COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Engineering and Technology

Curriculum Structure & Detailed Syllabus

F. Y. and S.Y. M.Tech.

New Material Process and Technology

Department of Metallurgy and Material Engineering

(Effective from: A.Y. 2025-26)

List of Abbreviations

Abbreviation	Title
AEC	Ability Enhancement Course
PSMC	Programme Specific Mathematic Course
PSBC	Programme Specific Basic Course
PCC	Programme Core Course
PEC	Programme Elective Course
OE/SE	Open/School Elective other than particular program
RM	Research Methodology
MLC	Mandatory Learning Course
LC	Laboratory Course
LLC	Liberal Learning Course

F. Y. M. Tech. New Material Process and Technology

Semester-I

<table>
<tr><th rowspan="3">Sr. No.</th><th rowspan="3">Course Type</th><th rowspan="3">Course Code</th><th rowspan="3">Course Name</th><th rowspan="3">L</th><th rowspan="3">T</th><th rowspan="3">P</th><th rowspan="3">S</th><th rowspan="3">Cr</th><th colspan="5">Evaluation Scheme (Weightages in %)</th></tr>
<tr><th colspan="3">Theory</th><th colspan="2">Laboratory</th></tr>
<tr><th>MSE</th><th>TA</th><th>ESE</th><th>ISE</th><th>ESE</th></tr>
<tr><td>01</td><td>PSMC</td><td>NMPT-25001</td><td>Heat and Mass Transfer</td><td>3</td><td>1</td><td>-</td><td>1</td><td>4</td><td>30</td><td>20</td><td>50</td><td>-</td><td>-</td></tr>
<tr><td>02</td><td>PSBC</td><td>NMPT-25007</td><td>Composite Materials</td><td>2</td><td>-</td><td>2</td><td>1</td><td>3</td><td>30</td><td>20</td><td>50</td><td colspan="2">CIE: 100</td></tr>
<tr><td>03</td><td>PCC</td><td>NMPT-25004</td><td>Advances in Iron and Steel Making</td><td>3</td><td>1</td><td>-</td><td>1</td><td>4</td><td>30</td><td>20</td><td>50</td><td>-</td><td>-</td></tr>
<tr><td>04</td><td>PCC</td><td>NMPT-25003</td><td>Welding Technology</td><td>3</td><td>-</td><td>-</td><td>1</td><td>3</td><td>30</td><td>20</td><td>50</td><td>-</td><td>-</td></tr>
<tr><td>05</td><td>PCC</td><td>NMPT-25002</td><td>Electrochemical Engineering</td><td>3</td><td>-</td><td>-</td><td>1</td><td>3</td><td>30</td><td>20</td><td>50</td><td>-</td><td>-</td></tr>
<tr><td>06</td><td>PCC</td><td>NMPT-25005</td><td>Lab Practice-I</td><td>-</td><td>-</td><td>4</td><td>-</td><td>2</td><td>-</td><td>-</td><td>-</td><td colspan="2">CIE: 100</td></tr>
<tr><td rowspan="4">07</td><td rowspan="4">PEC-I</td><td>NMPT(PE)-25001</td><td>Particulate Technology</td><td rowspan="4">3</td><td rowspan="4">-</td><td rowspan="4">-</td><td rowspan="4">1</td><td rowspan="4">3</td><td rowspan="4">30</td><td rowspan="4">20</td><td rowspan="4">50</td><td rowspan="4">-</td><td rowspan="4">-</td></tr>
<tr><td>NMPT(PE)-25002</td><td>Additive Manufacturing</td></tr>
<tr><td>NMPT(PE)-25003</td><td>Sustainable Metallurgy</td></tr>
<tr><td>NMPT(PE)-25004</td><td>Simulation and Modelling</td></tr>
<tr><td>08</td><td>RM</td><td>SET-25001</td><td>Research Methodology</td><td>2</td><td>1</td><td>-</td><td>1</td><td>3</td><td>30</td><td>20</td><td>50</td><td>-</td><td>-</td></tr>
<tr><td colspan="3"></td><td>Total Credits</td><td colspan="5">25</td><td colspan="5"></td></tr>
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Legends: L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits

ISE-In-Semester-Evaluation, ESE-End-Semester-Evaluation, MSE-Mid-Semester-Evaluation, TA-Teachers' Assessment, CIE-Continuous-Internal-Evaluation

F. Y. M. Tech. New Material Process and Technology

Semester –II

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	OE	OEC	*Open Elective	3	-	-	1	3	30	20	50	-	-
02	PCC	NMPT-25008	Casting Technology	3	-	2	1	4	30	20	50	CIE: 100	
03	PCC	NMPT-25009	Waste Management	3	-	-	1	3	30	20	50	-	-
04	PCC	NMPT-25010	Tribology and Wear	3	-	-	1	3	30	20	50	-	-
05	PEC-2	<tbd>	Fracture Mechanics	3	-	-	1	3	30	20	50	-	-
		<tbd>	Light Metals and Alloys										
		<tbd>	Surface Science of Engineering Materials										
06	PEC-3	<tbd>	High Temperature Corrosion	3	-	-	1	3	30	20	50	-	-
		<tbd>	Semiconductor Processing										
		<tbd>	Forming of Materials										
07	PCC	NMPT-25011	Lab Practice-II	-	-	4	-	2	-	-	-	CIE: 100	
08	AEC	SET-25002	Technical Communication Skills	1	-	2	1	2	50	50	-	100	-
09	LLC	<tbd>	Liberal Learning Course	-	-	2	2	1	-	-	-	100	-
		Total Credits		24									

Legends: L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits
ISE-In-Semester-Evaluation, ESE-End-Semester-Evaluation, MSE-Mid-Semester-Evaluation, TA-Teachers' Assessment, CIE-Continuous-Internal-Evaluation

*Department offers "Design and Selection of Materials" Course as Open Elective to other program students

- Summer internship after semester II for two months and before semester III.
- Exit option to qualify for PG Diploma in **New Material Process and Technology**

Sr. No.	Course Type	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
								Theory			Laboratory	
								MSE	TA	ESE	ISE	ESE
01	Exit Course	Eight Weeks Domain Specific Industrial Internship	-	-	-	-	3	-	-	100	-	-
		Total	**-**	**-**	**-**	**-**	**03**					

S. Y. M. Tech. New Material Process and Technology

Semester -III

Sr. No.	Course Type	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
								Theory			Laboratory	
								MSE	TA	ESE	ISE	ESE
01	SLC	Massive Open Online Course-I (MOOC-I)#	3	-	-	1	3	-	-	100	-	-
02	SLC	Massive Open Online Course-II (MOOC-II)#	3	-	-	1	3	-	-	100	-	-
03	OJT	Internship	-	-	-	-	3	-	-	100	-	-
04	Project	Dissertation Phase-I	-	-	22	12	11	-	-	-	70	30
		Total Credits					**20**					

S. Y. M. Tech. New Material Process and Technology

Semester -IV

Sr. No.	Course Type	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
								Theory			Laboratory	
								MSE	TA	ESE	ISE	ESE
01	Project	Dissertation Phase-II	-	-	22	12	11	-	-	-	70	30
		Total Credits					**11**					

Legends: **L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits**
ISE-In-Semester-Evaluation, ESE-End-Semester-Evaluation, MSE-Mid-Semester-Evaluation, TA-Teachers' Assessment, CIE-Continuous-Internal-Evaluation

#Students are encouraged to take NPTEL online courses relevant to the field of specialization and dissertation (in consultation with dissertation/project supervisor). The evaluation of such courses will be done at university level based on the scores obtained in Assignments and Proctored Exam (on NPTEL Portal) as per the university directives. It is also mandatory for the students to pass the final Proctored Exam (on NPTEL Portal) and produce the passing certificate (obtained from NPTEL portal) to the respective department at the time of ESE/final evaluation.

Semester - I

Course: Heat and Mass Transfer

Course Code	NMPT-25001	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-1-0-1 = 4	**MSE and TA**	30 and 20
Credits	4	**ESE**	50

Course Outcome:

At the end of course students will be able to:

1. Understand and apply constitutive laws as to applied to fluid flow, heat and mass transfer.
2. Develop empirical equations using the knowledge of dimensionless analysis approach for modeling certain physical phenomena.
3. Analyze and quantify the kinetics of the processes.
4. Determine the concentration profile and mass conduction equation analogous to heat conduction equation.
5. Develop and design energy efficient systems.
6. Perform shell balances for heat, momentum and mass transfer to obtain differential equations describing the velocity, temperature and concentration gradient.

Syllabus:

Review of basic concepts in heat, mass and momentum transfer Integral mass, momentum and energy balances, Equation of continuity & motion, Concept of stream function and vorticity, Concept of laminar and turbulent flow, Boundary layer theory. Advanced topics in convective, conductive and radiation heat transfer, view factor, simultaneous heat and mass transfer. Diffusion- Ficks Law and Diffusivity of materials, Diffusion in Solids, Mass Transfer in fluids systems. Reaction Kinetics-Concepts Rate constant and order of reaction, reaction mechanism and reaction rate theories. Application of above principles to selected topics in metallurgical engineering-heat exchangers, flames and furnaces, slag-metal reactions, chimney draft, flow through packed and fluidized bed, motion of gas bubbles in liquid, reduction of hematite pellets in packed bed etc.

Suggested learning resources:

Text / Reference books:

1. Geiger G.H. and Poirier D.R., Transport Phenomena in Materials Processing, Addison Wesley, 2016.
2. A.K. Mohanty, Rate Processes in Metallurgy, Prentice Hall, New Delhi, 2009.
3. Bird R.B., Stewart W.E. and Lightfoot E.N., Transport Phenomena, Wiley, 1960.
4. H.S. Ray, Kinetics of Metallurgical Reactions, Oxford & IBH, New Delhi, 2018.
5. R.I.L. Guthrie, Engineering in Process Metallurgy, Oxford Science, 1992
6. Welty, James, Gregory L. Rorrer, and David G. Foster. Fundamentals of momentum, heat, and mass transfer. John Wiley & Sons, 2014.

Course: Composite Materials

Course Code	NMPT-25007	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	2-0-2-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. The major constituents & types of composite materials
2. Metallic, ceramic and polymeric materials as matrix materials and their properties and characteristics.
3. Processing methods used for PMC, MMC, and CMC manufacturing, their advantages and disadvatnages
4. Composite materials for structural, electrical, electromagnetic, dielectric, optical and magnetic applications

Syllabus:

Composite materials in engineering, reinforcements and the reinforcement matrix interface natural and synthetic fibers, synthetic organic and inorganic fibers, particulate and whisker reinforcement-matrix interface. Polymer matrix composites (PMC) polymer matrices, processing of polymer matrix composites, characteristics and applications, composites with metallic matrices - metal matrix composites processing (MMC), Interface reactions, properties of MMCs, characteristics and application, Ceramic matrix composites (CMC) - processing and structure of monolithic materials, processing of CMCs, some commercial CMCs. Mechanical properties in composites, large particle composites and the rule of mixtures for elastic constants, Mechanical properties of fiber reinforced composites, Effect of fiber length, Critical fiber length, Strength of continuous and aligned fiber composites, Discontinuous and aligned fiber composites, Toughening Mechanism, Impact Resistance, Fatigue and Environmental Effects. Structural Composites: Cement matrix composites, Steel Reinforced Concrete, Pre- stressed concrete, Thermal Control, Vibration reduction. Polymer matrix composites - vibration damping. Composite materials for Electrical, Electromagnetic and Dielectric applications, Microelectronics and Resistance heating, Electrical insulation, capacitors, piezoelectric, ferroelectric functions, electromagnetic windows, solid electrolytes, microwave switching. Composite materials for optical and magnetic applications, optical waveguide, optical filters and lasers, multilayer for magnetic applications.

Textbooks/ Reference Books:

1. Principles of Materials Science and Engineering, William F. Smith, Third Edition, 2002, McGraw-Hill.
2. Composite Materials: Engineering and Science, Matthews F.L., and Rawlings R. D., 1999, Woodhead Publishing Limited, Cambridge England.
3. Composite Materials - Functional Materials for Modern Technology, DDL Chung, Springer-Verlag Publications, London.
4. The Nature and Properties of Engg. Materials, Jastrzebaski, John Wiley & Sons, New York.

5. Composite Materials Handbook, Mel M. Schwartz (R), 2nd Edition, 1992, McGraw-Hill, New York.
6. Mechanics of Composite Materials, Autar K. Kaw, 1997, CRC Press, New York.
7. Fundamentals of Fiber Reinforced Composite Materials, A. R. Bunsell, J. Renard, 2005, IOP Publishing Ltd.
8. Composite Materials Science and Engg., Chawla K.K., Second Edition, 1998, Springer Verlag.

COMPOSITES LABORATORY

Course Code	NMPT-25007	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-0=1	**CIE**	100
Credits	1		

Course Outcome:

At the end of the laboratory work, students will demonstrate the ability to:

1. Select appropriate process for processing of polymers and composites.
2. Determine the mechanical properties of polymers and composites.
3. Determine theoretical and experimental density of polymers and composites.
4. Evaluate electrical and thermal properties of polymers and composites.

List of Experiments/Assignments: (Any 08 experiments):

1. To Cast Thin Polymer Film Using Film Casting Method.
2. Fabrication of Composites by Injection Moulding Process.
3. Fabrication of Composite Compacts by Hot Compaction Process.
4. To Measure Density of Composites by Archimedes's Principle.
5. Impact Properties of Polymer and Composites by Izod Impact Test
6. To Measure Hardness of Polymers and Composites by Durometers and Micro hardness Tester.
7. To Measure Melt Flow Index (MFI) of Polymer and Composites.
8. Tensile Properties of Rubber, Polymers and Fiber Reinforced Composites.
9. Study of Optical Microstructure of Composites.
10. Study of Tribological Properties of Polymer Based Composites.
11. Characterization of Composites by XRD.
12. Characterization of Fractured Composites by SEM.
13. To study Vicat Softening Point Apparatus
14. Numerical based on rule of mixture and inverse rule of mixture.

Course: Advances in Iron and Steel Making

Course Code	NMPT-25004	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-1-0-1 = 4	**MSE and TA**	30 and 20
Credits	4	**ESE**	50

Course Outcome:

At the end of course students will be able to:

1. Explain metallurgical benefits of ingot and continuous cast products.
2. Understand raw materials quality and sequence of refining for making clean steel.
3. Relate the cost of the steel by careful selection of the raw materials and other necessary ingredients required for steel manufacturing.
4. Develop ways for energy conservation and environmental pollution.
5. Design alloy chemistry for manufacturing /procurement of desired composition of the steel as per the specification.

Syllabus:

Raw Materials for Steel making, Refractories, Scrap, Fluxes, Sponge Iron production, Electric Furnace Steel Making, Construction, Operation, Transformer Rating, Primary and Secondary Circuit, Power Factor, Thermal efficiency of the furnace. Ladle Metallurgy: Construction and Operation of LRF, Principle of Steel making and Refining Technology, Gases removal, Deoxidation of Steel and Non-Metallic inclusions, Role of Slag Composition on Quality of Steel, Processes-AOD, VOD& VD. Continuous Casting M/Cs: Operation and Construction, bloom, Billet, Slab and Thin strip Caster, primary and Secondary Cooling, Process parameters of the caster. Ingot Casting: Types of Moulds. Defects in Cast Product, Electromagnetic Stirring (EMS) for Quality improvement, Types of EMS, Selection Advantages, and Disadvantages. Dust generation from Furnaces and environmental impacts.

Text / Reference books:

1. Irving, William R. Continuous casting of steel. CRC Press, 2024.
2. Steel Making –V. Kudrin, Mir. Publisher, 1998
3. Introduction to Modern Steel Making- Dr. R.H. Tupkari, Khanna Publishers, 2012
4. Electrometallurgy-I - By Edneral, 1962
5. Moore, John J. "Continuous Casting " Iron and Steel Institute, 1984
6. Ahindra Ghosh, Amit Chatterjee Iron and Steel making: Theory and practice, 2ndEdition, PHI learning Pvt. Ltd, New Delhi, 2011
7. Madias, Jorge. "Electric arc furnace." Ironmaking and Steelmaking Processes: Greenhouse Emissions, Control, and Reduction, 2016

Course: Welding Technology

Course Code	NMPT-25003	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcome:

At the end of the course, students will demonstrate the ability to:

1. Identify and define the basic welding processes and their applications in industries.
2. Explain the principles of welding and how different methods work in terms of heat, pressure, and material bonding.
3. Analyze welding defects and determine their causes by reviewing weld inspection reports and conducting visual or non-destructive testing (NDT).
4. Compare and contrast the advantages and limitations of various welding processes for specific industrial applications.
5. Design and fabricate a welded component or structure, incorporating appropriate welding techniques, materials, and joint types to meet specified design requirements.

Syllabus:

Fundamentals of Joining: Classification of Joining Processes, Heat Sources in Welding, Electric Arc, its Structure, Characteristics and Power, Metal Transfer and Mass Flow, Chemical Heat Source, Contact Resistance Heat Source Solid State Joining Processes: Pressure welding, friction welding, explosive welding, ultrasonic welding, diffusion bonding, resistance welding, Brazing and Soldering heating methods, wettability, joint design); Adhesive bonding, joint design) Fusion welding: Fusion Welding, Oxyacetylene Welding, Shielded Metal Arc Welding, TIG Welding, MIG Welding, Plasma Arc Welding, Flux-Core Arc Welding, Submerged Arc Welding, Electro Slag Welding, Electron Beam Welding, Laser Beam Welding, Thermit Welding, recent trends in fusion welding. Defects in Welded Joints: Classification of welding defects, Micro-Segregation, Macro-Segregation, Banding, Gas Porosity, Inclusions, Weld Metal Cracking, Liquation Cracking, Hydrogen Cracking. Residual Stresses, Distortion, Fatigue of Welded Joints. Quality Assurance of Welding Operations, Non-destructive testing, safety, measurement, control and recording, welding specific materials - Plain carbon, low alloy steels, stainless steels, copper and copper alloys, nickel & nickel alloys, aluminum and aluminum alloys (similar and dissimilar materials joining), Process selection and joint design with case studies

Textbooks / Reference books:

1. Sindo Kou, " Welding Metallurgy", 2nd ed, John Wiley Hoboken 2003.
2. Robert D. Messler Jr., "Principles of Welding Processes", Physics Chemistry and Welding 2nd Ed., Wiley – VCH 2004
3. Kenneth Easterling – 'Introduction to the Physical Metallurgy of Welding (Monographs in Materials)'. Butterworth-Heinemann Ltd, 1983.
4. ASM Metals Handbook: Welding and Joining, Vol. 6, 9th Ed., ASM Metals Park Ohio 2011

Course: Electrochemical Engineering

Course Code	NMPT-25002	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcome:

At the end of course students will be able to:

1. Describe basic principles of Electrochemistry
2. Explore application of thermodynamics and kinetic principles for electrochemical cell.
3. Correlate energy and mass transport in the electrochemical cell.
4. Connect electrochemical behavior of cell with efficiency and its performance.
5. Evaluate selection criterion for electrolyte composition and electrode selection.
6. Develop processes for sustainable manufacturing of metals and its deposition.

Syllabus:

Design of electrochemical processes, energy and mass balance, Electric Currents in Ionic Conductors, Thermodynamics of Electrochemical Systems, Mass Transfer in Electrolytes, Phase Boundaries (Interfaces) Between Miscible Electrolytes, Polarization of Electrodes, Nonaqueous Electrolytes. Industrial Electrolysis Processes, Batteries, Fuel Cell, Solid-State Electrochemistry, Electrowinning Electro deposition Electrophoresis, Electroplating, Electroless processes. High Temperature electrolysis- Types of electrolytes, application in extraction of rare earth metals, ferrous and nonferrous processes; Green and sustainable processes, application of renewable energy, environmental impact of disposal of electrolysis waste, Flue gases and its remedial actions.

Textbooks / Reference books:

1. Bagotsky, Vladimir S., ed. Fundamentals of electrochemistry. John Wiley & Sons, 2005.
2. Krishnamurthy, N., and C. K. Gupta. "Rare earth metals and alloys by electrolytic methods." (2002): 477-507.
3. Shamsuddin, Mohammad, and TMS. Physical chemistry of metallurgical processes. Wiley, TMS, 2016.
4. Comninellis, Christos, and Guohua Chen, eds. Electrochemistry for the Environment. Vol. 2015. New York: Springer, 2010.

Course: Laboratory Practice-I

Course Code	NMPT-25005	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-4-0 = 2	**CIE**	100
Credits	2		

Laboratory Outcome:

1. Apply standard sample preparation techniques for metallographic examination of ferrous and non-ferrous alloys.
2. Analyze microstructural features such as inclusions, grain size, and phase distribution using image analysis software.
3. Evaluate the chemical composition of metals using classical and instrumental methods.
4. Perform mechanical and non-destructive testing to assess material properties and integrity.
5. Demonstrate the use of spectroscopic and microscopic tools for detailed material analysis.
6. Interpret results from thermal and coating-related processes for surface and structural characterization.

List of Experiments/Assignments:

Wherever possible refer to BIS or ASTM standards.

1. Prepare metallographic samples of ferrous and non-ferrous alloys for microstructural analysis.
2. Conduct inclusion rating, grain size comparison, and phase size analysis using an image analyzer.
3. Perform chemical analysis for carbon-sulfur in ferrous samples and copper-lead in non-ferrous alloys like brass or bronze.
4. Carry out destructive mechanical tests including tensile, compression, and bending using UTM; determine hardness using standard techniques.
5. Apply non-destructive testing techniques such as dye penetrant, magnetic particle, and X-ray radiography to detect surface and subsurface defects.
6. Analyze elemental composition using atomic absorption spectroscopy and vacuum emission spectroscopy.
7. Use scanning electron microscopy with EDS for advanced chemical analysis and microstructure evaluation.
8. Characterize metal powders in terms of particle size, shape, and flow behavior.
9. Measure thickness of coatings and case depths using metallography or microhardness testing.
10. Demonstrate vacuum melting and casting procedures for metallic systems.
11. Use dilatometry to measure CTE, and dimensional changes in materials.
12. Conduct precipitation hardening of aluminum alloys and analyze thermal behavior of steels.

Course: Particulate Technology

Course Code	NMPT(PE)-25001	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Identify various powder manufacturing processes
2. Explain effect of particle size and shape on compressibility of powders and its sinterability
3. Apply various characterization techniques for phase transformation and properties
4. Analyze sinterability of powders and processing variables
5. Evaluate structure-property of sintered products
6. Design alloy and process cycle for the materials

Syllabus:

Introduction, characterization and testing of metal powders: astm/mpif standards, production of metal powders: mechanical, atomization; physico-chemical processes, thermal decomposition, reduction, electrodeposition, mechanical alloying. Consolidation of metal powder: powder conditioning, cold die compaction techniques, tooling system, hot and cold isostatic pressing of metal powders, roll compaction and extrusion of powders, powder forging, metal injection molding. Sintering furnaces and atmospheres, types of sintering processes, different mechanisms of sintering, liquid phase sintering and activated sintering, sinter hardening, sinterability of ferrous and al, cu, cr, contacts materials, precious metals, diamond cutting tools, hss tools and carbide tools, magnetic materials; sintering stages of mim compacts. High entropy alloys: thermodynamics principles in designing of alloys; hard facing alloys for thermal coating /cladding/weld overlay; powders for additive manufacturing of engineering and biomedical components, and secondary operations such as surface hardening treatment, heat treatment and microstructural transformations, machinability. Sustainable process and circular economy: extraction of metal powders, recycle and reuse of wastes, case studies on bearing materials, tool materials, ferrites, cermet, friction materials, medical and dental applications, nuclear and automotive applications

Textbooks/ Reference Books:

1. Anish Upadhyaya and G S Upadhyaya, "- Powder Metallurgy Technology", University Press, 2011.
2. Randall M German, "Powder Metallurgy and Particulate Materials Processing" MPIF, 2005
3. Powder Metallurgy, ASM Handbook, Vol.7, 1984.
4. Randall M German, "Sintering Theory and Practices", John Wiley and Sons,1996.

Course: Additive Manufacturing

Course Code	NMPT(PE)-25002	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Classify and explain the principles of various additive manufacturing (AM) technologies
2. Analyze the impact of AM processes on the microstructure and mechanical properties of metals
3. Design and optimize components for AM.
4. Evaluate and apply post-processing techniques
5. Identify and mitigate common defects in AM parts

Syllabus:

Introduction to Additive Manufacturing (AM): Definition and evolution of AM, Comparison with traditional manufacturing methods, Applications in aerospace, automotive, medical, and tooling industries, Overview of AM standards and classifications (ASTM F42), Introduction to AM processes: Powder Bed Fusion (PBF), Directed Energy Deposition (DED), Binder Jetting, Material Jetting, and Extrusion-based systems. Metallurgical Fundamentals for AM: Phase diagrams and phase transformations, Solidification and microstructure development, Influence of thermal cycles on microstructure, residual stress and distortion in AM parts. Materials for Additive Manufacturing: Selection criteria and Metals commonly used in AM, Feedstock forms: Powders, wires, filaments, post-processing techniques: Heat treatment, surface finishing, machining, Challenges in material qualification and standardization. Post-Processing and Quality Assurance: Post-processing techniques: Heat treatment, surface finishing, machining, Quality assurance methods: Non-destructive testing (NDT), destructive testing, Dimensional accuracy and surface roughness assessment, Case studies of quality control in AM. Future trends: Hybrid manufacturing, AI in AM, 4D printing.

Textbooks/ Reference Books:

1. Gibson, I., Rosen, D., & Stucker, B. (2015). Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. Springer.
2. Milewski, J.O. (2017). Additive Manufacturing of Metals: The Technology, Materials, Design and Production. Springer.
3. Leach, R., & Carmignato, S. (2020). Precision Metal Additive Manufacturing. CRC Press.
4. Balasubramanian, K.R., & Senthilkumar, V. (2020). Additive Manufacturing Applications for Metals and Composites. IGI Global.
5. ASTM F42 Committee. (2020). Standard Terminology for Additive Manufacturing Technologies. ASTM International.

Course: Sustainable Metallurgy

Course Code	NMPT(PE)-25003	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the environmental and energy-related challenges in conventional metallurgical processes.
2. Evaluate strategies for minimizing waste, emissions, and energy usage in metallurgy.
3. Apply principles of circular economy and life cycle assessment to metallurgical processes.
4. Compare sustainable practices in ferrous, non-ferrous, and secondary metal industries.
5. Design conceptual metallurgical processes incorporating sustainability and green engineering.

Syllabus:

Need for sustainability in metals and materials, Environmental impact of mining and metallurgy, Sustainable development goals (SDGs) and the metals industry, Overview of carbon footprint and ecological footprint, Hydrogen metallurgy and CO_2 reduction techniques, Electrolytic and solvent-based extraction routes, Waste heat recovery systems, Zero-waste and closed-loop processes, Life cycle assessment (LCA) of metals, Emissions control (SOx, NOx, particulate matter), Water and waste management in metallurgical industries, Designing alloys and materials for recyclability, Biomimicry and materials substitution, Circular economy principles in metallurgy, Industry best practices and innovation in sustainable metallurgy, Case studies: Green steel, low-impact alloy design. Environmental regulations and standards (ISO 14001, REACH, etc.).

Textbooks:

1. Sustainable Materials - With Both Eyes Open by Julian Allwood et al.
2. Innovations in Mini Blast Furnaces: Toward Sustainable Metallurgy by Aitber Bizhanov, Pruet Kowitwarangkul, Sergey Gavrilovich Murat, Alexander Rostovskiy, Suporn Kittivinitchnun, Springer, 2025.
3. Sustainable Metals Management: Securing Our Future - Steps Towards a Closed Loop Economy: 19 (Eco-Efficiency in Industry and Science), by Arnim von Gleich (Editor), Robert U. Ayres (Editor), Stefan Gößling-Reisemann (Editor), Springer-Verlag New York Inc.; 2006.
4. Design for Sustainability: Green Materials and Processes by S. M. Sapuan, Muhd Ridzuan Mansor, Elsevier Science Publishing Co Inc, 2021.

Reference Books:

1. Selected journal articles from Journal of Sustainable Metallurgy, Resources, Conservation and Recycling, etc.

Course: Simulation And Modelling

Course Code	NMPT(PE)-25004	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand model roles, classifications, functions, and limitations.
2. Formulate mathematical models using conservation and constitutive laws.
3. Develop physical models, including phase-field methods.
4. Apply basic solution strategies and validate models.
5. Overview modern simulation and AI applications in materials.

Syllabus:

Introduction to Modeling in Materials Science and Engineering: Types, Applications, and Limitations; Modelling procedure and assumptions; conservative and constitutive equations; dynamic, lumped parameter, and distributed parameter models; development of mathematical, rigorous, and semi-rigorous physical models; phase-field methods for simulating solidification microstructures; solution strategies for basic equations; sensitivity analysis; data acquisition, analysis, and model validation.

Simulation: Survey of simulation techniques including molecular dynamics and Monte Carlo simulations. Thermal and stress analysis using FEA. Introduction to fuzzy logic, neural networks, and genetic algorithms; applications in phase diagram computation, blast furnace modelling, steelmaking, and materials processing.

Self-study: Mathematical tools: basic calculus, ordinary and partial differential equations, linear algebra, Curve fitting, and introductory statistics.

Textbooks:

1. S. Szekely, J.W. Evans and J.K. Brimakombe: The Mathematical and Physical Modelling of Primary Metals Processing Operations, Wiley.
2. D. Mazumdar and J.W. Evans: Modelling of Steel Making Processes, CRC.
3. N. Provatas and K. Elder: Phase-field Methods in Materials Science and Engineering, Wiley-VCH.
4. S. Rajasekaran, G.A.V. Pai: Neural networks, Fuzzy Logic and Genetic Algorithms Synthesis and Applications, Prentice-Hall of India.

Reference Books:

1. R.J. Arsenault, J.R. Beeler, Jr. and D.M. Esterling (Eds.): Computer Simulation in Materials Science, ASM.
2. S. Yip: Modelling and Simulation Handbook
3. W.H. Press, S.A. Teukolsky, W.T. Vetterling and B.P. Flannery: Numerical Recipes - The art of scientific computing, 3rd ed., Cambridge.
4. I.M. Sibol: The Monte-Carlo method, Little Mathematics Library, Mir.

SEMESTER – II

Course: Design and Selection of Materials

Course Code	OEC	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of course, students will be able to

1. Design process and its relation to material selection.
2. Interpret mechanical properties of materials and apply these material properties into the design of components.
3. Determine the mechanical properties of materials and apply these material properties in the design system components.
4. Explain the interrelationship between design, function, materials and process.

Syllabus:

Materials in Design, Evolution of Engineering Materials, Design process, Types of design, Design flow chart. tools and material data, Interaction between Function, Material, Shape and Process. Revision of engineering materials and properties, Material properties interrelationship charts such as Young's modulus-density, Strength-density, Young's modulus-Strength, wear rate-hardness, Young's modulus - relative cost, strength-relative cost and others. Materials selection, selection strategy: material attributes, translation of design requirements, screening attribute limits, ranking by indices, search supporting information ,Local conditions, method of finding indices, Weighted-Properties Method, computer aided selection, structural index; Case studies: table legs, flywheel, springs, elastic hinges, seals, pressure vessels, kiln wall, passive solar heating, precision devices, bearings, heat exchangers, airframes, ship structures, engines and power generation, automobile structures. Materials Substitution, Pugh Method, Cost–Benefit Analysis, Cost basis for selection, causes of failure in service, Specifications and quality control, Selection for static strength, toughness, stiffness, fatigue, creep, corrosion resistance, wear resistance, material databases. Process selection, ranking processes, cost, computer-based process selection, Case studies: fan, pressure vessel, optical cable, cast tables, manifold jacket, spark plugs, Insulator. Selection under multiple constraints, conflicting objectives, penalty-functions, exchange constants, Case studies: connecting rods, windings of high field magnets, casings of minidisk player, disk-brake caliper.

Text Books:

1. Michael F. Ashby, Materials Selection in Mechanical Design, third edition, Butterworth-Heinemann, 2005
2. J. Charles, F.A.A. Crane, J. A.G. Furness, Selection and Use of Engineering Materials, third edition, Butterworth-Heinemann, 2006

Reference Books:

1. ASM Metals Handbook, Materials Selection and Design, Vol.20,2010
2. Myer Kutz, Handbook of Materials Selection, John Wiley & Sons, Inc., New York, 2002, ISBN0-471-35924-

Course: Casting Technology

Course Code	NMPT-25008	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-2-1 = 4	**MSE and TA**	30 and 20
Credits	4	**ESE**	50

Course Outcome:

At the end of course students will be able to:

1. Understand the various casting processes, solidification.
2. Understand details of mould design.
3. Analyze the effect of solidification technique on the microstructure and properties of a casting.
4. Apply knowledge of casting processes to identify and solve problems associated with casting defects.

Syllabus:

Introduction to Casting, mechanism of solidification, solidification of pure metals and alloys, problem solving on solidification, technology of pattern making, allowances in pattern making, moulding sands and its ingredients, testing of molding sands, sand preparation for casting, technology of mould and core making, binders, special molding process, Introduction to additive manufacturing for Mold and core making, rapid prototyping in foundries (e.g., 3D sands printing), benefits and limitations. Types of gates, Gating design, problem solving on gating design pouring time calculation, risering methods, shape factor, feeding & chills effect, problem related to riser design, melting technology, melting practices, melting & casting of ferrous and non-ferrous heat treatment of castings, casting defects and remedies. Industry 4.0 and Digital Foundry. Case Studies on Recent Trends in Casting Industries (Additive Manufacturing, Digital Foundry, and Industry 4.0 Applications)

Textbooks/ Reference Books:

1. P.L. Jain- Principles of Foundry Technology, 5th edition, Tata-McGraw-Hill, New Delhi, 2017.
2. A.K. Chakrabarti, Casting Technology and cast alloys, Prentice-Hall of India, 2022.
3. R.W. Hiene, C.R. Loper and P.C. Rosenthal, Principles of Metal Casting, Tata-McGraw-Hill, Reprint 1998.
4. Peter Beeley, Foundry Technology, 2nd edition, Butterworth-Heinemann, Oxford, 2001.
5. ASM Handbook, Vol. 15, ASM International, OH, USA.
6. Campbell, John. Complete casting handbook: metal casting processes, metallurgy, techniques and design. 2nd edition, Butterworth-Heinemann, 2015.

Course: Casting Technology (Laboratory)

Course Code	NMPT-25008	Scheme of Evaluation	CIE
Teaching Plan	0-0-2-0=1	CIE	100
Credits	1		

Course Outcome:

At the end of the laboratory work, students will demonstrate the ability to:

1. Understand fundamental casting processes through experiments on solidification, pattern making, moulding, and core preparation.
2. Analyze moulding and core sand properties, gating and riser design, and their influence on casting quality.
3. Evaluate melting practices, cast metal behaviour, and identify casting defects with their root causes.
4. Apply modern casting technologies, including digital foundry tools and Industry 4.0 concepts, to improve process understanding and design.

List of Experiments/Assignments: (Any 08 experiments):

1. Sieve Analysis and Grain Fineness Number (GFN) Determination of Moulding Sand
2. Cooling Curve Experiment: Solidification Study of Pure Metals and Alloys
3. Pattern Making and Allowance Measurement for Casting Applications
4. Preparation and Testing of Moulding Sand Properties
5. Core Making and Evaluation of Core Sand Properties
6. Design and Calculation of Gating System and Pouring Time
7. Riser Design Using Shape Factor, Modulus and Feeding Efficiency Concepts
8. Melting and Casting Practice for Ferrous and Non-Ferrous Alloys
9. Identification and Analysis of Casting Defects
10. Demonstration of Digital Foundry Tools and Industry 4.0 Applications
11. Case Study on Modern Casting Technologies (AM Molds, 3D Sand Printing, Digital Foundry)
12. Industrial visit.

Course: Waste Management

Course Code	NMPT-25009	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcome:

At the end of course students will be able to

1. To understand various types of wastes and their environmental impacts.
2. To introduce principles and technologies of waste collection, treatment, and disposal.
3. To explore regulatory, economic, and social aspects of waste management.
4. To promote sustainable and circular approaches to waste handling.

Syllabus:

Introduction to Waste Management: Definition and classification of waste: solid, liquid, hazardous, biomedical, e-waste, Sources and characteristics of waste, History and evolution of waste management, Impacts of improper waste disposal on health and environment, Hierarchy of waste management: 5Rs (Refuse, Reduce, Reuse, Repurpose, Recycle). Electronic Waste Management: Classification and sources of electronic waste (home appliances, EV batteries, etc.), Hazardous substances in e-waste (lead, mercury, cadmium), Environmental and Health Impacts. Biomedical and Agro Waste Management: Types of agricultural waste: Crop residues, animal waste, food processing waste, Agro waste generation and environmental concerns. Plastic Waste Management: Sources and global generation of plastic waste, Environmental and health impacts of plastic waste accumulation, Alternatives to Traditional Plastics, Development of biodegradable and compostable plastics. Industrial and Hazardous Waste Management: Classification of industrial waste, Sources and types of hazardous waste, Secure landfills and hazardous waste incinerators, Waste minimization strategies in industries. Waste to Energy, Resource Recovery and Recycling**:** Conversion of agricultural waste to value-added products (animal feed, biomaterials), Agro waste-to-chemicals, Waste-to-Energy from Plastics, Recovery of valuable metals from electronic waste, Conversion of thermal power ash into value added products. **Case Study:** Challenges and Innovations in Biomedical Waste Management

Textbooks:

1. Waste Management and Treatment Advances and Innovations by Rajpal A., CRC Press I Inc; 1st edition, 2025.
2. Electronic Waste Management: Policies, Processes, Technologies, and Impact by Sunil Kumar, Vineet Kumar, Wiley; 1st edition 2024.
3. Integrated solid waste management: engineering principles and management issues, by George Tchobanoglous, Hilary Theisen, S. A. Vigil, 1993.
4. Waste Management and Resource Recovery by Charles R. Rhyner, Leander J. Schwartz, Mary G. Kohrell, Robert B. Wenger, CRC Press Inc; 1st edition, 1995.

Reference Books:

1. Selected journal articles and case studies.

Course: Tribology and Wear

Course Code	NMPT-25010	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcome:

At the end of course students will be able to:

1. Relate material, external parameters and lubricant properties on wear behaviour
2. Explain the different wear processes and governing laws
3. Identify a suitable material combination for tribological contacts and wear mechanism
4. Analyse the material tribological system
5. Evaluate wear map for tribological system
6. Design new materials/ processes for improving wear resistance of the materials

Syllabus:

Definitions and development of wear studies, material properties, mechanical properties and environmental parameters on wear behaviour, impact Hertzian and non-hertzian contact, contact pressure and deformation in non-conformal contacts, causes of friction, stick-slip friction behaviour and friction instability, sliding and rolling friction, frictional heating and temperature rise, wear and wear types, mechanisms of wear. Lubricants and their physical properties, Reynolds equation, infinite bearing, short bearing, elastohydrodynamic lubrication: principle and application, pressure - viscosity term in Reynolds equation, Hertz theory, Ertel-Grubin equation, Gas lubrication: Lubrication in metal working: rolling, forging, drawing and extrusion. Surface coatings, selection of coating for wear and corrosion resistance, potential properties and parameters of coating; vibration analysis, lubricant analysis, wear and friction measurement techniques, microscopy techniques, micromechanical properties techniques. Case studies on various sectors of engineering and non-engineering applications.

Textbooks:

Tribology, Friction and Wear of Engineering Material, I. M.Hutchings, Edward Arnold, London.

Reference Books:

Basic Lubrication Theory, A. Cameron, Ellis Hardwoods Ltd., UK.

Engineering Tribology, J. A. Williams, Oxford Univ. Press.

Engineering Tribology, G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann.

Engineering Tribology, P. Sahoo, PHI, New Delhi.

Course: Fracture Mechanics

Course Code		Scheme of Evaluation	MSE, TA and ESE
Teaching Plan	3-0-0-1=3	MSE and TA	30 and 20
Credits	3	ESE	50

Course Outcome:

On successful completion of this course, students will be able to:

1. Understand fundamental concepts in fracture mechanics, elasticity, and plasticity theory.
2. Analyze stress and strain states using stress and strain tensors, and solve problems using Mohr's circle.
3. Quantify fracture toughness using methods like stress intensity factor (K_IC), J-integral, R-curve, and CTOD.
4. Design materials for damage-tolerant applications based on fracture mechanics principles.

Syllabus:

Introduction to Fracture Mechanics, Elasticity and plasticity theory, Fundamental equations in theory of elasticity and plasticity, Mohr's circle, Stress and Strain tensors, brittle and ductile fracture, strain energy release rate, Griffith theory of brittle fracture, Stress intensity factor in various modes, relation between strain energy release rate and stress intensity factor, Classification of fracture mechanics; (i) linear elastic fracture mechanics, and (ii) elastic plastic fracture mechanics, quantifying fracture toughness (i) J-integral, (ii) R-Curve, (iii) CTOD. Case studies of designing materials for damage tolerant applications.

Textbooks/ Reference Books:

1. R. W. Hertzberg, R. P. Vinci, J. L. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, 5th Edition, Wiley, 2012, ISBN-10: 0470527803.
2. G. E. Dieter, Mechanical Metallurgy, 3rd Edition, McGrawHill, 2017, ISBN: 0071004068.
3. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, 4th Edition, CRC Press, 2017, ISBN10: 1498728138.
4. R. J. Sanford, Principles of Fracture Mechanics, 1st Edition, Pearson, 2002, ISBN-10: 0130929921.

Course: Light Metals and Alloys

Course Code		**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcome:

At the end of the course, students will demonstrate the ability to:

1. Understand extraction of light metals.
2. Explain solidification processes, thermodynamics involved and physical metallurgy of light alloys.
3. Compare processing routes used for manufacturing light alloys.
4. Depict structure-property relationship of various light metal alloys and select these alloys for real-world applications.
5. Design new alloy systems or processing route or heat treatment for light metals and alloys.

Syllabus:

Introduction: Definition, Characteristics, production of aluminum, production of magnesium, production of titanium, usage and economics, Recent trends

Thermodynamics and kinetics of solidification: homogeneous and heterogeneous nucleation, dendritic growth, solid/liquid Interface stability, Heat flow, heat evolution, shrinkage, macro and micro segregation, Recent advances in processing: Semi solid processing (SSP), Thixographic processing,

Aluminum Alloys: Wrought Al Alloys: Designation and Tempers heat treatable and non-heat treatable alloys, Li containing alloys, joining. Special products- aircraft alloys, automotive alloys, packaging alloys, electrical conductor alloys, Cast Aluminum Alloys: Designations, tempers and characteristics, alloys based on Al-Si, Al-Cu, Al-Mg, Al-Zn-Mg systems, modification in Al-Si alloys, joining

Physical Metallurgy of Al Alloys: Work hardening and annealing, forming limit curves, textures, principles of age hardening, microalloying effects, hardening mechanisms, aging processes, mechanical behavior, corrosion behavior.

Magnesium Alloys:

Introduction to alloying behavior, alloy designations, Zr-free and Zr-containing alloys, wrought magnesium alloys, extrusion alloys, forging alloys, trends in applications of Mg alloys, electrochemical aspects

Titanium Alloys:

Introduction and classification, basic principles of heat treatments, wrought and cast commercial titanium alloys, texture effects, surface treatments, engineering performance- tensile, creep, and fatigue behaviour, Applications- general application of Titanium Alloys, aerospace, power generation, automotive, marine, biomaterials

Suggested learning resources:

1. Polmear I.J., Light Alloys, 4th Ed., Butterwort Heinemann 2006
2. Brandes E.A. and Brook G.B., Smithells Light Metals Handbook, Elsevier 1998
3. Totten G.E. and Mackenzie D.S., Handbook of Aluminum Vol.1: Physical Metallurgy and Processes, CRCPress 2003
4. Friedrich H.E., Mordike B.L. and Friedrich H., Magnesium Technology, 1st Ed. Springer 2004
5. Ber L.B., Kolobnev N. and Kablov E.N., Heat Treatment of Aluminum Alloys: Advances in Metallic Alloys, CRC Press,2010
6. Lütjering G., Williams J.C., Titanium, 2nd edition, Springer,2007

Course: Surface Science of Engineering Materials

Course Code		**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand the fundamentals of surface engineering and surface modification methods.
2. Analyze the effects of surface treatments on material performance.
3. Compare various surface processing techniques for different engineering applications.
4. Apply suitable surface treatments in practical engineering scenarios.
5. Interpret material characterization data to evaluate surface properties.
6. Select appropriate surface engineering methods based on application needs.

Syllabus:

Importance of surface processing in modifying the properties of engineering components subjected to abrasion, wear, corrosion and fatigue. Preparation of the substrate for surface processing: Physical, chemical, electrochemical. Various methods of surface modifications such as: Physical Vapor Deposition, Chemical Vapor Deposition (Chromium, Nickel, Titanium, Copper etc.), Ion Implantation method, Coatings for high temperature Performance, Electrochemical and spark discharge processes, Plasma coating methods, Organic and Powder coatings, Thermal barrier coating, Advanced electron beam techniques, Laser surface processing, Coating on plastics. Applications of these methods in the fields like Mechanical, Metallurgical engineering, optical, electronics and surgical instruments, medicine and biotechnology. Comparison of solar induced surface transformation of materials (SISTM) in processing of electronic materials with other direct energy methods such as Ions, Laser, Electron beam and thin film deposition. Techniques for evaluation and characterization.

Textbooks/ Reference Books:

1. Edited by J. R. Davis – Surface Engineering for Corrosion and Wear Resistance, ASM International, 2001.
2. George J. Rudzki – Surface Finishing Systems: metal and non-metal finishing handbook guide, Metals Park: ASM, 1983.
3. James A. Murphy – Surface Preparation and Finishes for Metal,McGraw-Hill,New York (USA) 1971.
4. H. Hochman – Ion plating & Implantation application to material – ASM.
5. P. G. Sheasby and R. Pinner – Surface treatment and finishing of Aluminium and its alloy, Volume-2, 5th ed., ASM, Metals Park, 1987.
6. K. E. Thelning – Steel and its Heat Treatment Bofors Handbook, London Butterworths, 1975.
7. Keith Austin – Surface Engineering Handbook, London: Kogan Page, 1998.

Course: High Temperature Corrosion

Course Code		**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Establish correlation between thermodynamic and high temperature corrosion.
2. Solve numerical.
3. Understand concepts and fundamentals in high temperature corrosion.
4. Knowledge of material selection for different

Syllabus Contents:

Introduction to high Temperature corrosion & oxidation of Metals and Alloys, Thermodynamics of gas/metal reactions; stability of oxides and sulphides, & Ellingham diagram, vapor species diagram, Isothermal stability diagram, Rate Laws, Kinetics and Mechanics. Wagner's Parabolic Law of Oxidation. Derivation and Limitations, Types of oxidations: general oxidation, selective oxidation, internal oxidation, breakaway and catastrophic oxidation, Role of Diffusion and Defect structure of oxides in Oxidation, multiple scale formation & cracking. Forms of Corrosion with Special reference to External and Internal Oxidation. Liquid Metal Embrittlement, Hot Corrosion, Corrosion in Mixed Gaseous Environment. Prevention of Corrosion, Material Selection and Design, Alteration of Environment, Inhibition, Metallic and Ceramic Paints, Coatings, Special Treatment. High temp. Materials: superalloys, intermetallics, ceramics. Case Study of high temperature oxidation, power plants, gas turbines, petrochemical plants etc.

Textbooks/ Reference Books:

1. High Temperature Corrosion of Materials-by Kofstadt
2. High Temperature Oxidation of Metals and Alloys –by N.Birks and Meir
3. Fundamentals of Corrosion- Scully
4. Riedel H. – Fracture of High Temp., Springer-Verlag, Berlin,1987.
5. J.M.West-Basic Corrosion & Oxidation, 2nd Edition, Ellis Harwood Publication, 1986.
6. ASM Metals H.B., Vol. 13, ASM international, Metals park, Ohio, 1986.

Course: Semiconductor Processing

Course Code		**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcome:

At the end of this course, the students will demonstrate the ability to:

1. Understand and classify various crystal growth techniques and wafer preparation methods.
2. Analyze doping techniques and correlate them with desired electrical and structural characteristics.
3. Evaluate different thin film deposition processes and their impact on microstructure and material properties.
4. Interpret lithographic and etching processes with respect to pattern resolution and material interaction.
5. Design integrated process flows considering materials compatibility, packaging, and reliability.
6. Critically assess advanced processes for MEMS, nanoelectronics, and modern device miniaturization.

Syllabus:

Single Crystal Growth and Wafer Processing: CZ, Bridgman, FZ, defects during growth, surface polishing, stress and crystal quality evaluation. Doping Techniques: Solid/gas diffusion, ion implantation, dopant profiles, defect engineering, annealing, RTA and laser annealing. Thin Film Deposition: PVD, CVD, ALD, MBE; film stress, microstructure, nucleation/growth mechanisms; applications in interconnects and gates. Lithography and Etching: Photolithography process flow, photoresist behavior, wet and dry etching, plasma effects on material surfaces. Integration, Metallization and Packaging: Contact formation, electromigration, barrier layers, encapsulation, lead-free soldering, reliability issues**.** Advanced Processing: Materials and process challenges in miniaturization, nanofabrication, emerging packaging, Thermoelectric materials and processing, Special semiconductor materials for energy applications, Advanced semiconductor materials for extreme environments.

Textbooks

1. Raghavan, V. 2015. Materials Science and Engineering: A First Course. 6th ed. New Delhi: PHI Learning Pvt Ltd.
2. Smith, William F., and Javad Hashemi. 2023. Foundations of Materials Science and Engineering. 7th ed. New York: McGraw Hill.
3. Dhir, S. M. 2002. Electronic Components and Materials: Principles, Manufacture and Maintenance. New Delhi: Tata McGraw-Hill.
4. Campbell, Stephen A. 2001. Fabrication Engineering at the Micro- and Nanoscale. 2nd ed. New York: Oxford University Press.

Reference Books

1. Kasap, S. O. 2018. Principles of Electronic Materials and Devices. 4th ed. New York: McGraw-Hill Education.
2. ASM International. 1989. Electronic Materials Handbook. Vol. 1: Packaging. Materials Park, OH: ASM International.
3. Wolf, Stanley, and Richard N. Tauber. 2000. Silicon Processing for the VLSI Era, Vol. 1: Process Technology. 2nd ed. Sunset Beach, CA: Lattice Press.
4. Runyan, W. R., and K. E. Bean. 1990. Semiconductor Integrated Circuit Processing Technology. Reading, MA: Addison-Wesley.
5. Madou, Marc J. 2011. Fundamentals of Microfabrication and Nanotechnology. 3rd ed. Boca Raton, FL: CRC Press.
6. Ghandhi, S. K. 1994. VLSI Fabrication Principles: Silicon and Gallium Arsenide. 2nd ed. New York: Wiley.
7. Sze, S. M., and Kwok K. Ng. 2006. Physics of Semiconductor Devices. 3rd ed. Hoboken, NJ: Wiley-Interscience.

Course: Forming of Materials

Course Code		**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	3-0-0-1 = 3	**MSE and TA**	30 and 20
Credits	3	**ESE**	50

Course Outcome:

On successful completion of this course, students will be able to:

1. Understand and Apply Fundamental Principles of Rolling and Extrusion Processes
2. Analyze and Prevent Defects in Rolling and Extrusion
3. Understand Sheet Metal Forming and Plastic Forming Operations

Syllabus:

Theory and applications of rolling, Types of rolling, Rolling mill setup and control parameters, Defects in rolling and preventive measures. Types of extrusion process, Metal Flow, Extrusion dies and tool design. Wire drawing and tube drawing. Deep drawing and its applications. Spinning of metals and plastics. Sheet Metal Forming operations and applications. Material formability criteria (limit strains, strain hardening). Plastic Forming Processes: Injection molding, Compression molding and Rotational molding of plastics. Electromagnetic forming. Additive manufacturing (3D printing) for metals and polymers. Defects and its remedies in all above forming processes. Industry 4.0 in forming processes.

Textbooks / Reference books:

1. Kalpakjian, Serope. Manufacturing Engineering and Technology. 7th ed. Boston: Pearson, 2019.
2. Dieter, George E. Mechanical Metallurgy. SI Metric ed. New York: McGraw-Hill Book Company, 1988.

Course: Laboratory Practice-II

Course Code	NMPT-25011	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-4-0 = 2	**CIE**	100
Credits	2		

Laboratory Outcome:

1. Analyse crystal structures and perform indexing using X-ray diffraction techniques.
2. Evaluate retained austenite and residual stress in treated components using XRD.
3. Investigate fracture behaviour and surface wear using SEM and tribological testing.
4. Apply computational tools for thermal analysis, crystal modelling, and electronic structure simulations.
5. Conduct data interpretation through plotting, fitting, and regression analysis using appropriate software.
6. Characterize materials using thermogravimetric, optical, and scanning probe microscopy techniques.

List of Experiments/Assignments:

1. Perform X-ray diffraction analysis and indexing of crystal structures in metals.
2. Measure retained austenite and evaluate residual stresses in heat-treated and processed components using XRD.
3. Conduct fracture surface analysis using scanning electron microscopy to identify failure modes.
4. Assess wear resistance of surface-treated materials using pin-on-disc wear testing apparatus.
5. Study oxidation behaviour using DSC as a function of temperature, time, and gaseous environment; determine oxidation mechanisms.
6. Use MATLAB modules to solve practical heat transfer problems in metallurgical systems.
7. Model crystal structures and simulate XRD patterns using VESTA; analyse electronic band structure and magnetic moments using VASPKIT.
8. Perform–data plotting, curve fitting, and regression analysis using tools like Excel, Origin, or MATLAB.
9. Evaluate corrosion resistance of materials using techniques such as salt spray, immersion, or electrochemical tests.
10. Analyze material degradation using thermogravimetric analysis (TGA) under different heating regimes.
11. Use UV-visible and FTIR spectroscopy for the optical and functional group analysis of materials.
12. Explore material surfaces and nanoscale topography using scanning probe microscopy (AFM/STM).

SEMESTER – III

Massive Open Online Course –I (MOOC-I): To be selected in consultation with the Faculty Advisor. The evaluation scheme will depend on the instructor or the host institute.

Massive Open Online Course –II (MOOC-II): To be selected in consultation with the Faculty Advisor. The evaluation scheme will depend on the instructor or the host institute.

Dissertation Phase-I

Course Code		**Scheme of Evaluation**	ISE and ESE
Teaching Plan	0-0-22-12 = 11	**ISE**	70
Credits	11	**ESE**	30

Course Outcome:

At the end of this course, the students will demonstrate the ability to:

1. Carry out an in-depth literature survey and determine the objectives of the project work.
2. Design the experiment to accomplish the set objectives.
3. Effectively utilize the available resources of the Institute as well as other outside agencies (other Institutes, Labs, and Industry etc.)
4. Work independently to manage and complete a research project within a given time frame.
5. Communicate effectively in both oral and written forms.

Guidelines:

The Dissertation has to be the bonafide work of the student himself. The students shall be assigned a project which will test their ability to formulate objectives based on literature survey and their creativity on the basis of the experiments they design/ simulation and models developed by them. The project work shall be defined on the basis of literature survey (on the basis of previous work done at international level in related area by referring books, journal papers, patents and web resources search) to locate for the lacunas/shortcomings etc. and its feasibility in the dept., may be on seeking the help of external agencies such as industry/R&D labs/higher level academic institutes etc. At the end of the Dissertation Phase-I, students shall submit a write-up in prescribed format. Evaluation will be on the basis of the attendance, literature survey and objectives, experimental planning (and work done), set up created if any, and presentation- viva voce (understanding of the concepts) of the student.

SEMESTER – IV

Dissertation Phase-II

Course Code		**Scheme of Evaluation**	ISE and ESE
Teaching Plan	0-0-22-12 = 11	**ISE**	70
Credits	11	**ESE**	30

Course Outcome:

At the end of this course, the students will demonstrate the ability to:

1. Independently conduct experiments, analyze and interpret results.
2. Lean modern characterization techniques, software tools etc.
3. Understand professional and social responsibilities and socio-economic aspects of the work undertaken.
4. Working as part of a team is necessary for a professional life and to work on multidisciplinary projects.
5. Communicate the technical information and knowledge in both written and oral form.
6. Inculcate a habit of lifelong learning of new ideas and applying the same in all work undertaken.

Guidelines:

The Dissertation has to be the bonafide work of the student himself. At the end of the Dissertation Phase-II, students shall submit a write-up in prescribed format. Due care will be taken to check plagiarism, giving proper reference wherever other's work is cited, properly arranging the references inclusive of all essential details. Evaluation will be on the basis of the attendance, accomplishment of objectives, quality and quantity of the experimental work done, analysis and interpretation of experimental results and presentation- viva voce of the student.