strengthening Mechanisms: Solid solution, strain hardening, grain boundary strengthening, second-phase strengthening (precipitation hardening, GP zones, particle cutting/Orowan mechanism), dispersion and fiber strengthening.
Material Property Testing:
Hardness Testing: Types (Mohs, Brinell, Rockwell, Vickers, microhardness, rebound/dynamic).
Tensile Testing: Elastic/plastic deformation, stress-strain diagram, yield point, strain aging.
Compression Testing: Test setup, behavior of ductile and brittle materials, barreling effect.
Impact Testing: Notch sensitivity, DBTT, metallurgical factors, embrittlement.
Fracture Mechanics: Griffith's brittle fracture, ductile fracture mechanisms.
Fatigue Testing: S-N curve, fatigue limit, stress concentration, effect of metallurgy.
Creep Testing: Creep curve, stress-rupture test, deformation at elevated temps, creep-resistant materials.

Text Books:

1. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw Hill, New York, 1986.

Reference Books:

2. Norman E. Dowling, Mechanical Behavior of Materials, 2nd Edition, Prentice-Hall, Upper Saddle River, New Jersey, 1999.

3. Thomas H. Courtney, Mechanical Behavior of Materials, 2nd Edition, McGraw Hill, New York, 2000.
4. M.A. Meyers and Chawla K, Mechanical Behavior of Materials, 2nd Edition, Cambridge University Press, 2009.

MM2541	Principles of Heat Treatment	PCC	2-0-0	2 Credits

Pre-Requisites: Physical Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Interpret Fe-Fe_3C diagram and TTT/CCT behavior.
CO2	Explain heat treatment processes and defect mechanisms.
CO3	Describe heat treatment of alloy steels and cast irons.
CO4	Apply surface and age hardening techniques.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	S	–	–	–	–	–	L	–	M	S	S	–	S
CO2	S	S	M	S	M	L	–	–	–	L	–	S	S	S	–	S
CO3	S	S	M	S	–	L	–	–	–	M	L	S	S	S	–	S
CO4	S	M	M	S	–	M	L	L	–	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Fe-Fe_3C phase diagram, Austenite grain growth, determination of grain size, Isothermal Transformation Diagrams (Pearlite, Bainite, Martensite), CCT, effect of alloying on TTT/CCT curves..

Heat Treatment Processes: Annealing, Normalizing, Hardening, Tempering of Steels, hardening defects, temper embrittlement, sub-zero treatment, quenching media, residual stress, quench cracks, martempering, austempering. Hardenability and its measurement, effect of alloying on hardenability.

Heat Treatment of Alloy Steels: Classification of alloy steels, advantages and disadvantages, heat treatment of HSLA, tool steels, Hadfield Mn steel, and stainless steels.

Heat Treatment of Cast Irons: Structure-property correlation, manufacturing, malleableization, austempered ductile irons, alloy cast irons.

Age Hardening: Concept of age hardening, steps, applications, study of age-hardened alloys (ferrous/non-ferrous).

Case Hardening and Surface Treatments: Carburizing, nitriding, cyaniding, carbonitriding, nitrocarburizing, boronizing, case depth measurement, flame, induction, and laser hardening, industrial heat treatment practices, and case studies.

Text Books:

1. D. A. Porter, K. E. Easterling, M.Y. Sherif, Phase Transformation in Metals and Alloys, CRC press, 2009.

Reference Books:

2. R. C. Sharma, Phase Transformations in Materials, CBS Publishers, 2017.
3. V. Raghavan, Solid State Transformations, Prentice-Hall India, 1987.
4. T.V. Rajan & C.P. Sharma, Heat Treatment: Principles and Techniques, PHI, 1994.

MM2552	Heat Treatment Laboratory	PCC	0-0-2	1 Credits

Pre-Requisites: Physical Metallurgy

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Observe and analyze microstructures of treated steels.
CO2	Compare effects of various quenching media.
CO3	Perform Jominy end-quench and hardness testing.
CO4	Conduct ageing treatment and study Al alloy behavior.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	S	M	–	–	–	M	–	–	M	M	S	–	S
CO2	M	M	M	M	M	–	–	–	M	–	–	M	M	S	–	S
CO3	M	S	M	S	S	L	–	–	M	M	M	S	M	S	–	S
CO4	M	S	M	S	S	–	–	–	M	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, “–”: No correlation

Syllabus:

List of Experiments:

1. To study Microstructure of Annealed steel samples.
2. To study Microstructure of Normalized steel samples.
3. To study the Microstructure of Hardened Steels (oil quenching, agitated oil quenching, water quenching, agitated water, flowing water quenching.
4. To study Microstructure of tempered steel samples.
5. Jominy End Quench Test and Hardness testing.
6. Ageing treatment of Aluminium alloy (2XXX or 7XXX)

Text Books:

1. Heat Treatment Laboratory Manual

MM2562	Mechanical Behaviour of Materials Laboratory	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Measure material hardness using standard testing methods.
CO2	Determine impact strength using Charpy/Izod tests.
CO3	Evaluate tensile behavior using UTM.
CO4	Analyze fatigue and creep behavior from theoretical data.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	S	M	–	–	–	L	L	L	M	M	S	–	S
CO2	S	M	–	S	M	M	–	–	L	M	L	M	M	S	–	S
CO3	S	S	M	S	M	–	–	–	L	M	L	S	M	S	–	S
CO4	S	S	M	S	–	L	L	L	L	M	L	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

1. To determine the hardness of steel / aluminum / copper alloy using Vickers, Brinell and Rockwell testing systems.
2. To determine impact strength of steel / aluminum / copper alloy using Charpy and Izod Testing.
3. To determine tensile behavior of steel / aluminum / copper alloy using Universal Testing Machine.
4. To determine fatigue life from the S-N curve using a fatigue testing machine theoretically.
5. To determine Creep curve and stages of creep using creep machine theoretically.

Text Books:

1. Mechanical Behaviour of Materials Laboratory Manual.
2. C. Suryanarayana, Experimental Techniques in Materials and Mechanics, CRC press, 2011.

HS1052	Social Service	HSC	0-0-2	1 Credits

III – Year: I – Semester

	Open Elective/DAC approved Free Electives (NPTEL, MOOCs, etc.)-II	**OEC**	**3-0-0**	**3 Credits**

MM3011	**Powder Metallurgy**	**PCC**	**2-0-0**	**2 Credits**

Pre-Requisites: Physical Metallurgy, Strength of Materials

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain powder production techniques and performance metrics.
CO2	Evaluate powder characteristics and testing methods.
CO3	Describe shaping techniques and defect control strategies.
CO4	Apply sintering concepts and explore PM applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	M	–	–	–	–	–	L	–	M	M	M	–	–
CO2	S	S	M	M	M	–	L	–	–	L	–	S	M	S	–	–
CO3	S	S	M	S	M	–	–	–	–	M	L	S	S	S	–	–
CO4	S	S	M	S	M	M	M	L	–	M	M	S	S	S	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

General Concepts: Introduction and history of Powder Metallurgy (P/M), past, present, and future trends of P/M.

Powder Production Techniques: Methods like mechanical, chemical, and electrochemical, atomization, high-energy ball milling, mechanical alloying, self-propagating high-temperature synthesis, performance evaluation, and process selection.

Characteristics of Powder: Particle size, shape, distribution, flowability, compressibility, porosity, tap and green density, surface area, and toxicity.

Powder Shaping: Powder blending, compaction methods (die compaction, isostatic pressing, injection molding, extrusion), defect analysis, and applications in additive manufacturing and powder coating.

Sintering: Sintering theory and mechanisms, types of furnaces and atmospheres, spark plasma sintering, microwave sintering, and Laser Engineering Net Shaping (LENS), structure-property correlations.

Applications of Powder Metallurgy: Filters, tungsten filaments, self-lubricating bearings, porous materials, alloys, biomaterials, and case studies.

Text Books:

1. R. M. German, Powder Metallurgy & Particulate Materials Processing, MPIF USA, 2005.

Reference Books:

2. A. Upadhyaya and G S Upadhyaya, Powder Metallurgy, Universities Press, 2011.
3. J. S. Hirschhorn: Introduction to Powder Metallurgy, American Powder Metallurgy Institute, 1976.
4. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, Prentice-Hall India, 2008.

MM3021	Steel Making	PCC	2-0-0	2 Credits

Pre-Requisites: Iron Making, Principles of Extractive Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain modern steelmaking processes and thermodynamics.
CO2	Describe ladle metallurgy and continuous casting steps.
CO3	Identify casting defects and clean steel practices.
CO4	Classify various steel grades and their applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	–	–	–	–	–	–	M	S	S	–	M
CO2	S	S	M	S	M	–	–	–	–	–	–	M	S	S	–	S
CO3	M	S	M	S	M	–	M	–	–	–	L	S	M	S	–	S
CO4	M	M	M	M	M	–	M	–	–	–	–	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Steel Making: Early methods (Bessemer, open-hearth), modern methods (Basic Oxygen Furnace, Electric Arc Furnace), thermodynamics and kinetics in steelmaking, slag-metal and gas-metal reactions, alternative steelmaking processes.

Steel Casting: Ladle metallurgy, impurity removal, degassing, inclusion engineering, clean steel production, continuous casting process, casting defects, and near-net manufacturing of steel.

Various Steel Categories:

Carbon Steels: Low Carbon, Medium Carbon and High Carbon Steels

Stainless Steels: Ferritic, Austenitic, Martensitic, Duplex and Precipitation Hardened Steels

Alloy Steels: Aluminum, Copper, Manganese, Molybdenum, Tungsten, Silicon.

Tool Steels: Air-Hardened, Water-Hardened, Oil-Quenched, High Speed, Hot-worked and Shock Resistant.

Text Books:

1. Ahindra Ghosh and Amit Chatterjjee, Ironmaking and steelmaking: Theory and practice, PHI learning private limited, 2008.

Reference Books:

2. S.K. Dutta, Y. B. Chokshi, Basic Concepts of Iron and Steel Making, Springer, 2020.
3. R. H. Tupkary, Modern Steel Making, 4th Edition, Khanna Publishers, 2017.
4. A. K. Chakrabarti, Steelmaking: Fundamentals and Processes, PHI Learning, 2010.

MM3031	Metal Joining	PCC	2-0-0	2 Credits

Pre-Requisites: Engineering Mechanics

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain basics and types of metal joining techniques.
CO2	Describe fusion, resistance, and high-energy welding.
CO3	Analyze welding defects, testing methods, and remedies.
CO4	Interpret welding metallurgy and weld microstructures.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	M	M	–	–	–	–	–	–	M	S	S	–	–
CO2	S	S	M	S	S	–	L	–	–	–	–	M	M	S	–	M
CO3	M	S	M	S	M	M	M	–	–	–	L	S	M	S	–	S
CO4	S	S	M	S	M	–	M	–	–	–	–	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Metal joining: Basics of welding, brazing, soldering, and weld joint design.

Fusion Welding: Gas welding, Oxyacetylene welding, types of flames, process description, and applications. Arc welding, heat sources, and arc characteristics. Shielded Metal Arc Welding, Gas-Tungsten Arc Welding, Plasma Arc Welding, Gas-Metal Arc Welding, Flux-Core Arc Welding, Submerged Arc Welding, Electro Slag Welding.

Resistance Welding: Spot, seam, projection, and flash butt welding.

High-Energy Beam Welding: Electron Beam and Laser Beam Welding.

Solid-State Welding: Friction welding, Friction Stir Welding, Diffusion bonding, Ultrasonic, and Explosion welding.

Welding Defects: Types, causes, residual stress, distortion, remedies, and testing.

Welding Metallurgy: Solidification, post-solidification transformations, and microstructures in weld zones.

Text Books:

1. N.K.Srinivasan, Welding Technology, Khanna publishers, 2008.

Reference Books:

2. Sindo Kou, Welding metallurgy, John Willey, 2003, 2nd Edition, USA.
3. J.F. Lancaster, Metallurgy of Welding, Abington Publishing, 6th edition, England. 1999.
4. Richard Little, Welding and Welding Technology, McGraw Hill, 1st Edition, 2001.

MM3041	Non-Ferrous Extractive Metallurgy	PCC	3-0-0	3 Credits

Pre-Requisites: Ores & Mineral Processing, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain classification and importance of non-ferrous metals.
CO2	Describe oxide ore processing and refining techniques.
CO3	Apply extraction methods for sulphide and halide ores.
CO4	Explain recovery and refining of precious metals.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	M	L	–	–	–	–	–	–	M	S	S	–	–
CO2	S	S	M	S	M	–	–	–	–	–	–	M	S	S	–	M
CO3	S	S	M	S	M	–	L	–	–	–	–	M	S	S	–	M
CO4	M	S	M	S	M	–	M	–	–	–	L	S	S	S	–	M

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of metal extraction history, classification of extraction processes, sources and industrial importance of non-ferrous metals.

Extraction of Metals from Oxide Sources: Principles and techniques for oxide ore processing; production of magnesium, aluminium, and tin; refining and recycling.

Extraction of Metals from Sulphide Ores: Pyrometallurgical and hydrometallurgical routes—roasting, smelting, leaching, electro-winning and electro-refining; extraction of copper, lead, zinc, nickel.

Extraction of Metals from Halides: Halide production and refining; extraction of titanium, zirconium, beryllium, uranium, thorium, and rare earths.

Extraction of Precious Metals: Recovery of gold, silver, and PGMs; cyanidation, amalgamation, refining, and secondary recovery from wastes.

Text Books:

1. H. S. Ray, R. Sridhar and K.P. Abraham, Extraction of Non-Ferrous Metals, Affiliated East-West press, 2008.

Reference Books:

2. R. Raghavan, Extractive Metallurgy of Non-Ferrous Metals, Vijay Nicole Imprints, 2016.
3. Roger Rumbu, Non-Ferrous Extractive Metallurgy - Industrial Practices, Createspace Independent pub, 2015.
4. Alain Vignes, Extractive Metallurgy 1: Basic thermodynamics and kinetics, Wiley-ISTE, 2013.

	Department Elective-3	DEC	3-0-0	3 Credits

	Department Elective-4	DEC	3-0-0	3 Credits

MM3052	Powder Metallurgy Laboratory	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Determine powder density and flow using standard methods.
CO2	Perform mechanical milling and alloying using ball mills.
CO3	Compact powders and understand behavior during pressing.
CO4	Study sintering behavior and structure-property correlation.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	S	S	–	–	–	L	L	L	M	S	S	–	–
CO2	S	S	M	S	S	–	–	–	L	M	L	S	S	S	–	–
CO3	S	S	M	S	S	–	–	–	L	M	M	S	S	S	–	–
CO4	S	S	M	S	M	L	L	L	L	M	M	S	S	S	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

1. To determine Apparent Density, Tap Density and Flowability of various powders using Hall-Flow meter.
2. To study the concept of mechanical milling and mechanical alloying using planetary ball mills.
3. To study the compaction of elemental and milled powders (ductile and brittle) using a die compaction machine.
4. To study the sintering behavior of ferrous, non-ferrous and / or ceramic powder compacts.
5. To study structure property correlation of compacted and / or sintered samples.

Text Books:

1. Powder Metallurgy Laboratory Manual.

MM3062	Casting and Welding Laboratory	PCC	0-0-3	2 Credits

Pre-Requisites: None

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Perform sand testing to evaluate molding sand properties.
CO2	Demonstrate mold preparation and metal casting techniques.
CO3	Execute GTA welding and interpret weld microstructures.
CO4	Identify casting and welding defects using NDT methods.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	S	S	–	–	–	L	L	L	M	S	M	–	–
CO2	S	S	M	S	S	M	–	–	L	M	M	S	S	M	–	–
CO3	S	S	M	S	M	–	–	–	L	M	L	S	M	S	–	S
CO4	S	S	M	S	M	M	L	L	L	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

1. Sand Testing: Green and dry strength testing, determination of permeability, shatter index, clay content, moisture content.
2. Demonstration of Mould preparation and pattern making.
3. Demonstration of melting and casting in sand moulds, metal moulds.
4. Demonstration of gas tungsten arc (GTA) welding of a given sample.
5. Interpretation of the microstructure and hardness of the given weldment.
6. Identification of cast/weld defects using liquid penetrant and magnetic particle testing.

Text Books: Lab Manual

- Casting and Welding Laboratory manual

SM3011	**Introduction to Entrepreneurship (for BTE, CHEM, CE, ME, MME Depts)**	**HSC**	**0-0-0**	1 **Credits**

Pre-Requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Acquaint themselves with starting new ventures and introducing new products and service ideas
CO2	Explore the processes of establishing a start-up and develop strategies and methods to mobilize resources
CO3	Create venture capitalists, consultants to new firms or new business development units of larger corporates

Syllabus:

The entrepreneur’s role, task, and personality- typology of entrepreneurs: entrepreneurship as a style of management.

Identify problems worth solving-political, economical, and social- technical analysis-opportunity recognition-business model identification-new product franchising- sponsorship and acquisition- internal & external entry strategies.

Startup ecosystem and support system- role of incubators- government initiatives.

Writing and pitching business plan-entrepreneurial tool-venture capital and other forms of financing-sources of external support-developing entrepreneurial marketing-competencies-maintaining competitive advantage.

References:

1. B.D.Singh. Managing Conflict and Resolution. Excel Books.2008
2. B. R. Barringer and D. Ireland, Entrepreneurship, Prentice Hall,2009.
3. G. Kawasaki, L. Filby, The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything , Penguin,2015.
4. R. Bansal, Connect the Dots, Westland, 2011.
5. Ries, Eric The Lean Startup: How Today’s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Crown Business, 2011.
6. S. S. Khanka, Entrepreneurial Development, S. Chand & Co.2006.

III – Year: II – Semester

	Open Elective/DAC approved Free Electives (NPTEL, MOOCs, etc.)-III	OEC	3-0-0	3 Credits

MM3511	Corrosion Engineering	PCC	2-0-0	2 Credits

Pre-Requisites: Engineering Chemistry, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain corrosion principles using thermodynamics and kinetics.
CO2	Identify and distinguish various forms of corrosion.
CO3	Apply corrosion testing and monitoring techniques.
CO4	Propose corrosion prevention strategies and analyze failures.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	L	–	–	–	–	–	M	S	S	–	M
CO2	S	S	M	S	M	L	L	–	–	–	–	M	M	S	–	S
CO3	S	S	M	S	S	L	–	–	–	–	–	S	M	S	–	S
CO4	M	S	M	S	M	M	M	L	–	–	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Principles of Corrosion: Introduction to corrosion, thermodynamics, kinetics, galvanic/EMF series, Pourbaix diagrams, passivity, Evans diagram, and Flade potential.

Forms of Corrosion: Mechanisms of uniform, galvanic, pitting, crevice, intergranular corrosion, stress corrosion cracking, corrosion fatigue, dealloying, and high-temperature oxidation.

Corrosion Testing and Monitoring: Weight loss method, electrochemical techniques (Tafel extrapolation, linear polarization, EIS).

Corrosion Prevention: Control strategies including material selection, environmental modification, design optimization, inhibitors, protection, and coatings.

Case Studies: Analysis of corrosion failures in materials and industrial applications, focusing on advanced materials.

Text Books:

1. M G Fontana, N D Greene, Corrosion Engineering, McGraw Hill, New York, 1967.

Reference Books:

2. Zaki Ahamad, Principles of Corrosion Engineering and Corrosion Control, Elsevier, 2006.
3. ASM Metal Hand book, Vol 13A- Corrosion-Fundamentals Testing & Protection, ASM, 2004.

MM3521	Metal Forming	PCC	2-0-0	2 Credits

Pre-Requisites: Strength of Materials, Mechanical Behaviour of Materials

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand stress states and plasticity in forming.
CO2	Analyze forging processes and calculate forming loads.
CO3	Explain rolling, extrusion, and their mechanical analysis.
CO4	Evaluate drawing processes and identify forming defects.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	–	–	–	–	–	–	M	S	S	–	M
CO2	S	S	M	S	M	–	–	–	–	–	–	M	S	S	–	M
CO3	S	S	M	S	S	–	–	–	–	–	–	S	M	S	–	S
CO4	M	S	M	S	M	–	L	–	–	–	L	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Plane stress, Mohr's circle for stress and strain, hydrostatic and deviatoric stress components, elastic stress-strain relations.

Theory of Plasticity: Flow curve, yield criteria (Von Mises, Tresca), combined stress tests, anisotropy in yielding, forming process classification, workability, friction, strain rate effects.

Forging: Forging process classification, open/closed-die forging, load calculations, defects, residual stresses.

Rolling: Rolling process classification, rolling mills, hot/cold rolling, force/geometry relationships, torque/power calculations, defects.

Extrusion: Extrusion process classification, cold/hot extrusion, defects, lubrication, analysis, hydrostatic extrusion and extrusion of tubing.

Drawing: Introduction Rod/wire drawing, tube-drawing, deep drawing, forming limits, defects in parts.

Text Books:

1. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw Hill, New York, 1986.

Reference Books:

2. Surender Kumar, Technology of Metal Forming Processes, PHI learning, 2008.
3. William F. Hosford, Metal Forming - Mechanics and Metallurgy, Cambridge, 2011.
4. Fritz Klocke, Manufacturing Processes, Volume 4, Forming, Springer, 2013.

	Department Elective-5	**DEC**	**3-0-0**	3 **Credits**

	Department Elective-6	**DEC**	**3-0-0**	3 **Credits**

MM3531	**Materials Characterization Techniques**	**PCC**	**2-0-0**	**2 Credits**

Pre-Requisites: Engineering Physics, Engineering Chemistry, Introduction to Metallurgical & Materials Engineering

Course Outcomes: At the end of the course, student will be able to:

CO1	Use optical microscopy and digital imaging techniques.
CO2	Explain SEM, TEM, and electron diffraction principles.
CO3	Interpret XRD patterns for phase and structural analysis.
CO4	Identify surface, spectroscopic, and thermal analysis tools.

Course Articulation Matrix:

PO/PSO → CO ↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	S	M	M	S	S	L	–	–	L	–	L	M	M	S	–	S
CO2	S	S	M	S	S	–	–	–	L	–	L	S	M	S	–	S
CO3	S	S	M	S	S	–	–	–	L	–	L	S	M	S	–	S
CO4	S	S	M	S	S	L	M	–	L	M	L	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Optical Microscopy: Principles of optical microscopy, bright-field, dark-field, phase contrast, polarized light microscopy, digital imaging, and image analysis.

Electron Microscopy: Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray Spectroscopy (EDS), Transmission Electron Microscopy (TEM) with Selected Area Electron Diffraction (SAED) and High-Resolution TEM (HRTEM).

Basic X-ray Diffraction (XRD): Bragg's Law, powder diffraction method, phase identification, qualitative analysis, crystallite size and lattice parameter determination.

Surface and Thin Film Characterization: Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), and Secondary Ion Mass Spectrometry (SIMS).

Spectroscopic Techniques: Fourier Transform Infrared Spectroscopy (FTIR), Raman Spectroscopy, UV-Vis Spectroscopy, and Nuclear Magnetic Resonance (NMR) Spectroscopy.

Thermal Analysis: Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), and Thermomechanical Analysis (TMA).

Text Books:

1. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd Edition, Wiley, 2013.

Reference Books:

2. P.E.J. Flewitt and R.K. Wild, Physical Methods for Materials Characterization, 2nd Edition, Taylor & Francis, 2017.
3. B.D. Cullity and S.R. Stock, Elements of X-ray Diffraction, 3rd Edition, Prentice Hall, 2001.
4. D. Brandon and W.D. Kaplan, Microstructural Characterization of Materials, 2nd Edition, Wiley, 2008.

MM3542	Corrosion Engineering Laboratory	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Determine corrosion rate using weight loss methods.
CO2	Perform polarization and impedance testing using workstation.
CO3	Evaluate pitting, intergranular, and stress corrosion.
CO4	Analyze cavitation erosion-corrosion in different alloys.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	S	M	L	L	–	M	L	L	M	M	S	–	S
CO2	S	S	M	S	S	L	–	–	M	L	L	S	M	S	–	S
CO3	S	S	M	S	M	M	L	L	M	L	M	S	M	S	–	S
CO4	M	S	M	S	M	M	M	L	M	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

1. Determination of corrosion rate of carbon steel under various environments by weight loss measurements.
2. Impedance and polarization studies using electrochemical workstation and understanding localized corrosion behaviour.
3. Pitting corrosion studies on similar/dissimilar weld joints using a weld tester.
4. Intergranular corrosion studies on sensitized stainless steels using quantitative and qualitative methods.
5. Stress corrosion cracking of carbon steels.
6. Cavitation erosion-corrosion studies on steels/aluminium alloys/stainless steels.

Reference Books:

1. Corrosion Laboratory Manual

MM3552	Metal Forming Lab	PCC	0-0-2	1 Credits

Pre-Requisites: Physical Metallurgy

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Perform open/closed die forging and analyze microstructure.
CO2	Analyze deformation behavior in cold rolling of alloys.
CO3	Conduct and interpret results of hot rolling processes.
CO4	Correlate forming conditions with material properties.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	S	S	L	–	–	M	L	L	M	S	S	–	S
CO2	S	S	M	S	S	L	–	–	M	L	L	S	M	S	–	S
CO3	S	S	M	S	S	–	–	–	M	L	L	S	M	S	–	S
CO4	M	S	M	S	M	L	L	–	M	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

1. Structure property correlation in open and closed die forging of
   - I. Plain carbon steel
   - II. Stainless steel
   - III. Aluminum Alloy
   - IV. Copper Alloy
2. Microstructure evaluation in cold rolling of
   - I. Plain carbon steel
   - II. Stainless steel
   - III. Aluminum Alloy
   - IV. Copper Alloy
3. Hot Rolling of plain carbon steel
4. Partial rolling of plain carbon steels

Text Books:

1. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw Hill, New York, 1986.
2. Surender Kumar, Technology of Metal Forming Processes, PHI learning, 2008.

HS3011	**Liberal Arts/Creative Arts Courses-I** **or** **English for Engineers - II**	**HSC**	**0-0-0**	3 **Credits**

Pre-Requisites: English for Engineers - I

Course Outcomes: At the end of the course, student will be able to:

CO1	To equip students to develop Questionnaires and to pitch ideas.
CO2	To cultivate delegation skills and strategic planning.
CO3	To equip students to create career related documents.
CO4	To equip students with technical and business writing.
CO5	To improve oral communication and interview readiness.

Syllabus

Module 1: Cover letter - resume - statement of purpose
Module 2: Technical report writing - proposal writing - minutes of the meeting
Module 3: Pitching ideas - client correspondence - preparation of questionnaire
Module 4: Diplomacy skills - strategic planning - delegation skills - feedback
Language Laboratory Group presentation-presentation with emphasis on body language-public speaking- extempore speech Pronunciation practice (Automatic Speech Recognition).
Mock interview: Interview etiquette, common interview questions

Text Books:

Brown, Carla L. Essential Delegation Skills. Routledge, 2017.
Carter, Ronald and Michael McCarthy. Cambridge Grammar of English: A Comprehensive Guide. Cambridge University Press, 2006.
Harris, David.F. Complete Guide to Writing Questionnaires. I& M Press, 2014.
Hering, Lutz and Heike Hering. How to Write Technical Reports: Understandable Structure, Good Design, Convincing Presentation. Springer; 2010.
Mohan, Krishna and Meera Banerji. Developing Communication Skills. Macmillan India Limited, 2000.
Muralikrishna and Sunitha Mishra. Communication Skills for Engineers.Pearson, 2011.

References:

Busan, Tony. Mind Map Mastery. Walkins, 2018.
Huckin N. Thomas and Leslie A. OlsenTechnical Writing and Professional Communication for Non-native Speakers. McGraw-Hill Education,1991.
Laplante, Phillip A. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals. CRC Press, 2018.
Mc Quail, Dennis. Audience Analysis. Sage, 1997 Ogden, Richard. Introduction to English Phonetics. Edinburgh University Press, 2017.
Parker, Glenn M. Team Players and Teamwork: New Strategies for Developing Successful Collaboration. Wiley, 2011.
Seely, John. Oxford Guide to Effective Writing and Speaking: How to Communicate Clearly. Oxford University Press: 2013.

SM3021	**Introduction to Design Thinking (for BTE, CHEM, CE, ME, MME Depts)**	**HSC**	**0-0-0**	**1 Credits**

Pre-Requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand and apply advanced Design Thinking techniques for problem-solving.
CO2	Develop proficiency in ideation and visualization tools to structure innovative concepts, analyze biases in user and developer perspectives to enhance communication.
CO3	Implement frameworks to sustain a culture of innovation, apply Design Thinking principles to real-world challenges through exercises and case-based discussions.

Syllabus:
Listening and empathizing techniques, observation techniques, structured open-ended approaches, overcoming cognitive fixedness, behavior models, innovation heuristics, case-based discussions-exercises.
Use of diagrams and maps in design thinking, empathy map, affinity diagram, mind map, journey map-combining ideas into complex innovation concepts, storytelling and scenario planning-improvisation, scenario development, evaluation tools, frog design-prototyping, interactive workshops, case-based discussions.

References:

1. Roger Martin, The Design of Business: Why Design Thinking is the Next Competitive Advantage, Harvard Business Press , 2009.
2. Christoph Meinel, Larry Leifer, and Hasso Plattner (eds), Design Thinking: Understand – Improve– Apply, Springer, 2011.
3. Idris Mootee, Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School, John Wiley & Sons, 2013.

IV – Year: I – Semester

	Open Elective/DAC approved Free Electives (NPTEL, MOOCs, etc.)-IV	**OEC**	**3-0-0**	3 **Credits**

	Open Elective/DAC approved Free Electives (NPTEL, MOOCs, etc.)-V	**OEC**	**3-0-0**	3 **Credits**

MM4034	**Professional Major Work**	**PRC**	**0-0-12**	6 **Credits**

MM4011	**Computational Materials Engineering**	**PCC**	**3-0-0**	**3 Credits**

Pre-Requisites: Problem Solving through Computer Programming, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain modeling approaches in computational materials engineering.
CO2	Apply CALPHAD and Thermo-Calc for alloy design.
CO3	Implement numerical methods and atomistic simulations.
CO4	Simulate materials behavior using DFT, MD, and phase field.

Course Articulation Matrix:

PO/PSO → CO ↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	S	S	M	M	M	L	–	–	L	L	L	M	M	M	–	M
CO2	S	S	M	S	S	–	L	–	L	L	L	S	S	S	–	S
CO3	S	S	S	S	S	–	–	–	L	L	L	S	S	S	–	S
CO4	S	S	S	S	S	–	M	–	L	M	M	S	S	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of computational materials engineering, modeling techniques, simulations in materials design, multi-scale modeling, and real-world applications.

Thermodynamic Modeling: CALPHAD method, Thermo-Calc software for phase equilibria and alloy design, application to high-entropy alloys and advanced steels.

Numerical Methods: Finite difference and finite element methods, explicit and implicit techniques, diffusion simulations, and LAMMPS for atomistic simulations.

Density Functional Theory and Quantum Calculations: Quantum mechanical approaches, Schrödinger equation, electronic structure calculations using VASP and Quantum ESPRESSO, predicting mechanical and optical properties.
Molecular Dynamics and Monte Carlo Simulations: Molecular modeling basics, interatomic potentials, MD simulations, Monte Carlo methods for thermodynamic predictions, grain growth simulations.
Microstructure Modeling: Phase field modeling (Cahn-Hilliard, Allen-Cahn equations), microstructural evolution, dendritic solidification, tools like OpenPhase and Micress.

Text Books:

1. June Gunn Lee, Computational Materials Science-An Introduction, CRC Press, 2015.

Reference Books:

2. Richard Lesar, Introduction to Computational Materials Science: Fundamentals to Applications, Cambridge University Press, 2013.
3. W. Hegert, A. Ernst, M. Dane (Eds), Computational Materials Science, Springer, 2004.
4. E. B. Tadmor and R. E. Miller, Modeling Materials (Continuum, Atomistic and Multiscale Techniques), Cambridge University Press, 2011.

MM4023	**Industrial Lectures & Industrial Visits**	**PCC**	**1-0-1**	2 **Credits**

Pre-Requisites: None

Syllabus:

Industrial Lectures & Industrial Visits

MM4562	Computational Materials Engineering Lab	PCC	0-0-2	1 Credits

Pre-Requisites: Problem Solving through Computer Programming Lab, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the lab course, student will be able to:

CO1	Perform structure-property correlations via first-principles methods
CO2	Simulate transient and steady-state heat transfer problems.
CO3	Calculate phase compositions and phase diagrams numerically.
CO4	Use ThermoCalc for thermodynamic property evaluation.
CO5	Analyze alloy behavior using computed binary phase diagrams.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	S	S	S	L	–	–	L	L	L	M	M	S	–	S
CO2	S	S	M	S	S	–	L	–	L	L	L	S	S	S	–	S
CO3	S	S	M	S	S	–	–	–	L	L	L	S	S	S	–	S
CO4	S	S	M	S	S	–	M	–	L	M	M	S	S	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

1. Density functional theory basics-lattice parameter, magnetic moments, oxidation states calculation
2. Program for finding the transient temperature profile of a metallic rod for the given boundary conditions
3. Program for finding the equilibrium temperature profile of a thin plate
4. Program for calculation of equilibrium compositions of the solution phases at the given temperature
5. Program for calculation of equilibrium phase diagram, for simple isomorphous systems.
6. Calculate the variation of various thermodynamic properties for the selected systems using ThermoCalc.
7. Calculation of equilibrium binary phase diagram using ThermoCalc.

Reference Books:

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw-Hill Education, 7th edition.
2. Press, William H. Numerical recipes 3rd edition: The art of scientific computing. Cambridge university press, 2007.
3. User manuals of ThermoCalc.

HS1052	**Liberal Arts/Creative Arts Courses-II**	**HSC**	**0-0-0**	3 **Credits**

IV – Year: II – Semester

MM4024	**Semester-Long Internship (SLI)/Additional Project at the institute/Additional department elective courses for 6 credits**		**0-0-12**	6 **Credits**

Departmental Elective Courses 1

MM2601	Fuels, Furnaces, and Refractories	DEC	3-0-0	3 Credits

Pre-Requisites: Engineering Thermodynamics, Transport Phenomenon

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand the classification and applications of fuels, furnaces, and refractories.
CO2	Explain properties and processing of conventional and alternative fuels.
CO3	Describe furnace types, working principles, and heat efficiency aspects.
CO4	Evaluate refractory types, testing, and application-specific selection.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	M	–	L	L	–	–	L	–	M	M	–	–	–
CO2	S	S	M	M	M	M	M	–	L	M	L	S	S	M	–	–
CO3	S	S	M	S	–	M	L	–	L	M	L	S	S	M	–	–
CO4	S	S	M	S	–	M	M	L	L	M	M	S	S	M	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Importance, classification, and roles of fuels, furnaces, and refractories in metallurgical processes..

Fuels: Coal, petroleum, and natural gas – types, properties, processing (carbonization, refining, gasification, cracking).
Alternative fuels – biofuels, hydrogen, synthetic fuels.

Furnaces: Types – blast, electric arc, induction, cupola, rotary kiln.
Working principles, heat transfer, efficiency, and energy conservation.

Refractories: Classification, composition, properties, production, testing, and applications of key refractories (silica, fire clay, magnesite, chrome, dolomite).

Selection of Refractories: Criteria for furnace-specific applications – coke ovens, blast furnaces, LD/converters, soaking pits, and heat treatment units.

Text Books:

1. O.P. Gupta, Elements of Fuels, Furnaces, and Refractories, Khanna Publishers, 2012.

Reference Books:

2. A.V. Krishnan, Industrial Furnaces and Refractories, CBS Publishers & Distributors, 2016.
3. J.D. Gilchrist, Fuels, Furnaces, and Refractories, Pergamon Press, 1977.
4. S. Banerjee and N. P. Gakkhar, Industrial Furnaces, Alpha Science International, 2016.

MM2611	Theory of Metallurgical Processes	DEC	3-0-0	3 Credits

Pre-Requisites: Metallurgical Thermodynamics and Kinetics, Transport Phenomena

Course Outcomes: At the end of the course, student will be able to:

CO1	Apply thermodynamic and kinetic concepts to metallurgical processes.
CO2	Analyze phase equilibria and reaction mechanisms in metallurgical systems.
CO3	Evaluate key processes in pyrometallurgy, hydrometallurgy, and electrometallurgy.
CO4	Select appropriate extraction methods based on process principles.

Course Articulation Matrix:

PO/PSO → CO ↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	S	M	M	S	–	–	–	–	L	M	–	–	S	M	L	–
CO2	M	S	S	M	–	–	–	–	–	L	–	–	M	S	M	–
CO3	L	M	S	M	L	–	–	–	–	S	–	M	S	M	S	M
CO4	M	L	M	S	S	–	–	–	–	S	–	M	M	S	M	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Fundamentals of metallurgical processes with focus on thermodynamics, kinetics, and rate-controlling steps in pyrometallurgy, hydrometallurgy, and electrometallurgy.

Thermodynamic Principles: Gibbs phase rule, stability diagrams, standard states, interaction coefficients, solution models, and kinetics of thermally activated processes.

Reaction Equilibria: Equilibria in solid-liquid, liquid-liquid, and gas-liquid systems; interfacial thermodynamics, adsorption, diffusion, nucleation, and growth.

Pyrometallurgical Processes: Roasting thermodynamics and kinetics, slag behavior, Ellingham diagrams, redox reactions, and blast furnace chemistry.

Hydrometallurgical Processes: Leaching principles, Pourbaix diagrams, leaching kinetics, and electrochemical aspects.

Electrometallurgical Processes: Faraday's laws, electrode reactions, and electrochemical thermodynamics and kinetics.

Text Books:

1. M. Shamsuddin, Physical Chemistry of Metallurgical Processes, Wiley, 2016.

Reference Books:

2. David R. Gaskell, Introduction to Metallurgical Thermodynamics, CRC Press, 2017.
3. H. S. Ray and S. K. Ray, Kinetics of Metallurgical Processes, Springer, 2018.
4. H. S. Ray and A. Ghosh, Principles of Extractive Metallurgy, New Age International, 2010.

MM2621	Non-Destructive Testing	DEC	3-0-0	3 Credits

Pre-Requisites: Engineering Physics, Physical Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand fundamentals of NDT and recognize inspection techniques.
CO2	Explain working principles and applications of ultrasonic and liquid penetrant testing.
CO3	Apply magnetic particle, eddy current, and radiographic methods for flaw detection.
CO4	Select suitable NDT techniques for industrial applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	–	–	–	–	–	–	–	–	L	S	M	–	–
CO2	M	S	M	–	–	–	–	–	–	–	–	L	S	M	–	–
CO3	S	M	S	–	–	–	–	–	–	M	–	M	S	M	–	–
CO4	M	M	S	M	–	–	–	–	–	M	–	S	M	S	L	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of manufacturing-related discontinuities and defects in metals, alloys, and ceramics; basics of fracture mechanics and life prediction; visual inspection, pressure testing, and leak detection methods.

Ultrasonic Testing: Wave behavior (reflection, refraction, mode conversion), piezoelectric effect, transducer types, equipment variables, test result interpretation, and limitations.

Liquid Penetrant Testing: Principles, system components, testing procedures, advantages, and limitations.

Eddy Current Testing: Basics of eddy currents, test system operation, and effectiveness in flaw detection.

Magnetic Particle Testing: Magnetic properties, magnetization methods, testing principles, equipment, procedures, interpretation, and applications.

Radiographic Testing: Radiation principles, industrial radiography techniques, film processing, safety, and radiation protection.

Industrial Applications: Use of NDT in railways, aerospace, nuclear, automotive, offshore, and pressure-containing structures like castings and welds.

Text Books:

1. Baldev Raj, Practical Non-destructive Testing, Wood head publishing limited, 2002.

Reference Books:

2. Ravi Prakash, Non-Destructive Testing Techniques, New Age International, 2010.
3. J.B. Hull and Vernon John, Non-Destructive Testing, Macmillan, 2015.
4. G. V. Crowe, An Introduction to Nondestructive Testing, American Society for NDT, 2009.

MM2631	Electronic, Optical and Magnetic Materials	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Engineering Physics

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand structure-property correlations in functional materials.
CO2	Analyze electronic, optical, and magnetic properties of materials.
CO3	Apply principles of semiconductor and dielectric materials in devices.
CO4	Investigate advanced materials and their engineering applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	M	M	–	S	M	S	M	M	M	S	M	L	M
CO2	S	M	M	L	M	–	S	S	S	M	M	M	S	M	L	M
CO3	M	S	M	L	M	–	S	M	S	S	M	M	S	M	M	L
CO4	M	L	M	S	L	–	M	M	S	L	M	M	S	M	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Classification and importance of functional materials; structure-property correlations in electronic, optical, and magnetic materials; relevance in modern engineering applications.

Electronic Materials: Band theory of solids (free electron model, Bloch's theorem, Kronig-Penney model); energy bands, effective mass, E–k diagrams; conductors and semiconductors—carrier concentration, mobility, Hall effect, doping, direct/indirect band gaps.

Dielectric and Optical Materials: Polarization mechanisms (electronic, ionic, orientation, space charge), dielectric constant and loss, frequency dependence, ferroelectricity, piezoelectricity, and optical properties of dielectrics

Magnetic Materials: Origin of magnetism, types (dia-, para-, ferro-, ferri-, antiferro-); domain structure, hysteresis, soft/hard magnets (Fe-Si, ferrites, SmCo, NdFeB); advanced phenomena—superparamagnetism, magneto-optical and magnetocaloric effects.

Applications: Semiconductors (diodes, transistors, photodetectors), capacitors, sensors/actuators, magnetic storage, spintronics, biomedical uses.

Emerging materials: Nanostructured and 2D materials (e.g., graphene, MoS_2); advanced devices in electronics, optics, and magnetics.

Text Books:

1. Y. K. Sharma, Electronic, Magnetic and Optical Materials, CRC Press, 2013.

Reference Books:

2. David Jiles, Introduction to Electronic Properties of Materials, Taylor & Francis, 2001.
3. S.O. Kasap, Principles of Electronic Materials and Devices, McGraw Hill, 2018.
4. B. D. Cullity, C.D. Graham, Introduction to Magnetic Materials, Wiley, 2009.

Departmental Elective Courses 2

MM2641	Ferroalloy Technology	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Physical Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand classification, production processes, and significance of ferroalloys.
CO2	Analyze thermodynamic and kinetic principles in ferroalloy manufacturing.
CO3	Apply processing techniques to manufacture key ferroalloys.
CO4	Evaluate energy demands and environmental impact in ferroalloy production.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	M	M	–	S	M	S	M	M	M	S	M	L	M
CO2	M	S	M	L	M	–	S	M	S	S	M	M	S	M	M	L
CO3	M	M	S	M	L	–	S	S	M	M	M	M	S	M	M	M
CO4	S	L	M	M	M	–	S	M	S	L	S	M	M	S	M	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Ferroalloys: History, classification of ferroalloys and their production processes, overview of the Indian ferroalloy sector.

Theory of Ferroalloy Production: Thermodynamic and kinetic principles governing ferroalloy manufacturing.

Ferroalloy Processing: Electrical and thermal processes, production techniques for key ferroalloys such as Fe-Cr, Fe-Mn, Fe-Si, Fe-V, Fe-Ti, Fe-W, Fe-Nb, Fe-Mo, Fe-Ni, Fe-Zr, and Fe-B. Recent advances in ferroalloy technology.

Energy and Environmental Considerations: Energy demands in ferroalloy manufacturing, CO_2 emissions, and modern emission control strategies.

Text Books:

1. B. P. Bhardwaj, The Complete Book on Ferroalloys, NIIR Project Consultancy Services, 1st Edition, 2008.

Reference Books:

2. Mikhail Gasik et al. Ferroalloys: Theory and Practice, Springer, 1st Edition, 2020.
3. Michael Gasik, Handbook of Ferroalloys: Theory and Technology, Elsevier, 1st Edition, 2013.
4. C. W. Amen and T. A. Green, Ferroalloys and Other Alloys of Manganese, McGraw-Hill, 1st Edition, 1939.

MM2651	Extractive Metallurgy of Refractory Metals	DEC	3-0-0	3 Credits

Pre-Requisites: Extractive Metallurgy, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand ore breakdown and purification processes for refractory and rare metals.
CO2	Explain production processes of strategic refractory and rare metals.
CO3	Analyze extraction methods for niobium, molybdenum, tantalum, tungsten.
CO4	Assess sustainability and environmental aspects of extraction processes.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	–	L	–	M	–	–	M	–	M	S	S	M	L
CO2	S	S	M	M	S	–	M	–	–	M	M	M	S	S	S	M
CO3	S	S	S	M	M	–	L	–	–	M	M	M	S	S	S	S
CO4	M	M	L	–	L	M	S	M	–	M	L	S	M	M	M	M

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Ore Breakdown Techniques: Acid/alkali leaching, chlorination, and fluoride-based breakdown of refractory and rare metal ores.

Purification Processes: Solvent extraction, ion exchange, fluidized bed and dry conversion processes for uranium and thorium purification.

Metal Production Techniques: Production of UF_4 and ThF_4, high-temperature reduction, sponge and powder metallurgy, molten salt electrolysis, $BeCl_2$ electrolysis, uranium and zirconium metal production, iodide decomposition, process flow sheets.

Niobium Metallurgy: Properties, applications, ore treatment, chemical processing, reduction, and consolidation.

Molybdenum Metallurgy: Resources, hydrometallurgical, pyrometallurgical, and electrometallurgical processing.

Tantalum Extraction: Resources, intermediate preparation, reduction, and purification of tantalum metal.

Tungsten Extraction: Processing from scheelite and wolframite ores, refining techniques.

Environmental and Sustainability Aspects: Waste management, recycling, and emerging green extraction technologies.

Text Books:

1. K. M. Abhijit, B. S. Ghosh, Extractive Metallurgy of Refractories, Springer, 2017.

Reference Books:

2. P. R. J. T. Turner, Refractory Materials: Science and Technology, CRC Press, 1999.
3. B. A. Wills, Mineral Processing Technology, 7th Edition, Elsevier, 2006.
4. A. T. I. B. E. White, Introduction to the Extractive Metallurgy of Non-Ferrous Metals, Butterworth-Heinemann, 2001.

MM2661	Metallurgical Waste Recycling	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Engineering Chemistry

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand types and characteristics of metallurgical waste and recycling.
CO2	Explain energy-saving methods in metallurgical processes and recycling.
CO3	Analyze environmental issues and waste management strategies in metallurgy.
CO4	Evaluate recycling techniques for ferrous, non-ferrous, and electronic wastes.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	–	L	–	M	–	–	M	–	M	S	S	M	L
CO2	M	S	M	M	S	–	M	–	–	M	M	M	S	S	M	M
CO3	M	M	L	–	M	S	S	M	–	M	L	S	M	M	M	M
CO4	M	S	S	M	S	M	S	M	–	S	M	S	M	S	S	M

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of metallurgical waste, types, waste characterization, energy conservation, and recycling.

Metallurgical waste: Primary and secondary solid wastes from the metallurgical and powder industries, waste generation during ore processing, extraction, refining, and gaseous waste minimization.

Energy saving: Energy-efficient metal extraction routes, direct reduction vs. conventional steelmaking, and methods for waste heat recovery.

Environmental protection: Environmental concepts, metal toxicology, stack gases from Electric Arc Furnaces, and their treatment.

Recycling of metals: Economic, technological, and environmental aspects of metal recycling, including the use of solid wastes like blast furnace slag, fly ash, and non-ferrous industry wastes.

Case study: Recycling of ferrous/non-ferrous metals, scraps, and electronics waste.

Text Books:

1. R.C. Gupta, Energy and environmental management in metallurgical industries, Prentice-Hall India, 2012.

Reference Books:

2. S. Ramachandra Rao, Resource recovery and recycling from metallurgical wastes, Elsevier, 2011.
3. L. K. Wang, N. K. Shammas, Y.T Hung, Waste Treatment in the Metal Manufacturing, Forming, Coating, and Finishing Industries, CRC press, 2016.
4. S. Ndlovu, G. S. Simate, E. Matinde, Waste Production and Utilization in the Metal Extraction Industry CRC press, 2017.

MM2671	**Introduction to Nano Science and Technology**	DEC	3-0-0	3 Credits

Pre-Requisites: Metallurgical Thermodynamics and Kinetics, Engineering Chemistry

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand nanomaterials' classification, properties, and significance.
CO2	Explain nanomaterials synthesis techniques: bottom-up and top-down approaches.
CO3	Analyze structural and chemical characterization methods for nanomaterials.
CO4	Evaluate properties and applications of various important nanomaterials.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	–	L	–	M	–	–	M	–	S	M	S	M	L
CO2	M	S	S	M	S	–	L	–	–	M	M	M	S	M	S	M
CO3	S	S	M	S	S	–	L	–	–	M	L	M	M	S	S	S
CO4	M	M	S	M	M	M	M	–	M	S	M	M	M	M	S	M

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of nanomaterials, their history, classification, and unique properties. Impact of nano-dimensions on material behavior and applications.

Processing of Nanomaterials: Methods for fabricating nanostructures (powders, bulk materials, thin films) through physical and chemical approaches. Comparison of bottom-up and top-down synthesis techniques.

Characterization and Properties of Nanomaterials: Structural characterization using techniques such as XRD, SAXS, SEM, TEM, AFM, and STM. Chemical characterization through optical spectroscopy, electron spectroscopy, and ion spectrometry. Physical properties including melting points, mechanical properties, optical properties, and quantum size effects.

Nanomaterials of Interest: Study of key nanomaterials, including quantum dots, carbon nanotubes, GaN nanowires, nanocrystalline ZnO, and TiO_2.

Text Books:

1. S. M. Gupta, R. C. Kurchania, Nanomaterials: Synthesis, Properties, and Applications, Springer, 2013.

Reference Books:

2. C. P. Poole Jr., F. J. Owens, Introduction to Nanotechnology, Wiley-Interscience, 2003
3. B. S. Murty et al., Textbook of Nanoscience and Nanotechnology, Universities Press, 2013.
4. G. Cao, Nanostructures and Nanomaterials, Imperial College Press, 2004.

Departmental Elective Courses 3

MM3101	Materials for Renewable Energy	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand global energy challenges and renewable energy fundamentals.
CO2	Explain materials for nuclear, solar, wind, and hydropower systems.
CO3	Describe biofuel production and materials for artificial photosynthesis.
CO4	Analyze materials used in energy storage technologies and applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	–	L	M	S	M	–	M	–	S	L	M	M	L
CO2	S	S	S	M	S	–	M	–	–	M	M	M	M	S	M	S
CO3	M	S	M	L	M	–	S	M	–	M	–	M	L	M	M	M
CO4	S	S	S	S	S	–	M	–	M	S	M	S	M	S	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of global energy challenges, conventional vs. renewable energy, and future energy needs; types and significance of green energy sources.

Nuclear Energy: Fundamentals of nuclear energy technology and materials used in reactors and energy generation systems.

Biofuels: Classification of biofuel materials and their production; concept of artificial photosynthesis.

Solar Energy: Principles of solar thermal and photovoltaic systems; types, structures, and working mechanisms of solar cells; role of materials in solar applications.

Hydropower: Basics of hydroelectric power and ocean energy; benefits, limitations, and materials used in these systems.

Wind Energy: Wind energy generation, its status in India, pros and cons, and key materials involved in turbine construction.

Energy Storage: Introduction to batteries and capacitors; their working principles and materials used in energy storage technologies.

Text Books:

1. Renewable Energy – A First Course, By Robert Ehrlich, CRC Press - 2013.

Reference Books:

2. Renewable Energy: Power for a Sustainable Future, By Godfrey Boyle, Oxford University Press, ISBN-13: 978-0199545339 - 2012.
3. The Science of Renewable Energy, By Frank R. Spellman; Revonna M. Bieber, CRC Press - 2011.

MM3111	Diffusion in Solids	DEC	3-0-0	3 **Credits**

Pre-Requisites: Engineering Physics, Physical Metallurgy, Metallurgical Thermodynamics and Kinetics

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand diffusion fundamentals and Fick's laws in solids.
CO2	Explain atomic diffusion mechanisms and influencing factors.
CO3	Solve mathematical diffusion problems under different conditions.
CO4	Apply diffusion concepts to materials characterization and engineering applications.

Course Articulation Matrix:

PO/PSO → CO ↓	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	S	L	M	–	–	–	–	–	–	M	–	S	S	L	M	–
CO2	S	M	L	–	L	–	–	–	–	M	–	M	S	M	M	L
CO3	S	S	S	M	M	–	–	–	–	M	–	M	M	S	M	S
CO4	S	M	S	S	M	–	M	–	M	S	M	S	M	S	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Basics of diffusion and its importance in materials science; Fick's laws, steady and non-steady-state diffusion, error function solutions, and diffusion-controlled processes.

Atomic Mechanisms: Vacancy and interstitial diffusion, self- and impurity diffusion; factors affecting diffusion like temperature, bonding, and structure; diffusion in solid solutions and the Kirkendall effect.

Mathematical Treatment: Analytical solutions of diffusion equations under various conditions; diffusion in multi-component systems and temperature-dependent kinetics.

Experimental Techniques: Methods for measuring diffusion—diffusion couples, radiotracers, EPMA, SIMS, and advanced microscopy.

Diffusion in Materials: Diffusion behavior in metals, alloys, ceramics, semiconductors, polymers, and composites; grain boundary and surface diffusion.

Applications: Engineering relevance of diffusion in phase transformations, surface treatments (carburizing, nitriding), oxidation, corrosion, and energy materials like batteries.

Text Books:

1. P. G. Shewmon, Diffusion in Solids, 2nd Edition, Springer, 1989.

Reference Books:

2. H. Mehrer, Diffusion in Solids: Fundamentals, Methods, Materials, Diffusion - Controlled Processes, Springer, 2007.
3. J. Philibert, Atom Movements – Diffusion and Mass Transport in Solids, Les Editions de Physique, 1991.
4. R. E. Reed-Hill & R. Abbaschian, Physical Metallurgy Principles, 4th Edition, Cengage Learning, 2009.

MM3121	Physical Metallurgy of Non-Ferrous Metals and Alloys	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Physical Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Classify aluminium, magnesium, and titanium alloys and their treatments.
CO2	Analyze strengthening mechanisms in nickel and other superalloys.
CO3	Interpret compositions, heat treatments, and uses of copper alloys.
CO4	Describe properties and applications of other non-ferrous and rare metals.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	–	L	–	–	–	–	M	–	S	S	M	M	–
CO2	S	S	S	M	M	–	–	–	–	M	–	M	S	S	M	S
CO3	S	M	M	–	L	–	–	–	–	M	–	M	S	M	M	–
CO4	M	L	M	–	L	–	–	–	–	M	–	M	M	M	L	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Aluminium and its alloys: Classification and designation of aluminium alloys; non-heat treatable, heat treatable wrought and cast types; Al-Cu, Al-Zn, Al-Li, Al-Si systems—phase diagrams, compositions, heat treatments, properties, and applications.

Magnesium and Titanium alloys: Classification of wrought and cast magnesium alloys and titanium alloys; phase diagrams, compositions, heat treatments, properties, and applications.

Nickel and Superalloys: Ni-Cr, Ni-Al, Ni-Cr-Al, Ni-Cr-Al-Ti systems; Ni-based superalloys and their strengthening mechanisms (solid solution, precipitation, carbide); anti-phase boundary energy, lattice mismatch, γ′ coarsening; Fe- and Co-based superalloys, phase diagrams, alloying, oxidation/corrosion resistance, and stability.

Copper and its alloys: Brasses and bronzes (Cu-Zn, Cu-Sn), their compositions, phase diagrams, treatments, and uses.

Other non-ferrous alloys: Lead, zinc, tin, and Babbitt alloys—compositions, treatments, and properties; precious metals (Ag, Au, Pt, Pd) and rare metals (Ir, Os, Rh, Ru) with emphasis on electrical and mechanical applications.

Text Books:

1. W.F. Hosford, Physical Metallurgy, 2nd Edition, CRC Press, 2010.

Reference Books:

2. R. Rumbu, Non-Ferrous Extractive Metallurgy – Industrial Practices, Lulu Press, 2016.
3. J. Polmear, D. StJohn, J.-F. Nie, M. Qian, Light Alloys: Metallurgy of the Light Metals, 5th Edition, Elsevier, 2017.
4. W. Gowland, The Metallurgy of the Non-Ferrous Metals (Classic Reprint), C. Griffin & Company, 1914J. Polmear, Light Alloys, 5th Edition, Elsevier, 2017.

MM3131	Advanced Manufacturing Processes	DEC	3-0-0	3 Credits

Pre-Requisites: Casting and Solidification, Powder Metallurgy, Metal Joining, Mechanical Behaviour of Materials

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand advanced casting techniques and bulk metallic glass processing.
CO2	Explain severe plastic deformation and nanostructure formation methods.
CO3	Analyze friction stir welding process, tools, and material flow.
CO4	Evaluate additive manufacturing techniques and microstructural evolution challenges.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	L	L	–	L	L	L	M	S	M	–	M
CO2	S	S	M	S	M	L	L	–	L	L	L	S	S	S	–	S
CO3	S	S	M	S	S	M	M	L	L	L	M	S	M	S	–	S
CO4	S	S	M	S	S	M	M	L	L	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of manufacturing innovations in metallic materials; fundamentals of casting, forming, and joining with emphasis on recent advancements.

Advanced Casting Techniques: Rapid solidification processing; techniques like melt spinning, water quenching, and high-pressure die casting; bulk metallic glasses—formation routes, contamination effects, and casting methods (suction, arc, cap, and squeeze casting).

Advanced Forming Techniques: Severe plastic deformation (SPD) for ultrafine/nanograined metals; grain refinement in FCC and HCP systems; SPD methods such as Equal-Channel Angular Pressing and High-Pressure Torsion; effects of nanostructures on mechanical performance.

Advanced Joining Techniques: Friction Stir Welding—process principles, tool design, heat generation, and material flow; comparison with fusion welding; joint design and post-weld treatment; FSW applications in aluminum, magnesium, and titanium alloys.

Additive Manufacturing Techniques: Selective Laser Melting—principles, processing parameters, microstructure evolution, and defects; material considerations like powder quality and laser interaction; challenges including porosity, balling, cracking, and compositional loss; microstructures in metals and metal matrix composites.

Text Books:

1. Ian Gibson, David W Rosen, Brent Stucker., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.

Reference Books:

2. C. Suryanarayana and A. Inoue, Bulk Metallic Glasses, CRC press, 2017.
3. G. Faraji, H. S. Kim and H. T. Kashi, Severe Plastic Deformation: Methods, Processing and Properties, Elsevier, 2018.

Departmental Elective Courses 4

MM3141	Thin Films and Coatings	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Physical Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand vacuum systems and thin film deposition techniques.
CO2	Explain thermodynamics and kinetics of film growth processes.
CO3	Characterize thin films for structural, optical, and electrical properties.
CO4	Analyze coating types, processing methods, and engineering applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	M	M	L	L	–	L	L	L	M	M	S	–	M
CO2	S	S	M	S	S	–	L	–	L	L	L	S	S	S	–	S
CO3	S	S	M	S	S	–	–	–	L	M	L	S	M	S	–	S
CO4	S	S	M	S	S	L	M	L	L	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Thin Films: Vacuum systems – Need for vacuum, ways to achieve vacuum, determination of vacuum, dry and vapour pumps, pressure measurement gauges, conductance and other system design considerations.

Thin Film Deposition Techniques: *PVD Methods* – Molecular beam epitaxy, laser ablation, magnetron and ion beam sputtering, reactive ion plating. *CVD Methods* – Conventional CVD, PECVD, and ALD.

Thermodynamic and kinetic aspects of PVD and CVD; substrate selection, nucleation, and film growth.

Characterization Of Thin Films: Techniques for evaluating residual stress, thickness, and electrical, optical, chemical, and structural properties.

Applications of Thin Films: Use in sensors, optoelectronics, transistors, solar cells, and other technologies.

Coatings and Their Applications: *Types* – Hard and decorative coatings. *Processing* – Electro-deposition, spin coating, sol-gel, spray drying, doctor blade, inkjet printing. *Properties and Uses* – Hardness, corrosion resistance, biocompatibility, thermal stability; applied in TBCs, wear and corrosion protection.

Text Books:

1. M. Ohring, Materials Science of Thin Films: Deposition and Structure, Academic Press, 2001.

Reference Books:

2. A. Goswami, Thin Film Fundamentals, New Age International, 1996.
3. K. L. Chopra, Thin Film Phenomena, McGraw-Hill, 1969.

MM3151	Surface Engineering	DEC	3-0-0	3 Credits

Pre-Requisites: Physical Metallurgy, Phase Transformations and Heat Treatment

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand surface engineering processes, objectives, and classification.
CO2	Analyze wear, corrosion mechanisms, and surface modification strategies.
CO3	Explain metallurgical and chemical surface treatment techniques.
CO4	Evaluate advanced coatings, deposition methods, and modern trends.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	M	M	L	–	–	L	L	L	M	M	S	–	M
CO2	S	S	M	S	M	M	M	L	L	L	L	S	M	S	–	S
CO3	S	S	M	S	M	M	–	L	L	M	L	S	M	S	–	S
CO4	S	S	M	S	S	M	M	L	L	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Overview of surface engineering, objectives, scope, and process classification; types of surface layers, substrates, pre-treatment methods, and properties of single- and multi-layer coatings.

Wear and Corrosion Control: Mechanisms of wear and corrosion; categories and impact; material and process strategies for performance enhancement.

Metallurgical Modification: Surface hardening via flame, induction, electron, and laser beams; laser melting and shot-peening techniques.

Chemical Modification: Diffusion-based treatments like carburizing, nitriding, carbonitriding, cyaniding, and pack cementation (aluminizing, siliconizing, etc.); phosphate, chromate, anodizing, oxidation, plasma processes, ion implantation, and laser alloying.

Coatings and Surface Layers: Organic and ceramic coatings; hot-dip, electroplating, electroless plating; weld overlays and thermal spray methods (arc, plasma, flame, HVOF, detonation, cold spray, cladding).

Recent Trends: Advances in PVD and CVD (evaporation, sputtering, ion plating); lasers, plasma, directed energy beams, friction stir processing; nano-composites, DLC, sol-gel, and nano-engineered coatings.

Text Books:

1. P. A. Dearnley, Introduction to Surface Engineering, Cambridge University Press, 2017.

Reference Books:

2. J. R. Davis, Surface Engineering for corrosion and wear resistance, ASM International, 2001
3. M. Kamaraj and V. M. Radhakrishnan, Basics of Surface Technology, New Academic Science, 2018.

MM3161	Stainless Steels and Advanced Ferrous Alloys	DEC	3-0-0	3 Credits

Pre-Requisites: Physical Metallurgy, Steel Making, Mechanical Behaviour of Materials

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand types, properties, corrosion of stainless steels.
CO2	Analyze alloying effects and phase diagrams.
CO3	Describe processing, heat treatments of stainless and ferrous alloys.
CO4	Evaluate properties, applications of advanced ferrous alloys.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	M	M	–	L	L	L	M	M	S	–	M
CO2	S	S	M	S	M	–	L	–	L	L	L	S	M	S	–	S
CO3	S	S	M	S	S	–	–	–	L	M	M	S	M	S	–	S
CO4	S	S	M	S	M	L	M	L	L	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Stainless Steels: Definition, classification, key properties, and corrosion resistance; role of chromium and comparison with conventional steels.
Types of Stainless Steels: Ferritic, austenitic, martensitic, duplex, and PH grades; effects of alloying and relevant phase diagrams.
Manufacturing and Processing: Electric arc furnace (EAF), argon oxygen decarburization (AOD), secondary refining, casting; heat treatments like solutionizing, aging, and hardening.
Mechanical Properties and Applications: Creep resistance, strength-ductility trade-offs; applications in aerospace, biomedical, nuclear, and chemical sectors; failure case studies.
Advanced Ferrous Alloys: High-strength low-alloy (HSLA) steels, tool, maraging, and Transformation-Induced Plasticity (TRIP)/Twinning-Induced Plasticity (TWIP) steels; strengthening mechanisms and novel processing routes.

Text Books:

1. J.R. Davis, Stainless Steels, ASM International, 1994.

Reference Books:

2. P. Marshall, Austenitic Stainless Steels: Microstructure and Mechanical Properties, Springer, 1984.
3. H. Bhadeshia and R. Honeycombe, Steels: Microstructure and Properties, Butterworth-Heinemann, 4th Edition, 2017.
4. E. L. Dupont and J. C. Lippold, *Welding Metallurgy and Weldability of Stainless Steels*, Wiley, 2005.

MM3171	Metallurgical Failure Analysis	DEC	3-0-0	3 Credits

Pre-Requisites: Mechanical Behaviour of Materials, Physical Metallurgy

Course Outcomes: At the end of the course, student will be able to:

CO1	Understand failure types, mechanisms, and influencing factors.
CO2	Learn methodologies for metallurgical failure investigations.
CO3	Analyze failures using microscopy, fractography, and testing.
CO4	Propose failure prevention strategies based on case studies.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	–	M	L	–	–	–	–	L	S	–	–	–
CO2	S	S	M	–	–	–	L	–	–	–	–	L	S	–	–	–
CO3	S	S	S	M	M	–	–	–	–	L	–	–	S	S	M	–
CO4	S	S	S	M	S	–	S	L	M	S	–	M	S	S	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Fundamentals of Failure Analysis: Overview of failure types – ductile, brittle, fatigue, creep, corrosion, and wear; key mechanisms, embrittlement, environmental and processing effects; fracture mechanics, stress concentration, life prediction, and microstructural influence.

Methodologies in Failure Analysis: Steps in investigation – data collection, sample selection, visual and NDT inspection, mechanical testing, microscopy, and fractography for failure interpretation.

Case Studies and Prevention Strategies: Industrial failure cases; prevention via material/design choices, process control, quality assurance, and corrective measures for improved reliability.

Text Books:

1. A. Venugopal Reddy, Investigation of Aeronautical and Engineering Component Failures, CRC Press, 2004, 1st Edition.

Reference Books:

2. C. R. Brooks and A. Choudhury, Failure Analysis of Engineering Materials, McGraw-Hill, 2002.
3. Charles R. Brooks and Ashok Choudhury, Failure Analysis: Fundamentals and Applications in Mechanical Components, ASM International, 2020.
4. ASM International, Metallurgical Failure Analysis, ASM Handbook, Volume 11, ASM International, latest edition.

Departmental Elective Courses 5

MM3601	Materials Selection and Design	OEC	3-0-0	3 Credits

Pre-Requisites: Mechanical Behaviour of Materials, Strength of Materials

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Identify materials design factors, data analysis, and selection steps.
CO2	Apply Ashby method for material selection using property charts.
CO3	Select appropriate processes considering material, shape, and sustainability.
CO4	Evaluate materials for industrial design based on performance and lifecycle.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	–	L	L	–	–	–	–	L	S	–	–	–
CO2	S	S	S	M	–	–	L	–	–	–	–	L	S	S	–	–
CO3	S	M	S	S	M	–	S	–	–	–	–	M	S	S	S	–
CO4	S	S	M	M	S	M	S	–	–	L	–	S	S	S	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Materials Design: Materials in design; Evolution of engineering materials and their properties; Types and tools of design; Materials data and functional analysis (objectives, constraints, free variables); Steps in material selection..

Materials Selection: Ashby method; Property charts; Material indices; Selection strategies with single/multiple constraints and conflicting objectives; Shape factors and shape efficiency; Material-shape combinations; Hybrid materials: composites, sandwich, cellular, and segmented structures.

Processing Selection: Classification and attributes of processes; Steps in process selection; Material-process-shape relationships; Screening and ranking; Life-cycle analysis; Energy consumption; Eco-attributes and sustainable material choices.

Materials For Industrial Design: Requirements pyramid; Product character and material influence; Quality control; Multiple property optimization; Failure and long-term performance; Behavior under extreme conditions; Corrosion; Strategy for design and selection; Process economics; Life-cycle thinking and eco-design.

Text Books:

1. M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, 2005.

Reference Books:

2. ASM Metals Handbook, Vol. 20 - Materials Selection and Design, ASM International, 1997.
3. P. L. Mangonon, The Principles of Materials Selection and Design, Prentice Hall, 1999.

MM3611	**Materials for High Temperature Applications**	DEC	3-0-0	3 Credits

Pre-Requisites: Physical Metallurgy, Mechanical Behaviour of Materials

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Identify applications and requirements of high-temperature materials.
CO2	Explain strengthening mechanisms and their impact on material performance.
CO3	Understand creep, stress rupture, and failure behavior at high temperatures.
CO4	Assess protective coatings and materials for high-temperature applications.

Course Articulation Matrix:

PO/PSO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	M	S	L	-	M	M	M	L	M	L	S	S	M	-
CO2	M	S	M	M	M	L	S	L	M	L	M	M	S	M	M	S
CO3	M	L	S	M	M	M	M	M	-	S	S	L	S	M	S	M
CO4	L	M	S	L	M	M	S	-	M	L	-	S	M	S	L	M

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Importance and applications; Historical developments; Testing equipment; Performance requirements – mechanical properties, microstructural stability, environmental resistance, erosion and wear resistance.

Strengthening mechanisms: High-temperature strengthening in metals – solid solution, precipitation, dispersion, grain boundary strengthening; Ceramics – phase control, defect tolerance, thermal shock resistance; Role of composites in high-temperature performance.

Creep and stress rupture: Creep and stress rupture fundamentals; Testing methods; Microstructural changes; Creep mechanisms; Fracture behavior at elevated temperatures.

Creep-fatigue interaction: Failure modes under high temperature; Creep-fatigue synergy; Damage mechanisms; Fracture criteria; failure maps; Testing methods; Environmental effects.

Materials for high-temperature applications: Steels; titanium alloys; superalloys; high-performance ceramics – alumina, zirconia, SiC, Si_3N_4, glass-ceramics; composites – MMCs, CMCs, C–C composites.

Protective coatings: Coating technologies for corrosion and oxidation resistance; Metallic and ceramic coatings; reinforcement with rare and reactive metals; Erosion and wear mitigation; Thermal barrier coatings – applications and benefits.

Case studies: Aerospace; defense; nuclear; advanced engineering applications.

Text Books:

1. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications, Springer, 2000.

Reference Books:

2. R. W. Chan, High Temperature Structural Materials, Chapman & Hall, 2000.
3. S. Somiya, Handbook of Advanced Ceramics (Parts 1 & 2), Academic Press, 2006.

MM3621	Materials for Automotive Applications	DEC	3-0-0	3 Credits

Pre-Requisites: Mechanical Behaviour of Materials, Strength of Materials

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Identify automotive materials and their applications in the automotive industry.
CO2	Explain the mechanical and thermal performance of ferrous materials.
CO3	Describe non-ferrous alloys and polymers used in automotive applications.
CO4	Summarize the role of ceramics and coatings in automotive applications.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	L	–	–	L	–	S	–	–	–	–	S	S	L	M	–
CO2	S	S	M	M	M	–	S	–	–	–	–	S	S	M	S	–
CO3	S	S	M	S	S	–	S	–	–	–	–	S	S	S	S	–
CO4	M	M	S	S	S	M	S	–	–	–	L	S	S	S	S	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Automotive Materials: Importance of materials in the automotive industry; Mechanical, thermal, and environmental performance requirements; Trends in lightweight design, fuel efficiency, and sustainable materials..

Ferrous Materials for Automotive Applications: Advanced high-strength steels (AHSS); Dual-phase (DP), transformation-induced plasticity (TRIP), and twinning-induced plasticity (TWIP) steels; Cast irons; Microstructure-performance relationships; Case studies on body panels and chassis.

Non-Ferrous Alloys in Automobiles: Aluminum alloys for structural and body applications; Magnesium alloys for lightweight design; Titanium alloys for high-performance components; Copper alloys in electrical and thermal systems.

Polymers and Composites in Automotive Applications: Thermoplastics, thermosets, elastomers; Fiber-reinforced polymers, carbon fiber composites; Roles in weight reduction, safety, and energy absorption.

Ceramics and Advanced Coatings: Ceramic applications in engine parts, exhaust systems, and brakes; Thermal barrier coatings (TBCs) for heat protection; Anti-corrosion and wear-resistant coatings for durability.

Text Books:

1. M. J. Neale, Materials Selection for Automotive Bodies, SAE International, 2001.

Reference Books:

2. M. J. Neale, Materials Selection for Automotive Bodies, SAE International, 2001.
3. J. R. Davis, Automotive Steels: Design, Metallurgy, Processing, and Applications, ASM International, 2010.
4. P.K. Mallick, Materials, Design, and Manufacturing for Lightweight Vehicles, Woodhead Publishing, 2010.

MM3631	Energy Materials	DEC	3-0-0	3 Credits

Pre-Requisites: Metallurgical Thermodynamics and Kinetics, Physical Metallurgy

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Identify challenges in energy technology and role of materials.
CO2	Explain materials used for energy generation and conversion devices.
CO3	Describe various materials for electrochemical and thermal storage.
CO4	Summarize nuclear materials, sustainability concepts and emerging trends.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	L	M	L	–	S	–	–	–	–	S	S	M	M	L
CO2	M	S	M	S	M	–	S	–	–	–	L	S	S	S	M	M
CO3	M	M	S	S	S	M	M	L	–	M	L	S	S	S	S	S
CO4	L	M	M	S	M	S	M	L	–	M	M	S	S	M	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Energy supply and consumption, challenges in energy technology, linkage between energy and materials, requirement of energy efficient materials.

Materials for Energy Generation and Conversion: Photovoltaics (solar cells, thin films), fuel cell materials, and energy harvesting materials (piezoelectric, magnetoelectric, thermoelectric, caloric materials).

Materials for Energy Storage: Electrochemical (Li-ion, Na-ion, supercapacitors), electromagnetic (dielectric capacitors), and thermal (phase change materials) energy storage systems.

Nuclear Materials: Reactor types and materials for fuel, control, cooling, and structure; Radiation effects on materials.

Sustainability and Future Trends: Recycling, life-cycle analysis, environmental impact, computational design, and emerging innovations in energy materials.

Text Books:

1. R.A. Huggins, Energy Storage- Fundamentals, Materials and Applications, Springer, 2016.

Reference Books:

2. Kathy Lu, Materials in energy conversion, harvesting, and storage, Wiley, 2014.
3. CC Sorrell, Sumao Sugihar, and Janusz Nowotny (eds.), Materials for energy conversion devices, Woodhead Publishing, 2005.
4. K.L. Murty, I. Charit, An introduction to Nuclear materials, Wiley, 2013.

Departmental Elective Courses 6

MM3641	Ceramics, Polymers, and Composites	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Physical Metallurgy

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Classify ceramics, polymers, and composites based on properties and applications.
CO2	Explain crystal structure and defects in ceramics, and polymerization mechanisms.
CO3	Describe mechanical behavior and applications of polymers and ceramics.
CO4	Analyze properties, processing methods, and failure mechanisms in composites.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	L	L	–	L	L	L	M	M	S	S	S
CO2	S	S	M	M	M	L	L	–	L	L	L	M	M	S	S	S
CO3	S	S	M	S	M	L	M	L	L	M	L	S	M	S	S	S
CO4	S	S	M	S	M	M	M	L	L	M	M	S	M	S	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Ceramics: Introduction, properties, and applications; crystal structure, bonding, silicate and clay structures, and defects; classification into oxide and non-oxide ceramics; powder synthesis via sol-gel, co-precipitation, and vaporization; fabrication of dense and porous ceramics, glasses, and glass-ceramics; superplasticity, creep, toughening, and bioceramics; applications in structural, biomedical, and electronic industries.

Polymers: Classification, polymerization mechanisms, and degree of polymerization; structure-property relationships in thermoplastics, elastomers, and thermosets; mechanical behavior including deformation, strengthening, creep, and fracture; processing and recycling techniques; high-performance polymers and additives (fillers, plasticizers, stabilizers, etc.).

Composites: Overview, properties, and rule of mixtures; classification by matrix (MMC, CMC, PMC) and reinforcement type (particulate, fiber); fiber materials like glass, carbon, and hybrids; processing methods such as hand lay-up, injection and compression molding, RTM, and pultrusion; fracture and failure mechanisms, toughening strategies; applications in aerospace, automotive, biomedical, and energy sectors.

Text Books:

1. Michel W. Barsoum, Fundamentals of Ceramics, CRC Press, 2020.

Reference Books:

2. Y.M. Chiang, D. P. Birnie, and W. D. Kingery, Physical Ceramics, Wiley, 1997.
3. Anil Kumar and R. K. Gupta, Fundamentals of Polymer Engineering, CRC Press, 2018.
4. F.L. Matthews and R.D. Rawlings, Composite Materials: Engineering and Science, CRC Press, 1999.

MM3651	Smart and Bio Materials	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Engineering Physics

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Identify smart and bio-functional materials and their structure-property relationships.
CO2	Explain mechanisms of piezoelectric, electrostrictive, and magnetostrictives.
CO3	Describe shape memory alloys, conducting polymers, and applications.
CO4	Summarize advanced applications of bio-inspired materials in biotechnology.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	–	L	L	–	–	–	M	M	–	–	–	–
CO2	M	S	M	–	–	–	L	–	–	–	M	S	–	–	–	–
CO3	M	M	S	M	–	–	–	–	–	–	M	S	–	–	–	–
CO4	S	M	M	S	S	M	S	–	–	–	S	M	S	M	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Fundamentals of Smart and Bio-Functional Materials: Overview of smart and bio-functional materials, their classification, structure–property relationships, and the role of AI/ML in material design.

Piezoelectric, Electrostrictive, and Magnetostrictive Materials: Basics of functional mechanisms; perovskite piezoceramics, piezoelectric polymers, single vs. polycrystalline systems; magnetostrictive materials, MR/ER fluids; used in sensors, actuators, and vibration control.

Shape Memory and Electro-Active Materials: Shape memory alloys (SMAs), shape memory polymers (SMPs), conducting polymers, and ionic polymer-metal composites (IPMCs); Applications in soft robotics, artificial muscles, and flexible electronics.

Advanced Applications: Bio-inspired materials, smart hydrogels, nano-functional biomaterials for implants and bioelectronics, chromic materials, and sustainable smart materials for medical, optical, and industrial applications.

Text Books:

1. K Vijay, K.Varadan, J. Vinoy, S.Gopalakrisham, Smart Material Systems and MEMS: Design and Development Methodologies, Willey 2006

Reference Books:

2. B. Culshaw, Smart Structures and Materials, Artech House, 2000.
3. P. Gauenzi, Smart Structures: Physical Behaviour, Mathematical Modelling and Applications, Wiley Publishers, 2009.
4. M. Addington, Schodek, L. Daniel.: Smart materials and new technologies, Architectural Press, 2005.

MM3661	Secondary Steel Making	DEC	3-0-0	3 Credits

Pre-Requisites: Iron Making, Steel Making, Metallurgical Thermodynamics and Kinetics

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Describe primary and secondary steelmaking processes and importance.
CO2	Explain ladle metallurgy and steel refining operations.
CO3	Analyze deoxidation, desulfurization, and slag-metal interactions.
CO4	Summarize vacuum degassing and inclusion control techniques.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	S	M	M	M	M	L	–	–	–	L	M	S	S	–	M
CO2	S	S	M	S	S	–	–	–	–	L	L	S	M	S	–	S
CO3	S	S	M	S	S	–	–	–	–	–	L	S	M	S	–	S
CO4	S	S	M	S	S	M	M	L	–	M	M	S	M	S	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Steelmaking: Overview of primary and secondary steelmaking processes; significance of refining, quality control, and the role of secondary steelmaking in modern plants.

Ladle Metallurgy: Types of ladle furnaces, refining techniques, temperature and composition control, deoxidation, degassing, and inclusion cleanliness.

Deoxidation and Desulfurization: Methods using Al, Si, Ca, rare earths; oxide/sulfide formation and removal; principles and agents of desulfurization; slag-metal interactions.

Vacuum Degassing and Decarburization: Processes like VOD, LVD, RH; vacuum's role in gas removal and steel cleanliness; kinetics of hydrogen, oxygen, and nitrogen elimination.

Alloying and Inclusion Engineering: Controlled alloying, influence on properties, inclusion morphology and control, calcium treatment, and clean steel for advanced applications.

Advanced Refining Technologies: Modern developments, ladle stirring, CFD in process optimization, and sustainable practices in secondary steelmaking.

Text Books:

1. Ahindra Ghosh, Secondary Steelmaking: Principles and Applications, CRC Press, 2001.

Reference Books:

2. R. H. Tupkary & V. R. Tupkary, An Introduction to Modern Steelmaking, Khanna Publishers, 2018.
3. Winston J. Kuo, Theoretical Fundamentals of Steelmaking, Springer, 2015.
4. E. T. Turkdogan, Fundamentals of Steelmaking, The Institute of Materials, 1996.

MM3671	X-Ray Diffraction & Applications	DEC	3-0-0	3 Credits

Pre-Requisites: Introduction to Metallurgical & Materials Engineering, Physical Metallurgy, Mechanical Behavior of Materials.

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Describe fundamentals of X-rays and crystal geometry concepts.
CO2	Explain Bragg's law and principles of X-ray diffraction.
CO3	Illustrate experimental diffraction techniques and structure determination methods.
CO4	Summarize X-ray-based chemical analysis and stress measurement.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	M	–	–	–	–	L	L	M	M	–	–	S
CO2	S	S	M	–	M	–	–	–	–	L	L	M	S	–	–	S
CO3	S	S	M	S	S	–	–	–	L	M	M	S	S	–	–	S
CO4	S	S	M	S	S	L	L	–	L	M	M	S	S	–	–	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction: Fundamentals of X-rays including their properties, absorption, filters, production mechanisms, and detection techniques.

Crystal Geometry: Basics of crystal systems, lattice directions and planes, crystal structures, atomic coordination, twinning, and stereographic projection.

X-Ray Diffraction: Bragg's Law, X-ray spectroscopy and diffraction, electron and atomic scattering, structure factor, Lorentz and multiplicity factors, absorption and temperature effects, and intensity analysis of powder patterns.

Experimental Methods: Techniques like Laue, Debye-Scherrer, and focusing cameras; radiation sources, background effects, line intensity and position measurement; detectors including proportional, Geiger, scintillation, and semiconductor counters.

Structure Determination: Single-crystal orientation, unit cell parameters, indexing of diffraction patterns, texture analysis, and evaluation of crystal size and distortion.

Chemical Analysis: Quantitative phase analysis, comparison of wavelength vs. energy dispersion methods, and elemental microanalysis techniques.

Residual Stress Measurement: Concepts of residual stress, diffractometer-based methods, calibration, and accuracy considerations.

Text Books:

1. B.D. Cullity and S.R. Stock, Elements of X-ray Diffraction, 3rd Edition, Prentice Hall, 2001.

Reference Books:

2. C. Suryanarayana and M.G. Norton, X-ray Diffraction: A Practical Approach, Springer, 1998.

Open Elective - I

MM2701	Materials Science and Engineering Basics	OEC	3-0-0	3 Credits

Pre-Requisites: Engineering Physics, Engineering Chemistry

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Classify materials and explain their relevance in engineering.
CO2	Describe crystal structures, defects, and their influence on behavior.
CO3	Explain key mechanical, thermal, electrical, and optical properties.
CO4	Interpret phase diagrams and discuss material degradation and processing.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	S	M	-	-	-	-	-	-	-	-	-	-	L	M	-	-
CO3	S	M	-	-	-	-	-	-	-	-	-	-	L	M	-	-
CO4	S	M	M	-	-	-	L	-	-	-	-	M	M	M	-	-

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Materials: Material classification: Metals, ceramics, polymers, composites, semiconductors; Historical context and engineering relevance.
Atomic Structure and Bonding: Atomic structure, bonding types, and their impact on material properties.
Crystal Structures and Defects: Crystalline vs. non-crystalline materials; Unit cells, common structures; Defects and their effect on properties.
Mechanical Properties: Stress-strain behavior, elasticity, plasticity, hardness, toughness, fatigue, and creep.
Thermal Properties: Thermal expansion, conductivity, heat capacity.
Electrical & Magnetic Properties: Conductivity, insulation, magnetism.
Optical & Functional Properties: Light-matter interaction, optical behavior of materials; Introduction to smart materials.
Phase Diagrams & Transformations: Basics of phase diagrams, equilibrium/non-equilibrium transformations, role in processing.
Corrosion & Degradation: Corrosion mechanisms and prevention; Degradation in polymers and composites.
Material Processing: Overview of processing: Casting, welding, additive manufacturing.
Applications & Case Studies: Material selection examples from automotive, aerospace, biomedical, and electronics industries.

Text Books:

1. W. D. Callister and D. G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley, 2020.

Reference Books:

2. J. F. Shackelford, Introduction to Materials Science for Engineers, Pearson, 2014.
3. L. H. Van Vlack, Elements of Materials Science and Engineering, Pearson, 1989.

Open Elective - II

MM3201	Fundamentals of Materials Processing Technology	OEC	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, student will be able to:

CO1	Identify the classification of materials and their engineering applications.
CO2	Explain the processes and techniques used in metal casting and ceramic forming.
CO3	Describe metal forming, shaping processes, and friction/lubrication mechanisms.
CO4	Summarize powder processing, sintering, and design aspects

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	–	–	–	–	–	–	M	M	M	–	–	–
CO2	L	M	–	–	–	–	–	–	–	–	M	M	L	M	–	–
CO3	M	S	L	–	–	–	–	–	–	–	M	M	L	M	–	–
CO4	S	M	–	M	–	–	–	–	–	–	S	M	L	M	–	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Classification of Materials and Products: Metals, ceramics (oxide and non-oxide), polymers, composites; Forms of materials and engineering applications.

Metal Casting and Ceramic Forming: Metal casting: Melting, pouring, solidification, defects, and quality; Ceramic forming: Slip casting, pressure casting, gel casting, tape casting.

Mechanical Forming and Shaping: Metal forming processes: Rolling, forging, extrusion, drawing, sheet forming; Friction and lubrication; Ceramic shaping: Extrusion, injection moulding.

Powder Processing and Sintering: Powder characteristics; Processing of metal and ceramic powders; Pressing and sintering (conventional, microwave, spark plasma); Design aspects.

Thin Films and Coatings:

- **Films**: PVD, CVD, MBE, laser ablation, hot wire and microwave CVD.
- **Coatings**: Electro-deposition, spin coating, sol-gel, spray drying, doctor blade, ink printing.

Text Books:

1. S. Kalpakjian, S. R. Schmid, Manufacturing Engineering and Technology, Pearson, 2014.

Reference Books:

2. Phillip Boch, Ceramic Materials - Processes, Properties, and Applications, Wiley, 2010.
3. James S. Reed, Principles of Ceramics Processing, Wiley, 1995.
4. D.L. Smith, Thin-film deposition: principles and practice, McGraw Hill, 1995.

Open Elective - III

MM3701	Materials Testing & Evaluation	OEC	3-0-0	3 Credits

Pre-Requisites: Engineering Mechanics

Course Outcomes: At the end of the course, student will be able to:

CO1	Identify the significance and classification of materials testing methods.
CO2	Demonstrate mechanical testing methods for assessing material properties.
CO3	Analyze microstructural features using material characterization techniques.
CO4	Evaluate materials using NDT methods and thermal/chemical testing.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	M	–	–	–	–	–	M	–	L	–	–	–
CO2	S	M	M	–	M	–	–	–	M	–	M	–	L	M	–	–
CO3	M	M	L	M	M	–	–	–	M	–	M	M	L	M	–	–
CO4	M	M	M	L	M	–	–	–	S	–	M	L	M	L	M	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Materials Testing: Significance of testing; Classification into destructive and non-destructive methods; Standards (ASTM, ISO).

Mechanical Testing: Tensile, compression, hardness (Brinell, Rockwell, Vickers, Mohs), impact (Charpy, Izod), fatigue, creep, stress rupture, torsion, and fracture toughness tests.

Microstructural Evaluation: Optical microscopy, grain size, phase ID, inclusion rating, surface roughness, and sample preparation.

Non-Destructive Testing (NDT): Ultrasonic (UT), radiographic (RT), magnetic particle (MPT), dye penetrant (DPT), eddy current (ECT), and acoustic emission testing (AET).

Thermal and Chemical Testing: DSC, TGA, dilatometry, corrosion tests (salt spray, electrochemical), and chemical analysis (spectroscopy-based).

Evaluation and Failure Analysis: Fractography, failure modes (ductile, brittle, fatigue, creep); Case studies; Material selection for test conditions.

Text Books:

1. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw Hill, New York, 1986.

Reference Books:

2. R. E. Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, Cengage, 2008.
3. W. D. Callister and D. G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley.
4. J. F. Shackelford, Introduction to Materials Science for Engineers, Pearson, 2015.

Open Elective - IV

MM4201	Techniques for Materials Characterization	OEC	3-0-0	3 Credits

Pre-Requisites: Engineering physics, Engineering Chemistry

Course Outcomes: At the end of the course, student will be able to:

CO1	Identify and classify different materials characterization techniques.
CO2	Explain the principles and applications of microscopic techniques.
CO3	Describe X-ray-based techniques, spectroscopy, and thermal analysis methods.
CO4	Assess mechanical and surface characterization techniques for material evaluation.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	M	–	–	–	–	–	M	–	L	–	–	–
CO2	M	L	M	–	L	–	–	–	S	–	M	–	L	M	–	–
CO3	M	L	L	M	M	–	–	–	M	–	L	M	L	M	–	–
CO4	M	M	M	L	L	–	–	–	S	–	M	L	M	L	M	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Materials Characterization: Importance, classification of techniques (structural, microstructural, compositional, thermal), and selection criteria.

Optical Microscopy: Principles, sample preparation, bright/dark field, phase contrast, polarized light, and quantitative metallography.

Electron Microscopy: SEM – Working principle, imaging modes (secondary/backscattered), EDS for composition. TEM – Principle, diffraction, imaging modes, sample preparation.

X-ray Based Techniques: Basics of XRD, Bragg's law, powder diffraction method, phase identification, qualitative and quantitative analysis.

Spectroscopic Techniques: UV-Vis, FTIR (molecular vibrations), Raman (material analysis) – principles and uses.

Thermal Analysis Techniques: DSC, TGA, DTA – principles and relevance in material evaluation.

Mechanical and Surface Characterization: Nanoindentation (hardness, modulus); AFM (surface imaging, roughness, topography).

Applications and Case Studies: Use of characterization in automotive, aerospace, electronics, and biomedical industries.

Text Books:

1. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd Edition, Wiley, 2013.

Reference Books:

2. B. D. Cullity and S. R. Stock, Elements of X-ray Diffraction, Prentice Hall, 2001.
3. DB Williams and CB Carter, TEM: A Textbook for Materials Science, Springer, 2009.

Open Elective - V

MM3601	Selection of Materials	OEC	3-0-0	3 Credits

Pre-Requisites: Engineering Physics, Engineering Mechanics

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Identify types of materials and their role in design.
CO2	Evaluate key mechanical, thermal, and chemical properties.
CO3	Apply Ashby charts and material indices for selection.
CO4	Select suitable materials considering processing and sustainability.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	S	M	–	–	M	–	–	–	–	–	–	–	L	–	–	–
CO2	M	L	L	M	L	–	–	M	–	–	–	–	L	L	–	–
CO3	M	M	L	M	L	–	–	–	M	–	–	–	L	M	–	–
CO4	M	M	M	M	L	M	S	L	–	–	–	L	M	L	M	–

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Materials Selection: Role of materials in design; Classification—metals, ceramics, polymers, composites; Overview of key material properties.

Material Properties and Performance: Strength, toughness, hardness, fatigue, wear, corrosion resistance; Thermal, electrical, and magnetic properties.

Materials Selection Methods: Ashby method, material indices, performance constraints, cost and sustainability factors, selection charts.

Material Selection for Engineering Applications: Materials for mechanical, civil, electrical, and thermal systems (e.g., shafts, concrete, conductors, heat exchangers).

Processing and Manufacturing Considerations: Impact of processes on material properties; Selection for machining, welding, casting, forming, and additive manufacturing.

Materials and Sustainability: Environmental impact, recyclability, lifecycle assessment, green and eco-friendly materials.

Text Books:

1. M.F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, 2005.

Reference Books:

2. M.F. Ashby & Kara Johnson, Materials and Design: The Art and Science of Material Selection in Product Design, Butterworth-Heinemann, 2014.
3. J.E. Gordon, The New Science of Strong Materials, Princeton University Press, 2006.

Engineering Science Courses (offered to Biotechnology Dept.)

MM1601	Introduction to Materials Science and Engineering	ESC	3-0-0	3 Credits

Pre-Requisites: Engineering Physics, Engineering Chemistry

Course Outcomes (COs): At the end of the course, student will be able to:

CO1	Identify the role and classification of materials in biotechnology.
CO2	Explain atomic structure, crystal systems, and types of defects.
CO3	Describe properties of materials relevant to biotech.
CO4	Illustrate applications of metals, polymers, and nanomaterials in biological systems.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	M	L	-	-	-	-	-	M	S	M	-
CO2	S	S	M	M	S	-	L	-	-	-	-	M	M	M	-
CO3	M	S	S	M	M	M	M	M	M	L	M	M	S	M	S
CO4	S	M	S	M	S	M	S	M	M	M	M	S	S	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Materials Science: Overview and interdisciplinary nature; role of materials in biotechnology.

Classification of Materials: Metals, polymers, ceramics, composites, semiconductors; biomaterials for medical and drug delivery applications; materials paradigm: processing–structure–properties–applications.

Structure of Materials: Atomic bonding; crystal systems; defects – point defects, dislocations, grain boundaries.

Properties of Materials: Mechanical – stress-strain, elasticity, plasticity, hardness, toughness, fatigue, creep, biomechanics. Thermal – heat capacity, expansion, conductivity, phase changes, relevance in sterilization. Optical – reflection, absorption, transmission, refractive index, fluorescence; applications in imaging and biosensing. Electrical & Magnetic – conductivity, insulation, magnetism; applications in biosensors and electroactive materials. Deteriorative/Chemical – corrosion types, biocompatibility, biomaterial degradation in biological environments.

Biological and Biotechnology Applications of Materials: Structure of bone and teeth; metallic biomaterials – Mg, Ti, Zn, and 3D-printed implants; biomaterials in implants, prosthetics, and drug delivery; nanomaterials, scaffolds, biodegradable polymers; emerging trends in biotech materials.

Text Books:

1. W.D. Callister & D.G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley, 2019.

Reference Books:

2. B.D. Ratner, A.S. Hoffman, F.J. Schoen, J.E. Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Elsevier, 2004.
3. V. Raghavan, Materials Science and Engineering – A First Course, PHI Publications, 2011.

Engineering Science Courses (offered to Mechanical Engg. Dept.)

MM2061	Materials Science and Metallurgy	OEC	3-0-0	3 Credits

Pre-Requisites: Engineering Physics, Engineering Chemistry

Course Outcomes: At the end of the course, student will be able to:

CO1	Explain structure–property–processing–performance relationships in engineering materials.
CO2	Describe crystal structures, defects, and their influence on material behavior.
CO3	Interpret phase diagrams and transformation kinetics for alloy systems.
CO4	Assess mechanical properties and failure mechanisms of materials.

Course Articulation Matrix:

PO/PSO → CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	M	L	-	-	-	-	-	M	S	M	L
CO2	S	S	M	M	M	-	L	-	-	-	-	M	S	M	M
CO3	S	S	M	S	M	L	-	M	-	-	L	M	S	M	S
CO4	S	M	S	M	S	M	M	M	M	L	M	S	S	S	S

S: Strong correlation, M: Medium correlation, L: Low correlation, "–": No correlation

Syllabus:

Introduction to Materials Science and Metallurgy: Classification of materials; Engineering applications; Structure-property-processing-performance relationship.

Crystal Structure and Defects in Materials: Crystal systems, Bravais lattices; Defects: Point, Line, Surface, Volume.

Phase Diagrams and Phase Transformations: Gibbs phase rule; Binary and Iron-Carbon diagrams; Time-temperature transformation (TTT) and Continuous cooling transformation (CCT) diagrams..

Mechanical Properties and Testing of Materials: Stress-strain behavior; Elastic/Plastic deformation; Hardness, Toughness, Fatigue, Creep; Mechanical testing methods.

Heat Treatment of Steels: Annealing, Normalizing, Hardening, Tempering; Surface hardening: Carburizing, Nitriding, Induction, Flame Hardening.

Ferrous and Non-Ferrous Alloys: Steels, cast irons, and non-ferrous alloys (Cu, Al, Ti, Ni); Superalloys and applications.

Failure of Materials and Fracture Mechanics: Ductile/Brittle fracture; Griffith's theory; Fatigue and creep failure.

Advanced Materials and Manufacturing Techniques: Composites; Powder metallurgy; Additive manufacturing; Nanomaterials and smart materials.

Text Books:

1. W.D. Callister & D.G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley, 2019.

Reference Books:

2. V. Raghavan, Materials Science and Engineering: A First Course, PHI Learning, 2015.
3. W.F. Smith & J. Hashemi, Foundations of Materials Science and Engineering, McGraw-Hill, 2014.