NETAJI SUBHAS UNIVERSITY, JAMSHEDPUR

Estd. Under Jharkhand State Private University Act, 2018
Approved by AICTE, PCI, BCI, NCTE, INC & JNRC

EVALUATION SCHEME & SYLLABUS

FOR
MASTER OF TECHNOLOGY
IN
Metallurgical Engineering
(M. TECH-MT)

On

Choice Based Credit System

(Effective from the Session: 2025-26)

Netaji Subhas University
Pokhari, Near Bhilai Pahadi, Jamshedpur, Jharkhand

M. TECH. IN METALLURGICAL ENGINEERING

VISION

To strive for excellence in education, research, and entrepreneurship, with the ultimate goal of becoming a global hub for innovation. Committed to advancing scientific and technological services, we aim to contribute meaningfully to society.

MISSION

- To provide high-quality education that nurtures innovation, entrepreneurship, and ethical values, shaping future professionals equipped for a globally competitive landscape.
- To collaborate with stakeholders by sharing institutional expertise in education and knowledge, fostering mutual growth in technical learning.
- To Cultivate an environment that encourages fresh ideas, groundbreaking research, and academic excellence, paving the way for future leaders, innovators, and entrepreneurs.
- To drive socio-economic progress by offering impactful scientific and technological solutions to society.

PROGRAMME EDUCATION OBJECTIVES (PEOs)

PEO1: Postgraduates will develop advanced theoretical and practical knowledge in metallurgical engineering to solve real-world and research-oriented problems.

PEO2: Postgraduates will engage in high-quality research, innovation, and development of new materials, processes, and technologies.

PEO3: Postgraduates will demonstrate professionalism, ethical responsibility, and leadership in academic, industrial, and research organizations.

PEO4: Postgraduates will pursue doctoral studies, postdoctoral research, or continuous professional development to stay updated with emerging trends.

PEO5: Postgraduates will apply their skills to contribute meaningfully to sustainable development and address societal and environmental challenges.

PROGRAMME OUTCOMES (POs)

PO1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: An ability to handle techno-scientific challenges of the society.

M. TECH. IN METALLURGICAL ENGINEERING

M. Tech in Metallurgical Engineering (MT)
COURSE STRUCTURE

I- Semester

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
MTMT101	Thermodynamics and Kinetics of Materials	4	-	-	4	30	70	100
MTMT102	Advanced Physical Metallurgy	3	1	-	4	30	70	100
MTMT103	Advanced Process Metallurgy	3	1	-	4	30	70	100
MTMT104	Composite Material and its Development	4	0	-	4	30	70	100
MTMT105	Elective - I	4	0	-	4	30	70	100
MTMT106L	Advanced Physical Metallurgy Laboratory	-	-	4	2	15	35	50
MTMT107	Seminar-1	-	-	-	2	-	50	50
	Total	**18**	**2**	**8**	**24**	**165**	**435**	**600**

	Name of the Subject
Elective - I	Secondary Steel Making
	Surface Engineering
	Advances in Production of Non-Ferrous Metals.
	Recent advances in agglomeration of iron ore fines
	Materials Modelling and Simulation

II- Semester

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
MTMT201	Principles and Techniques of Materials Characterisation	4	-	-	4	30	70	100
MTMT202	Environmental Degradation of Materials	3	1	-	4	30	70	100
MTMT203	Strengthening Mechanisms of Materials	3	1	-	4	30	70	100
MTMT204	Advanced Powder Metallurgy	4	0	-	4	30	70	100
MTMT205	Elective - II	4	0	-	4	30	70	100
MTMT206L	Principles and Techniques of Materials Characterisation Laboratory	-	-	4	2	15	35	50
MTMT207	Minor Project with Seminar-II	-	-	-	2	-	50	50
	Total	**18**	**2**	**8**	**24**	**165**	**435**	**600**

	Name of the Subject
Elective - II	Finite Element Method for Metallurgy and Materials
	Solidification Processing
	Advanced Metal Forming Processes
	Advance Welding Metallurgy

III-SEMESTER

Code No.	Name of the Subjects	Periods			Credits
		L	T	P	
MTMT301	Dissertation-I	-	-	-	16
MTMT302	Project Seminar-I	-	-	-	4
	Total	**-**	**-**	**-**	**20**

IV-SEMESTER

Code No.	Name of the Subjects	Periods			Credits
		L	T	P	
MTMT401	Dissertation-II	-	-	-	16
MTMT402	Project Seminar-II	-	-	-	4
	Total	**-**	**-**	**-**	**20**

THERMODYNAMICS AND KINETICS OF MATERIALS (MTMT101)

Subject Code: -	**MTMT101**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Introduction and important thermodynamics functions: Laws of thermodynamics –enthalpy, heat capacity, entropy, free energy and their interrelationships: Solutions – chemical potential, Raoult Henry's law Gibbs-Duhem equations activity determination properties of different solutions, quasichemical theory: Heterogeneous systems-equilibrium constants. Ellingham-Richardson diagrams predominant area diagrams, Evolution of Phase diagrams phase rule free-energy- composition diagrams solidus-liquidus lines, Interfaces-energy: segregation at external and internal interfaces, solid electrolytes; Effect of high pressure on phase transformation. Point imperfections in crystalline solids –elementary and compound crystals. [12 hours]

Unit-2

Role of kinetics, heterogeneous and homogeneous kinetics. Role of heat & mass transfer in Metallurgical kinetics rate expression. Effect of Temperature and concentration on reaction kinetics effect of temperature (Arrhenius Equation). Effect of concentration (order of a reaction), significance and determination of activation energy. Kinetics of solid-fluid reaction: Definition of various resistance in series, shrinking core model, Chemical reaction as rate controlling step, Product layer diffusion as rate controlling step. Mass transfer through external fluid as rate controlling step, Heat transfer as the rate controlling step. Concentration boundary layer definition and significance of heat and mass transfer coefficient. Theoretical models for mass transfer coefficients. Correlations for heat and mass transfer coefficients. Kinetics of liquid-liquid reaction. [10 hours]

Unit-3

Solid state phase changes-classification nucleation and growth processes. Diffusion-driving force, Ficks laws, Diffusion coefficients. Kinetics of liquid –solid transformation –driving force. Homogeneous and heterogeneous Nucleation kinetics, kinetics of growth, kinetics of alloy solidification. [4 hours]

Unit-4

Kinetics of solid-state phase transformation-scope and classification kinetics of homogeneous and heterogeneous nucleation, interface growth velocity, kinetics of special transformations (Widmanstatten, massive, polymorphic, coarsening, recrystallization, age hardening) kinetics of invariant and moving boundry transformation, kinetics of phase transition in polymers, glass, ceramics. [4 hours]

Unit-5

Overall transformation Kinetics-Johnson-Mehl and Avram's model, kinetics of non-random nucleation, kinetics of diffusion controlled isothermal and non- isothermal analysis. [4 hours]

Course Outcomes: -

On completion of the course the learner shall be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Understand the concepts, formulations and applications of thermodynamics and kinetics of Engineering Materials.	K_1
CO2	Identify and solve reaction kinetics and mechanism of single and multi-steps reactions.	K_2
CO3	Analyse and solve various practical problems on applications of metallurgical systems.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Introduction to Metallurgical Thermodynamics – David R. Gaskell.
2. Textbook of Materials and Metallurgical Thermodynamics- A. Ghosh
3. Problems in Metallurgical Thermodynamics and Kinetics-G.S. Upadhyay and R. K. Dube.
4. Problems in Applied Thermodynamics- C. Bodsworth and A.S. Appleton.
5. Kinetics of Metallurgical Reactions – H. S. Ray
6. Metallurgical Thermochemistry-O. Kubaschewski, E.LL. Evans and C.B. Alcock.

Reference Books:

1. Physical Chemistry of Metals-Lawrence S, Darken and Robert W. Gurry;
2. Thermodynamics of Solids-Richard A. Swalin.
3. Stoichiometric and Thermodynamics of Metallurgical Processes- Y.K.Rao.
4. Chemical Kinetics-Keith J. Laidler.
5. Metallurgical Thermodynamics- R. H. Tupkary.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	**3**	**2**	**3**	
CO2	**2**	**3**	**3**	
CO3	**3**		**3**	
CO (Average)	**2.6**	**2.5**	**3**	

ADVANCED PHYSICAL METALLURGY (MTMT102)

Subject Code:-	**MTMT102**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours:-	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Origin of ionic, covalent and metallic solids in view of atomic structure and chemical bonding; Free-energy composition diagram; Phase equilibria in binary and ternary alloy systems: binary phase diagrams, ternary phase diagrams in view of ternary two-phase, three-phase and four-phase equilibria.

Hours [8]

Unit-2

Introduction and classification of phase transformation; conventional classification: homogeneous and heterogeneous phase transformations; Solidification: role of temperature gradient and interface velocity; planar, cellular, cellular dendritic, columnar dendritic and equiaxed dendritic growth in view of solidification parameter; solid state phase transformations: thermally activated transformation, athermal transformation; Buerger's classification: reconstructive transformation and displacive transformation; para equilibrium state, concept of invariant plane strain; reconstructive and displacive transformations in steel: evolution of allotriomorphic ferrite, idiomorphic ferrite, massive ferrite, pearlite, Widmanstatten ferrite, acicular ferrite, pearlite, bainite and martensite.

Hours [10]

Unit-3

Analytical treatment to solid state phase transformation: stable and metastable matrix, concept of fluctuation, embryo, volume free energy change, surface energy, strain energy, free energy change for formation of an embryo, critical embryo, activation energy for critical embryo formation; homogeneous nucleation, heterogeneous nucleation, expressions of homogeneous nucleation rate and heterogeneous nucleation rate; effect of strain energy on shape of embryo, temperature dependence of nucleation rate, time dependence of heterogeneous nucleation rate; effect of prior cold working on nucleation rate, expression of growth rate; Johnson-Mehl equation- overall transformation rate, origin of time- temperature-transformation (TTT) diagram.

Hours [12]

Unit-4

Application of solid state phase transformation: Thermal treatment/Heat treatment: different heat treatment processes: annealing, normalizing, hardening and tempering; TTT and CCT diagram, Grange-kiefer approximation, effect of alloying elements on TTT/CCT

diagram; Precipitation hardening (age hardening): PTT diagram, age hardening behaviour of aluminium alloys and aluminium metal matrix composites.

Hours [10]

Unit-5

Structure-property correlation: Material deformation under load with regard to crystal structure and inherent crystal defects; role of dislocation; strengthening mechanism; Hall-Petch effect; Quantum confinement effect; strength, ductility, toughness, fatigue and creep properties in relation to material structure.

Hours [10]

Course Outcomes

On completion of the course the learner shall be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Understand the concept of bonding and evolution of three dimensional solid.	K_1
CO2	Conceive phase transformation in qualitative and quantitative (analytical) terms.	K_2
CO3	Understand the application of phase transformation	K_3
CO4	Understand detailed structure-property correlation in materials.	K_2

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Physical Metallurgy Principles,R.E.Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992.
2. The Theory of Transformations in Metals and Alloys- J.W. Christian, Pergamon Press, 1965.
3. Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press,1992.
4. T.H. Courtney, Mechanical Behavior of Materials, McGraw-Hill, 2nd Ed., 2000.
5. Physical Metallurgy Principles,R.E.Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992.
6. The Structure and properties of Materials (I – IV) – R.M. Rose, L. A. Shepard and J. Wulff, Wiley, 1966
7. Materials Science and Engineering: An Introduction - William D. CallisterJr. and David G. Rethwisch, Wiley 2018

Reference Books:

1. Heat treatment of metals- B. Zakharov, CBS publishing, 1998.
2. Principles of the heat treatment of plain carbon and low alloy steels- C.R. Brooks, ASM International, 1996.
3. Heat Treatment: Principles and Techniques- T. V. Rajan, C. P. Sharma and Sharma, PHI Learning Pvt. Ltd., 2012.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	-	-	2
CO2	3	3	2	
CO3	-	3	-	1
CO4	3	3	1	-
CO (Average)				

3 –High; 2 –Medium; 1 –Low

ADVANCE PROCESS METALLURGY (MTMT103)

Subject Code: -	**MTMT103**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

A brief process overview of process metallurgy including physicochemical principle and practice. [8 hours]

Unit-2

Basics and advanced technologies for mineral processing, including pyro, hydro, electrometallurgy and associated impact on costs, pollution, energy, cycle time, simplification. [10 hours]

Unit-3

Compelling innovative measures in agglomeration, BF technology, BOF, EAF, MBF, EOF and other such routes involving DRI/HBI. [8 hours]

Unit-4

Underlining principles of steel refining, physical chemistry, Continuous casting, Near net shape casting. [6 hours]

Unit-5

Recent advances in casting practice; Thixocasting, Semisolid Processing, Rhiocasting. Recent advancements in extractive metallurgy of nonferrous metals like Al, Cu, Pb, Zn, Ti, Mg etc. and their present status and application in India. [8 hours]

Course Outcomes

On completion of the course the learner shall be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Study the thermodynamic properties of Iron and Steel Extraction.	K_1
CO2	Ability to solve problems on Iron and Steel Extraction.	K_2
CO3	To obtain detailed understanding of current methods and technological principles used in extraction of iron and steel that are applied both in industrial and lab scale.	K_3

Text Books:

1. B.F. Iron making principles – Biswas (1985)
2. Physical chemistry of iron & steel manufacture – C. Bodsworth (1980)
3. Iron and steel making, theory and practice – Ghosh and Chatterjee (2012)
4. Fuels, Furnaces and Refractories, - R. C. Gupta (2016)
5. Extraction of Nonferrous Metals-H.S. Ray, R. Sridhar, K.P. Abraham

Reference Books:

1. The Production of aluminium and alumina, Vol. 20-Alfred Richard Burkin.
2. Extractive Metallurgy of Copper-A. K. Biswas & W. G. Davenport.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	2	3	-
CO2	3	2	2	-
CO3	3	-	-	1
CO (Average)				

3 –High; 2 –Medium; 1 –Low

COMPOSITE MATERIAL AND ITS DEVELOPMENT(MTMT104)

Subject Code: -	**MTMT104**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Introduction: Classification of composites based on matrix and reinforcement: Metal matrix composite, polymer matrix composites, ceramic matrix composite and carbon- carbon composite; application of different composite materials. Micromechanics of composite materials (10 hours)

Unit-2

Synthesis routes of composites: casting route and powder metallurgy route. Powder metallurgy processed Composite: high energy milling, Mechanical alloying: Fundamentals and parameters; Compaction and Sintering: material dependent routes and process parameters; process parameter-structure-property correlation. (10 hours)

Unit-3

Cast metal matrix composites: different synthesis routes: dispersion process (stir casting, compo-casting and screw extrusion)-contact angle, wettability and particle- matrix bonding; Liquid metal impregnation/infiltration (pressure infiltration, squeeze casting and Lanxide process)- principle of molten metal infiltration-capillary flow of molten metal; Spray process (Osprey process and rapid solidification process); In-situ production of dispersoids-XD process; (8 hours)

Unit-4

evolved microstructure: structural defects in cast metal matrix composites- porosity, particle segregation (macrosegregation and microsegregation), interfacial reaction and particle degradation; structure-property correlation. (5 hours)

Unit-5

Joining of metal matrix composites, limitations of conventional fusion welding, Application of transient liquid phase (TLP) diffusion bonding, basic mechanism and different stages of TLP bonding process for monolithic and composite system, process parameters of TLP bonding, joint efficiency. (10 hours)

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To understand classification and different synthesis routs of composite materials in view of industrially practiced routes of synthesis and industrial application.	K_1

CO2	To learn the different steps of processing composites through powder metallurgy route and casting route; in turn, the correlation of evolved microstructure with properties.	K_2
CO3	To learn the application of transient liquid phase diffusion bonding process for joining metal matrix composites with regard to basic process mechanism and joint efficiency achieved along with industrial relevance.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Metal Matrix Composites - Chawla and Chawla, Springer, 2006.
2. 'Joining of aluminium based metal matrix composites'- Joydeep Maity, in 'Engineered Metal Matrix Composites: Forming Methods, Material Properties and Industrial Applications', Editor: Luca Magagnin, 2012, NOVA Science Publishers, Inc., New York, USA, pp 329-354.
3. Materials Science and Engineering: An Introduction - William D. Callister, Jr., John Wiley & Sons, Inc., 2007.

Reference books:

1. Fundamentals of Metal-Matrix Composites - Andreas Mortensen and Alan Needleman, Butterworth-Heinemann, 1993.
2. An Introduction to Composite Materials–Derek Hull, Cambridge University Press, 1981.
3. Composite Materials –Deborah D.L. Chung, Springer, 2009.
4. Metal-Matrix composite – P.K. Rohatgi, Defence Science Journal, Vol 43, No 4, October 1993, pp 323-349.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	2	-	1
CO2	3	1	2	-
CO3	3	1	2	-
CO (Average)				

3 –High; 2 –Medium; 1 –Low

SECONDARY STEEL MAKING (MTMT105)

Subject Code: -	**MTMT105**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Introduction: Brief review of primary steel making processes, composition of the crude steel, need for secondary refining, objective of secondary steel making, secondary steel making

equipment and processes, preheating and recycling of ladles. **[4 hours]**

Unit-2 Chemical equilibrium, Activity-Composition relationships: Concentrated solutions, Activity- Composition relationships: dilute solutions, interaction coefficient, chemical potential and equilibrium, physico-chemical principles of Secondary steel making, Slag basicity and capacities. **[4 hours]**

Unit-3

Fluid flow in steel melts in Gas-Stirred ladle. Mixing, Mass transfer and kinetics: Introduction, mixing in steel melts in Gas-stirred ladles, kinetics of reactions among phases, Mass transferrin a Gas-Stirred ladle, Mixing Vs. Mass transfer control.

Powder injection refining: Introduction, Advantages and disadvantages, transitory and permanent contact reaction, bubbling-jetting phenomena.

Core wire injection: Introduction, Advantages and application Deoxidation of liquid steel: Introduction, slag Carry-over: Impact on Ladle Metallurgy, Thermodynamics of deoxidation of molten steel, Kinetics of deoxidation of molten steel, deoxidation in industry. **[9 hours]**

Unit-4

Degassing and Decarburization in liquid steel: Introduction, thermodynamics of reactions in vacuum degassing, side reactions during degassing, fluid flow and mixing in vacuum degassing, rates of vacuum degassing and decarburization, decarburization for Ultra-low carbon (ULC) and stainless steel. **[14 hours]**

Unit-5

Desulfurization in secondary steelmaking: Introduction, thermodynamics aspects, desulfurization with only top slag, injection metallurgy for Desulfurization.

Gas absorption during tapping and teeming from surrounding atmosphere, temperature changes of molten steel during secondary steelmaking, phosphorus control in secondary steelmaking, Nitrogen control in steel making.

Inclusions and inclusion modification: Introduction, origin of nonmetallic inclusions, Types and properties of inclusions, Influence of inclusions on the mechanical properties of steel, Inclusion identification and cleanliness assessment, formation of inclusions during solidification, inclusion modification. **[16 hours]**

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Learn fundamentals of physico-chemical principles of Secondary steel making.	K_1
CO2	Identify and solve reaction kinetics and mechanisms.	K_2
CO3	To learn the design & operational aspects of Vacuum technology.	K_3
CO4	Ability to analyze industrial processes to meet the current need.	K_1

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. A. Ghosh, and A. Chatterjee, , Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008.
2. A. Ghosh, Secondary Steelmaking, CRC Press, Boca Raton, 2000.

Reference Books:

1. Making, Shaping and Treating of Steel (Steelmaking and Refining), 10th Edition, 1985, AISE, Pittsburgh.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	2	2	2
CO2	3	2	2	3
CO3	2	3	2	3
CO4	-	-	2	1
CO (Average)				

3–High; 2–Medium; 1–Low

SURFACE ENGINEERING (MTMT105)

Subject Code: -	**MTMT105**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit- 1

Introduction of conventional casting: Introduction of surface engineering, Philosophy of surface, general applications and requirements. Engineering components, surface dependent properties and failures, importance and scope of surface engineering. [8 hours]

Unit- 2

Surface Degradation: Basic principles of electrochemistry and aqueous corrosion processes; Oxidation and related concept; Mechanical Friction and Wear like abrasive, erosive and sliding wear etc.; Interaction between wear and corrosion. Surface engineering processes and their types (only basic idea, Conventional surface heat treatment processes. Surface engineering by material removal: Cleaning, pickling, etching, grinding, polishing, buffing / puffing (techniques employed, its principle). Role and estimate of surface roughness, material addition: From liquid bath - hot dipping (principle and its application with examples). [12 hours]

Unit- 3

Surface engineering Process: General classification, scope and principles, types and intensity/energy deposition profile; Laser assisted microstructural modification – surface melting, hardening, shocking and similar processes; Laser assisted compositional modification – surface alloying of steel and non-ferrous metals and alloys; surface cladding, composite surfacing and similar techniques; Electron beam assisted modification and joining; Ion beam assisted microstructure and compositional modification. [12 hours]

Unit- 4

Advanced Process: Physical vapour-deposition, PEPVD, Chemical vapour-deposition, Electrodeposition, Anodizing, Galvanizing, Thermal Spraying (all types), Plasma based techniques like plasma nitriding, plasma carburizing, PSII, LSH, LSA, LSM etc. Weld-surfacing, friction surfacing, explosive cladding. [12 hours]

Unit- 5

Characterization of engineered surface: XRD, XPS, surface-mechanical characterization, corrosion study etc. (Apart from common techniques) [4 hours]

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To understand the basic principle for surface degradation of materials	K_1
CO2	To learn surface morphology of different kind of materials and their response in working conditions	K_2
CO3	To understand principles, theory, mechanism and key variables of different advanced surface modification techniques.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. T Burakowski and T. Wierzchon, Surface engineering of metals, CRC Press.
2. W. Batchelor, L. N. Lam and M. Chandrasekaran, Materials degradation and its control by surface engineering, Imperial college press.
3. S Grainger and J. Blunt, Engineering coatings, William Andrew Publishing.

Reference Books:

1. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.
2. Laser Surface Engineering Processes and Applications, J. R. Lawrence, C. Dowding, D. Waugh and J. B. Griffiths, A volume in Woodhead Publishing, 2015.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	2	2	2
CO2	3	2	2	3
CO3	2	3	2	3
CO (Average)				

3–High; 2–Medium; 1–Low

ADVANCES IN PRODUCTION OF NON-FERROUS METALS (MTMT105)

Subject Code: -	**MTMT105**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Aluminium:

Bayer process, its chemistry and practice, Soda-Lime Sinter Process. Hall Heroult process: carbon anodes, theoretical principles, factors influencing the process, current and energy efficiencies. Alternane Al production like, Mitsubisi Kwara process. Modern development of Aluminium production like Inert anode drained cathode. [8 hours]

Unit-2

Copper: Advances in Concentration, Roasting, matte smelting, converting, fire-refining and electro-refining process. Slag-Matte characteristics. Recent development i concentration, roasting and smelting process. Outokumpu and INCO process, Ausmel/ Isasmelt process. [8 hours]

Unit-3

Zinc: Pyrometallurgy, sinter-roasting and Electrical and Blast furnace process. Hydrometallurgical extraction: roasting, leaching and electro- winning. Double leaching/ Jarosite process, Direct leaching process

Lead: Direct smelting of lead (ISP), thermodynamic consideration, Modern practices Refining of lead bullion. [6 hours]

Unit-4

Titanium: Up-gradation of ilmenite and Hunter and Kroll process, Specific advantages a limitation.

Uranium: Acid and alkali processes for digestion of uranium ores. Production o reactor grade uranium. [6 hours]

Unit-5

Gold: Cyanidation process. Carbon-in pulp process.

Nickel and Magnesium: Different production routes their advantages and limitation in Nickel and Magnesium production.

Status of Non-ferrous metal production in India.

Environmental aspects of Non-ferrous metal production. [8 hours]

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Ability to build up the concepts of non-ferrous metals production.	K_1

CO2	Ability to learn the modern advance technologies for nonferrous metal extraction.	K_2
CO3	Ability to analyze and solve various industrial problems during production and operation in nonferrous metal industries.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Textbooks:

1. K. Grjortheim and B.J. Welch: Aluminium Smelter Technology, Aluminium-Verlag.
2. A. K. Biswas and W.G. Davenport: Extractive Metallurgy of Copper, Pergamon.
3. S.W.K Morgaon: Zinc and its Alloy, Mac Donald and Evans.
4. H.S.Ray, R. Sridhar and K.P. Abraham: Extraction of Non-Ferrous Metals, Affiliated East–West.

Reference books:

1. A.R. Burkin (ed.): Production of Aluminium and Alumina Wiley.
2. A.R. Burkin (ed.): Extractive Metallurgy of Nickel, Wiley.
3. C. D. Harrington and AE. Reuhle: Uranium Production Technology, Van Naostrand.
4. N. Sevryukov, B.Kuzumin and Y. Chelishchev: General Metallurgy, Mir.
5. FathiHabashi; Principles of Extractive metallurgy, vol 1,2,3and4; Gordon and Breach.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	2	-	3	-
CO3	3	-	-	2
CO (Average)				

3–High; 2–Medium; 1–Low

RECENT ADVANCES IN AGGLOMERATION OF IRON ORE FINES (MTMT105)

Subject Code: -	**MTMT105**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

General Introduction: Need and scope, Different types of agglomerations techniques, Standard procedure for characterization of raw materials as well as agglomerates. [5 hours]

Unit-2

Sintering: Introduction to Sintering Process, Raw materials requirements and Preparation of Charge, Fundamentals of sintering reactions, liquid phase formation and bonding mechanism,

Heat transfer in sintering layers, Gas dynamics in sintering process, Sinter productivity, Sinter mineralogy and its effect on quality, Environmental aspects of sintering. [12 hours]

Unit-3

Palletization: General introduction to Palletization, Raw materials requirements and Preparation of Charge, Different types of binders both inorganic and organic binders, Mechanism of green pellet formation and kinetics of ball growth, Reactions and Formation of Phases During Induration, Environmental aspects. [8 hours]

Unit-4

Briquetting: General Introduction to Briquetting, Raw materials requirements and Preparation of Charge, Basic Industrial Technologies of Briquetting, Metallurgical Properties requirements of Briquettes. [6 hours]

Unit-5

Advances in agglomeration: Utilization of other source of fines and wastes like slimes, blue dust, LD sludge, BF dust and also slag, Micropelletization and sintering, Composite agglomeration techniques, Nonconventional pellet strengthening process. [15 hours]

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Ability to understand the fundamentals of different types Agglomeration techniques.	K_1
CO2	Ability to learn the fundamental basis of recent developments taking place in agglomeration technology.	K_2
CO3	Ability to analyze and solve the utilization iron ore fines and wastes generated in iron and steel industry.	K_3

Text Books:

1. Agglomeration of Iron Ores, Ram Pravesh Bhagat, CRC Press.
2. Pelletizing of iron ores, Kurt Meyer, Springer-Verlag.

Reference Books:

1. Agglomeration in Metallurgy by Aitber Bizhanov, Valentina Chizhikova, Springer Publication.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO/CO	PO1	PO2	PO3	PO4
CO1	2	1	3	1
CO2	3	1	3	1
CO3	3	1	3	3
CO (Average)				

3–High; 2–Medium; 1–Low

MATERIALS MODELLING AND SIMULATION (MTMT105)

Subject Code: -	**MTMT105**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Introduction to materials modelling and simulation; concept of multiscale materials modelling; different approaches used in materials modelling and their benefits and drawbacks. General overview of atomistic modelling techniques - molecular dynamics (MD) and montecarlo (MC) technique applied to engineering materials; DFT calculations; Ab-initio molecular dynamics; kinetic montecarlo simulation. **[5 hours]**

Unit-2

Molecular dynamics modelling and simulation - general steps; ensembles; interatomic potential; initial and boundary conditions; force calculation; phase space evolution; integration algorithms; thermostatting and barostatting; MD data analysis and property calculations. **[15 hours]**

Unit-3

General overview of continuum modelling techniques - finite element method (FEM) modelling and simulation - advantages and drawbacks of the method; types and applications of the method. **[8 hours]**

Unit-4

FEM modelling - general steps; different approaches for deriving element properties: direct approach, variational approach, and Galerkin's method; types of elements and interpolation functions; condensation and substructuring; continuity requirements; mesh refining; Gauss quadrature; FEM modelling for structural and thermal problems. **[12 hours]**

Unit-5

Coding and use of software for materials modelling using MD and FEM technique. Demonstration of a multiscale model developed by coupled MD - FEM simulation. **[8 hours]**

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To understand the concept of materials modelling and simulation for structure and properties of materials.	K_1
CO2	To understand molecular dynamics simulation.	K_2

CO3	To understand FEM simulation.	K_3
CO4	To apply materials modelling methodologies for extracting behaviour of materials in real applications.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Understanding Molecular Simulation*: D. Frenkel and B. Smit*, Academic Press, 2002.
2. The Finite Element Method for Engineers, 4th Edition: *Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, Ted G. Byrom,* Wiley, 2001

Reference Books:

1. The Art of Molecular Dynamics Simulation: *D.C. Rapaport*, Cambridge University Press, 2004.
2. Statistical mechanics: *Donald A. Mcquarrie*, Harper Row, 1976.
3. An Introduction to the Finite Element Method (Mcgraw Hill Series in Mechanical Engineering)3rd Edition: *J. N. Reddy.*

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO/PO	PO1	PO2	PO3	PO4
CO1	3	2	2	1
CO2	3		2	
CO3	3		3	
CO4	3	2	2	2
CO (Average)	3	2		

3–High; 2–Medium; 1–Low

ADVANCED PHYSICAL METALLURGY LABORATORY (MTMT106L)

Subject Code: -	**MTMT106L**	**IA Marks**	**15**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**35**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**02**

Topics Covered

Experiment 1: An investigation of the microstructures primarily evolved through reconstructive phase transformation and diffusional displacive phase transformation.

Part I: Investigation of the microstructure of Annealed Low Carbon Steel.

Part II: Investigation of the microstructure of Normalized Low Carbon Steel (subjected to normal air cooling).

Part III: Investigation of the microstructure of Normalized Low Carbon Steel (subjected to forced air cooling).

Experiment 2: Diffusionless displacive phase transformation and study of the evolved microstructure.

Part I: Hardening treatment of Low carbon (0.2%C) steel.

Part II: Hardening treatment of High carbon (0.6%C) steel.

Experiment 3: An investigation on evolution of combined soft and hard phases through Intercritical heat treatment of low carbon steel.

Experiment 4: A study on phase evolution and associated structural variation with regard to change in chemical composition and adopted heat treatment routes.
Part I: Study of the microstructure of as-carburized steel
Part II: Study of the microstructure of Carburized and core refined steel.
Part III: Study of the microstructure of carburized, core refined and case refined (case hardened) steel.

Course Outcomes

On completion of the course the learner shall be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Understand the evolution of phases through reconstructive phase transformation and diffusional displacive phase transformation along with morphological appearances.	K_1
CO2	Understand the evolution of phases through diffusion less displacive phase transformation along with morphological appearances.	K_2
CO3	Understand the evolution of dual-phase structure in correlation to morphological appearances.	K_2
CO4	Understand phase evolution and associated structural variation with regard to change in chemical composition and adopted heat treatment routes.	K_2

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press,1992.
2. Solid state phase transformations, V. Raghavan, PHI Learning Pvt. Ltd., 2004.

Reference Books:

1. Heat treatment of metals- B. Zakharov, CBS publishing, 1998.
2. Heat Treatment: Principles and Techniques- T. V. Rajan, C. P. Sharma and A. Sharma, PHI Learning Pvt. Ltd., 2012.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	2	2	2
CO2	3	2		2
CO3	3			2
CO4	3	1	2	2
CO (Average)	3			

PRINCIPLES AND TECHNIQUES OF MATERIALS CHARACTERIZATION (MTMT201)

Subject Code: -	**MTMT201**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Optical Metallography: metallographic specimen preparation, metallurgical microscope, magnification, numerical aperture, resolving power; quantitative metallography: Stereological approach: determination of volume fraction of different phases-point count method; grain size measurement-planimetric method, intercept method etc.; principles of quantitative image analysis. [hours 8]

Unit-2

X-ray diffraction Techniques: The continuous and characteristic spectrum; Absorption; Filters; Real and reciprocal lattice; Bragg's Law; Ewald sphere construction; Diffraction methods–Laue method, rotating crystal methods, powder methods; Diffractometers; Diffraction under non- ideal condition. Intensity of diffracted beams: scattering by an electron-Coherent scattering, Incoherent scattering; scattering by an atom-atomic scattering factor, Scattering by a unit cell: Structure factor, Structure factor calculations; Extinction rules, indexing. [hours 12]

Unit-3

Application of X-ray diffraction: Crystal structure determination; determination of precise lattice parameter; Phase diagram determination, Residual stress measurement, Chemical analysis by diffraction, particle size determination. [hours 8]

Unit-4

Electron Microscopy: Specimen beam interaction; Interaction volume; Construction, modes of operation and application of Scanning electron microscope; Different contrast formation; Effect of different operational variables on the resolution and depth of field of a SEM; Specimen preparation; EDS and WDS. Transmission electron microscopy (TEM): basic principles of electron diffraction in transmission electron microscope in view of Ewald sphere construction, Selected area diffraction: generation of spot pattern, spotted ring pattern and continuous ring pattern; basic relationship of electron diffraction in transmission electron microscope ($Rd = L\lambda$); Interpretation of SAD pattern for fine grained polycrystalline material: Indexing ring pattern, determination of camera constant; Interpretation of SAD patterns of single crystal (single grain): Indexing spot pattern; interpretation of the standard patterns from different crystals, viz. simple cubic, BCC, FCC etc. [hours 12]

Unit-5

Thermal Analysis: Differential thermal analysis, Differential scanning calorimetry and Thermo-gravimetric analysis. [hours 8]

Course Outcomes

On completion of the course the learner shall be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Learn fundamentals of X-ray diffraction, optical and electron microscopy.	K_1
CO2	Identify the crystal structure and index the diffraction patterns of different phases.	K_2
CO3	Solve diffractograms of different difficulty levels through tutorials.	K_3
CO4	Learn different applications of X-ray diffraction and different microscopes.	K_1

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. "Elements of X-Ray Diffraction", by B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 1968.
2. "X-ray diffraction-a practical approach", by C. Suryanarayana and M. Grant Norton, Springer, 1998.
3. "X-ray Diffraction: Its Theory and Applications", by S. K. Chatterjee, Prentice-Hall of India Pvt. Limited,2004.
4. "Electron Microscopy in the Study of Materials", by P.J. Grundy and G.A. Jones, Arnold, London, 1976.
5. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. Williams and C. Barry Carter, 2nd ed., Springer, 2009.

Reference Books:

1. "Electron Microscopy and Analysis", by Peter J. Goodhew, John Humphreys and Richard Beanland, Third Edition, CRC Press, 2000.
2. Principles of Metallographic laboratory Practice – G. L. Kehl, London: McGraw-Hill Publishing Co., Ltd., 1939.
3. *Metallography*, Principles and Practice-George F. *Vander Voort*,ASM International, 1984.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1			3	
CO2	2		3	
CO3		2	3	2
CO4	1			2
CO (Average)				

3–High; 2–Medium; 1–Low

ENVIRONMENTAL DEGRADATION OF MATERIALS (MTMT202)

Subject Code: -	**MTMT202**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Fault tree diagram, Case studies related to industrial components failure. Gas plant leakage, welding failure. Methods of study for failure analysis. Case studies of Failure analysis such s automotive component, railway bridge. [10 hours]

Unit-2

Study of cement structures and RCC structures and their failures [5 hours]

Unit-3

Introduction to high temperature corrosion, Pilling-Bedworth ratio, oxidation kinetics, oxide defect structures, catastrophic oxidation, internal oxidation. Scaling of binary and ternary alloys, Considerations in high temperature alloy design, prevention of high temperature corrosion-use of coatings [10 hours]

Unit-4

Study of corrosion of weld joints. Chemical degradation of non-metallic materials like ceramics, timbers. Corrosion during transit. Corrosion of Composite Materials: Galvanic Effects Matrix Nature Reinforcement Nature Prevention. [8 hours]

Unit-5

Paints and detailed analysis for corrosion combat. Corrosion Control: By design and electrical Methods Study of Delhi Iron Pillar – 'the rustless wonder' [5 hours]

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To study the degradation of materials in specific environment.	K_1
CO2	To study the causes of failure analysis of materials.	K_2
CO3	To obtain detailed understanding of current methods and technological principles used in combating degradation of materials in specific environment.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text books:

1. Principles and Prevention of Corrosion (2nd Edition) By Denny A. Jones Prentice Hall, 1995.

2. Environmental Degradation of Materials, R Balasubramaniam, Cengage International, 2010.
3. Corrosion and Corrosion Control, H.H. Uhlig and W. Revie, Wiley, New York, 2007.
4. Corrosion Science and Technology,By David Talbot, James Talbot, CRC Press, 1998.

Reference Books:

1. Corrosion Engineering By Mars. G. Fontana, Third ed., TMH.
2. Corrosion Basics:An Introduction By Pierre R. Roberge, 2nd Edition, NACE Press Book, 2006.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO/PO	PO1	PO2	PO3	PO4
CO1	3	2	2	1
CO2	3		2	
CO3	3		3	
CO (Average)	3	2		

3. 3–High; 2–Medium; 1–Low

STRENGHENING MECHANISM OF MATERIALS (MTMT203)

Subject Code: -	**MTMT203**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topics Covered

Unit-1

Introduction:

Basic structure of alloys, ceramics, polymer and composites. Relation between the structure of materials and their mechanical, thermal chemical and electrical magnetic properties.

[4 hours]

Unit-2

Elemental Plasticity and dislocation theory:

Mechanism and micro mechanism of strengthening in engineering materials. Plastic flow in metals and alloys, Strengthening and dislocation structure and solid solution strengthening, Resistance to dislocation induced flow, strengthening due to sub and grain boundaries, precipitation strengthening, dispersion strengthening, martensitic strengthening, grain size strengthening, order hardening, dual phase.

Unit-3

Physical phenomena that contribute towards high mechanical strength in engineering materials. Principle for designing high strength materials will be addressed, High temperature materials. Two Phase hardening, Solution hardening, Order strengthening. Strengthening mechanism of amorphous materials, Polymer, ceramic, glass and composites materials, fiber reinforcement, four stage of deformation, tensile strength, Anisotropy. Strengths at High Temperature, strengthening against diffusion flow, strengthening against dislocation creep, Strengthening against high rate of deformation.

[20 hours]

Unit-4

CERAMIC AND COMPOSITE MATERIALS:

Advanced Ceramic Materials - Crystal Structures - Silicate Ceramics - Glasses – Glass Ceramics – Functional properties and applications of ceramic materials – Classification of composites - Fiber reinforced materials –Law of mixtures – Continuous fibers – discontinuous fibers–Particle-reinforced materials–Ceramets–Dispersion strengthened materials–Laminates - Application of composites in electrical and mechanical components – nuclear industry. [10 hours]

Unit-5

POLYMER MATERIALS:

Classification of polymer – Mechanisms of polymerization - Some commercially important individual polymer – Thermoplastics - Elastomers – Thermosets – Engineering plastics - Liquid crystal polymers - Conductive polymers – High Performance fibers - Biomedical applications – Photonic polymers. [10 hours]

Course Outcomes:

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To understand the basic Fundamentals of strengthening mechanism of materials.	K_1
CO2	To learn the presence of different kinds of defects in metal or crystal that has significant effect on material properties.	K_2
CO3	To learn science and technological aspects for designing high temperature material or materials for adverse environments.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create.

Text Books:

1. William D. Callister, Jr., Materials Science and Engineering an Introduction, 6th Edition, John Wiley & Sons, Inc., 2004.
2. Structure of Metals, 3rd revised edition, C. S. Barrett, T. B. Massalski, Pergamon press Oxford, 1981.
3. George Dieter, Mechanical Metallurgy, McGraw-Hill, 3rd Edition

Reference Books:

1. William F. Smith, Structural Properties of Engineering Alloys, Tata Mc-Graw-Hill, Inc., 1993.
2. Kingery. W.D., Bowen H.K. and Uhlmann D.R., Introduction to Ceramics, 2nd Edition, John Wiley & Sons, New York, 1976.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	2	3	-

CO2	3	2	3	-
CO3	2	1	2	2
CO (Average)				

3–High; 2–Medium; 1–Low

ADVANCED POWDER METALLURGY (MTMT204)

Subject Code: -	**MTMT204**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Topic Covered

Unit-1

Introduction: Basic powderproduction and characterization; Powder Treatment and Sintering. [10 hours]

Unit-2

Advanced Powder Synthesis: Advances in atomization techniques; Powders by electrolysis; Mechanochemical synthesis of nanocrystalline powders; Plasma synthesis of metal nano-powders. [5 hours]

Unit-3

Powder metallurgy for steel; Powder metallurgy of titanium alloys [5 hours]

Unit-4

Advanced Densification Processes: Microwave sintering; Spark Plasma Sintering; Hot Pressing [10 hours]

Unit-5

Applications: Powder metallurgy in automotive applications; Applications of powder metallurgy in biomaterials; Applications of powder metallurgy to cutting tools. [10 hours]

Course Outcomes:

Upon the completion of this course, the student will be able to:

Course Outcome No.	Statement	Knowledge Level (KL)
CO1	Learn science and technological aspects of the Advanced Powder Metallurgy Techniques.	K_1
CO2	Emphasis is put on methods for those types of powders that are important for production of engineering components.	K_2
CO3	Solve problems of near net shape fabrication of powder metallurgy parts through tutorials/ assignment/ group task.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Powder Metallurgy – A Upadhyaya and G S Upadhyaya.
2. Powder Metallurgy Science – R. M. German, 2nd Edition, MPIF, 1994.
3. Advances in powder metallurgy- Edited by Isaac Chang and Yuyuan Zhao, Woodhead Publishing Limited, 2013.

Reference Books:

1. Powder metallurgy: principles and applications, Fritz V. Lenel, Metal Powder Industries Federation, 1980.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3		2	2
CO2	3	2		2
CO3	3	2		2
CO (Average)				

3–High; 2–Medium; 1–Low

FINITE ELEMENT METHOD FOR METALLURGY AND MATERIALS (MTMT205)

Subject Code: -	**MTMT205**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Unit-1

Introduction: Mathematical models, Numerical Simulations, how does Finite element work? Main ideas of FE, Comparison of Finite-Difference and Finite-Element Methods with Analytical Solutions. (3 hours)

Unit-2

The Weak Formulation: Nodal Finite Elements, Mesh Elements, The Finite Element Method Procedure, Weak Formulation of Governing Equations, Gradient and Divergence Theorems, Integration by Parts, Weak Formulations, Exercises. (5 hours)

Unit-3

Linear Interpolation Functions: Parameter Functions and Interpolating Functions, Interpolation, Weighting and Approximation Functions, Linear Interpolation Function for One-Dimensional Analysis, Linear Interpolation Functions for Two-Dimensional Analysis, Linear Interpolation Functions for Three-Dimensional Problems, Other Coordinate Systems Used in Derivation of Shape Functions, Iso-parametric Elements, Exercises. (8 hours)

Unit-4

Derivation of Element Matrices, Assembly and Solution of the Finite Element Equation: Derivation of Element Matrix for One-Dimensional Problems Using the Galerkin Method, Assembly and Solution, Derivation of Element Matrix for Two- Dimensional

Problems Using the Galerkin Method, Derivation of Element Matrix for Three-Dimensional Problems Using the Galerkin Method, Transient Problems, Derivation of Matrix Equations for Axisymmetric Problems, sample Solutions on Elements Matrix Computation, Assembly and Solution, One-Dimensional Fourth Order Differential Equation, The Use of Other Coordinate Systems in Derivation of Finite Element Equation, Exercises. (12 hours)

Unit-5

Steps of Finite Element Modeling using MATLAB: Specifying the Application Type, Drawing the Problem Geometry, Specifying the PDE, Specifying Boundary Conditions, Meshing the Domain and Mesh Refinement, Specifying Initial Conditions for Transient Problems, Solving the PDE, Extracting Values from Plots, Exercises. **Application of Heat Transfer Problems:** Steady-State Heat Transfer, Transient Problems (Heating and Cooling Problems), Transient Problem (Heat Generation in a Tubular Furnace). **Application of Elasticity Problems:** Basics of Elasticity in Finite Element Application, Modeling Elasticity Problems in Materials Engineering, Exercises. (10 hours)

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To understand the concept of Finite Element Method (FEM).	K_1
CO2	To recognize the important role played by FEM in today's engineering world.	K_2
CO3	To solve the challenging problems of heat transfer and different structural design.	K_3

Text Books:

1. An Introduction to the Finite Element Method- J. N. Reddy, Mcgraw Hill Series in Mechanical Engineering, 2005.
2. The Finite Element Method Basic Concepts and Applications- D. W. Pepper and J. C. Heinrich, CRC Press, 2013
3. Textbook of Finite Element Analysis- P. Seshu, PHI, 2016.

Reference Books:

1. The Finite Element Method for Engineers -Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, and Ted G. Byrom, Wiley, 2012.
2. An Introduction to Computational Micromechanics-T. I. Zohdi and P. Wriggers, Springer, Berlin Heidelberg New York, 2010.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	2	3	3	
CO2	3	3	3	
CO3	-	3	3	
CO (Average)				

3–High; 2–Medium; 1–Low

SOLIDIFICATION PROCESSING (MTMT205)

Subject Code: -	**MTMT205**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Unit-1

Plane front solidification of single-phase alloys, interface stability, Czochralski growth. [8 hours]

Unit-2

Growth of single crystals of high perfection, cellular solidification, cellular- dendritic transition, plane front solidification of polyphase alloys, macro- and micro-morphology of eutectic growth, growth of graphite in cast irons, some problems in solidification of polyphase alloys. [12 hours]

Unit-3

Rapid solidification processes (RSP). Classification of high cooling rates. Conventional and unconventional effects. Undercooling and recalescence. Amorphous state. Glaze-ability. Methods for preparing rapidly solidified material. The importance of RSP for heat treatment, foundry, powder metallurgy and beam technologies. [8 hours]

Unit-4

Inclusions - their formation and distribution; Rheocasting, thixocasting, electroslag casting, casting of composites. [10 hours]

Unit-5

Case studies of selected castings. The perspective of solidification processes. [8 hours]

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To study the solidification of pure metal and alloys.	K_1
CO2	To understand the behavior of inclusions.	K_2
CO3	To obtain detailed understanding of solidification of all types of castings to produce defect free product.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

TEXT BOOKS:

1. BIRD, R B. STEWART, W E.LIGHTFOOT, E N. Přenosovéjevy: Sdíleníhybnosti,

energie a hmoty. Praha : Academia, 1968. 799 p.
2. Batyšev, A.I. Kristallizacijametallovi splavov pod davlenijem., Izd. Metallurgija, Moskva, 1990.

REFERENCE BOOKS:

1. Kirkwood, D.H.– Suéry, M.– Kapranos, P.– Atkinson, H.V.– Young,K.P. Semi-solid processing of Alloys. Springer- Verlag Berlin Heidelberg, 2010, ISBN 978-3-642-00705-7, e-ISBN 978-3-642-00706-4.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	-	2	-
CO2	3	-	-	-
CO3	3	2	2	2
CO (Average)				

3–High; 2–Medium; 1–Low

ADVANCED METAL FORMING PROCESSES (MTMT205)

Subject Code:-	**MTMT205**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours:-	**60**	**CREDITS**	**04**

Topic Covered

Units-1

Introduction of metal forming as a manufacturing process, and its relation with other processes. [4 hours]

Units-2

Theoretical analyses (theory of elasticity and plasticity in 3 dimensions): stress- strain relationships, strain hardening, plastic deformation, yield criteria, flow rule, initiation and extent of plastic flow, forming limit diagram, solving problems. [10 hours]

Units-3

Overview of various metal forming operations: conventional vs high velocity forming methods, effects of strain rate and temperature, materials behavior, mechanics of various plastic flow problems - rolling; forging; extrusion; drawing; sheet metal forming; workability; solving problems and case studies. [10 hours]

Units-4

Details of high energy rate forming (HERF) processes: electro-magnetic forming, explosive forming; electro-hydraulic forming; stretch forming; contour roll forming, superplastic forming, etc. [10 hours]

Units-5

Severe plastic deformation: principles and different techniques.

[8 hours]

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To understand the theories and practices of advanced metal forming processes.	K_1
CO2	To know about advanced forming methods in comparison with conventional forming methods.	K_2
CO3	To solve problems and analyses the data related to various advanced forming processes.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Mechanical Metallurgy, SI Metric Edition, George E. Dieter, McGraw-Hill Book Company, London, 1988.
2. Principles of Industrial Metal Working Processes, G.W. Rowe, CBS Publishers & Distributors, New Delhi, 2005.
3. Metal Forming: Mechanics and Metallurgy, 3rd Edition, William F. Hosford and Robert M. Caddell, Cambridge University Press, New York, 2007.
4. Principles of Metal Working, Surender Kumar, Oxford & IBH Publishing Company, 1985.

Reference Books:

1. Metal Forming: Processes and Analysis, B. Avitzur, McGraw-Hill Book Company, New York, 1968.
2. Mechanical Working of Metals: Theory and Practice, J.N. Harris, Pergamon Press, 1983.
3. An Introduction to Plasticity, G.C. Spencer, Chapman & Hall, London, 1968.
4. Advanced High Energy Rate Forming, American Society of Tool Manufacturing, Henry E. Conrad (Editor), 2013.
5. Severe Plastic Deformation: Methods, Processing and Properties, Ghader Faraji, H.S. Kim, Hessam Torabzadeh Kashi, Elsevier, 2018.
6. Severe Plastic Deformation: Toward Bulk Production of Nanostructured Materials, Burhanettin Altan, Nova Science Publishers, Inc, 2006.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1	3	-	2	-
CO2	3	-	-	-
CO3	3	2	2	2
CO (Average)				

3–High; 2–Medium; 1–Low

ADVANCE WELDING METALLURGY (MTMT205)

Subject Code: -	**MTMT205**	**IA Marks**	**30**
Number of Lecture Hours/Week: -	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**60**	**CREDITS**	**04**

Unit-1

Introduction: Historical introduction, classification, abbreviation for welding processes, welding procedure, welding terms and characteristics, welding design, welding positions, welding vs. other joining processes.

Gas Welding: oxy-acetylene welding, flame characteristics, advantages and drawbacks of gas welding, oxy-acetylene cutting. [12 hours]

Unit-2

Arc Welding: Arc welding power sources, power source characteristics (PSC); Shielded Metal Arc Welding (SWAM)- welding electrodes, AWS and BIS electrodes specifications, arc blow, weaving, advantages and drawbacks; Submerged arc welding (SAW), advantages, limitations and applications; Gas Metal Arc Welding (GMAW), shielding gases, modes of metal transfer, advantages, limitations and applications; Gas Tungsten Arc Welding (GTAW), process description, welding techniques, advantages, limitations and applications.

[10 hours]

Unit-3

Resistance Welding: Heat generation and process description, welding sequence, resistance seam welding, limitations and application, projection welding.

Radiant Welding: Electron beam welding (EBW), process description, power density, weld characteristics, advantages, limitations and applications; Laser beam welding (LBW) – principles of LASE generation, process description, laser welding units, advantages, limitations and applications. [10 hours]

Unit-4

Other Welding processes: Friction welding, diffusion welding, induction, welding, thermit welding, ultrasonic welding etc.

Welding Metallurgy: introduction, structure and characteristics of weld metal, weld composition, heat affected zone, weldability, carbon equivalent, weldability vs. hardenability, actual weldability tests.

Welding of Specific Alloys: Welding of stainless steels, welding of cast irons, welding of copper base alloys, welding of dissimilar metals and alloys. [8 hours]

Unit-5

Weld Defects and Cracking: Weld defects, hot cracking, cold cracking, etc.

Testing and Inspection: All weld tests –tension, best, hardness, impact. Nondestructive tests, quality assurance, reliability of the weld.

Brazing and soldering: Introduction, brazing process, brazing filler metals, soldering, Soldering processes, solder alloys, applications. (12 hours)

Course Outcomes

Upon the completion of this course, the student will be able to:

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To learn the principles of all the welding and other joining processes.	K_1
CO2	To know the metallurgy of welding, and welding metallurgy of different engineering metal/alloys.	K_2
CO3	To assess the all-metal welding destructive and non-destructive tests and weld performance.	K_3

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Books:

1. Welding Engineering and Technology. R S Parmar, Khanna Publisher, New Delhi, 1997.
2. Welding Metallurgy, Sindo Kou, John Wiley and Sons, New York,1987.
3. Theory of Weldability of Metals and Alloys, Ivan Hrivnak, Elseview, Amsterdam, 1992.
4. Introduction to the Physical Metallurgy of Welding. Kenneth Eaterling, Butterworths, London, 1983.
5. Welding Technology. N K Srinivasan, Khanna Publisher, New Delhi, 1994.

Reference book:

1. AWS Welding Handbook, Vol 1–Fundamental of Welding, AWS, Miami, Florida,1976.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	CO1	CO2	CO3
PO1	3	3	2
PO2	3	2	2
PO3	3	1	2
CO (Average)			

3–High; 2–Medium; 1–Low

PRINCIPLES AND TECHNIQUES OF MATERIALS CHARACTERIZATION LABORATORY (MTMT206L)

Subject Code: -	**MTMT206L**	**IA Marks**	**15**
Number of Lecture Hours/Week: -	**02**	**Term End Exam Marks**	**35**
Total Number of Lecture Hours: -	**30**	**CREDITS**	**02**

Topics Covered

Experiment 1: Characterization of a metal matrix composite.
Part (I): Charaterization.by optical Metallography and Hardness measurement.
Part (II): Characterization by X-Ray diffraction.

Experiment 2: Indexing the X-ray diffraction (XRD) pattern of different phases.
Part (I): Indexing the XRD pattern of BCC structure.
Part(II): Indexing the XRD pattern of FCC structure.
Part(III): Indexing the XRD pattern of HCP structure.
Part(IV): Indexing the XRD pattern containing a mixture of BCC and FCC phases.

Experiment 3: Characterization of a nanocrystalline thin film electro deposit by XRD.

Experiment 4: X-ray diffraction of powders exhibiting the effect of powder size on peak broadening.

Experiment 5: Interpretation of microstructures obtained through scanning electron microscopy.

Experiment 6: Indexing selected area diffraction patterns (SADP) obtained through transmission electron microscopy.

Course Outcomes

On completion of the course the learner shall be able to:

Course Outcome No.	Statement	Knowledge Level (KL)
CO1	Learn fundamentals of X-ray diffractometer and different microscopes.	K_1
CO2	Identify the crystal structure and index the X-ray diffraction patterns of different phases.	K_2
CO3	Learn the operational aspect of X-ray diffractometer and different microscopes.	K_3
CO4	Ability to analyse diffractograms of industrial samples to meet contemporary need.	K_2

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

Text Book:

1. Elements of X-Ray Diffraction", by B.D. Cullity, Addison Wesley Publishing Co., Massachusetts, 1968.
2. "Electron Microscopy in the Study of Materials", by P.J. Grundy and G.A. Jones,

Arnold, London, 1976.
3. Principles of Metallographic Laboratory Practice – G. L. Kehl, London: McGraw-Hill Publishing Co., Ltd., 1939.

Reference Book:

1. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. Williams and C. Barry Carter, 2nd ed., Springer, 2009.
2. *Metallography*, Principles and Practice-George F. *Vander Voort*, ASM International, 1984.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO1	PO2	PO3	PO4
CO1			3	
CO2	3	3	3	
CO3			3	
CO4	3	2		3
CO (Average)				