COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Engineering and Technology

Curriculum Structure

S. Y. B.Tech.

Metallurgy and Materials Technology

(Regular + Lateral Entry)

Department of Metallurgy and Materials Engineering

(Effective from: A.Y. 2024-25)

List of Abbreviations

Abbreviation	Title
AEC	Ability Enhancement Course
BS	Basic Science Course
ESC	Engineering Science Course
PCC	Programme Core Course
PEC	Programme Elective Course
OE/SE	Open/School Elective other than particular program
MDM	Multidisciplinary Minor
VSEC	Vocational and Skill Enhancement Course
HSMC	Humanities Social Science and Management
IKS	Indian Knowledge System
VEC	Value Education Course
RM	Research Methodology
INTR	Internship
PBL	Project
CEA	Community Engagement Activity/Field Project
CCA	Co-curricular & Extracurricular Activities

S. Y. B. Tech. Metallurgy and Materials Technology [Regular]

[Level 5 UG Diploma] Semester -III

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	PCC	MT-24001	Principles of Physical Metallurgy	3	0	2	1	4	30	20	50	CIE: 100	
02	PCC	MT-24002	Materials Thermodynamics and Kinetics	3	1	0	1	4	30	20	50	--	--
03	PCC	MT-24003	Furnace Technology	2	0	0	1	2	30	20	50	--	--
04	PCC	MT-24004	Materials Testing Lab	0	0	2	1	1	--	--	--	CIE: 100	
05	OE	OEC-24005	Device Materials	2	0	0	1	2	30	20	50	--	--
06	HSMC	HS-24004	Principles of Economics	2	0	0	0	2	30	20	50	--	--
07	VEC-I	AS-24003	Constitution of India and Universal Human Values	1	0	0	0	1	CIE: 100			--	--
08	AEC-II	AS(HS)-24001_6	Indian Language: Sanskrit/Pali	2	0	0	0	2	CIE: 100			--	--
09	CEA	AS-24004	Social Summer Intern. or Field Project	0	0	0	0	2	--	--	--	CIE: 100	
			Total	**15**	**01**	**04**	**05**	**20**					

[Level 5 UG Diploma] Semester -IV

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	PCC	MT-24005	Fundamentals of Metal Working	3	0	2	1	4	30	20	50	CIE: 100	
02	PCC	MT-24006	Non-Ferrous Metallurgy Laboratory	0	0	2	1	1	--	--	--	CIE: 100	
03	PCC	MT-24007	Extractive Metallurgy	2	0	0	1	2	30	20	50	--	--
04	PCC	MT-24008	Modern Chemical Analysis of Materials Laboratory	0	0	2	1	1	--	--	--	CIE: 100	
05	PCC	MT-24009	Polymers and Composites	3	0	2	1	4	30	20	50	CIE: 100	
06	OE	OEC-24012	Manufacturing of Electronic Devices	2	0	0	1	2	30	20	50	--	--
07	MDM-I	<tbd>	Electronic waste management	3	0	0	1	3	30	20	50	--	--
08	VSEC	MT-24010	Micro Project	0	0	4	0	2	--	--	--	50	50
09	HSMC	HS-24001	Principles of Entrepreneurship	2	0	0	1	2	30	20	50	--	--
10	VEC-II	AS-24001	Environmental Studies	1	0	0	1	1	CIE: 100			--	--
			Total	**16**	**00**	**12**	**09**	**22**					

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

Exit option to qualify for Diploma in Materials Engineering:

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	Exit Course	<tbd>	Materials Process Laboratory (Powder Metallurgy, Casting, Materials Joining, Rolling, Forging)	0	0	6	1	3	--	--	--	CIE: 100	
02	Exit Course	<tbd>	Materials Testing Software and Microstructure Analysis Laboratory	0	0	6	1	3	--	--	--	CIE: 100	
			Total	**00**	**00**	**12**	**02**	**06**					

S. Y. B. Tech. Metallurgy and Materials Technology [Lateral Entry]

[Level 5 UG, Diploma] Semester -III

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	PCC	MT-24001	Principles of Physical Metallurgy	3	0	2	1	4	30	20	50	CIE: 100	
02	PCC	MT-24002	Materials Thermodynamics and Kinetics	3	1	0	1	4	30	20	50	--	--
03	PCC	MT-24003	Furnace Technology	2	0	0	1	2	30	20	50	--	--
04	PCC	MT-24004	Materials Testing Lab	0	0	2	1	1	--	--	--	CIE: 100	
05	OE	OEC-24005	Device Materials	2	0	0	1	2	30	20	50	--	--
06	AEC-II	AS(HS)-24001 to 6	Indian Language: Sanskrit/Pali	2	0	0	0	2	CIE: 100			--	--
07	VEC-I	AS-24003	Constitution of India and Universal Human Values	1	0	0	0	1	CIE: 100			--	--
08	BSC	MA-24001	Matrices, Differential Calculus and Probability	3	0	0	1	3	30	20	50	--	--
09	HSMC	HS-24004	Principles of Economics	2	0	0	0	2	30	20	50	--	--
			Total	**18**	**01**	**04**	**06**	**21**					

[Level 5 UG, Diploma] Semester -IV

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	PCC	MT-24005	Fundamentals of Metal Working	3	0	2	1	4	30	20	50	CIE: 100	
02	PCC	MT-24006	Non-Ferrous Metallurgy Laboratory	0	0	2	1	1	--	--	--	CIE: 100	
03	PCC	MT-24007	Extractive Metallurgy	2	0	0	1	2	30	20	50	--	--
04	PCC	MT-24008	Modern Chemical Analysis of Materials Laboratory	0	0	2	1	1	--	--	--	CIE: 100	
05	PCC	MT-24009	Polymers and Composites	3	0	2	1	4	30	20	50	CIE: 100	
06	OE	OEC-24012	Manufacturing of Electronic Devices	2	0	0	1	2	30	20	50	--	--
07	MDM-I	<tbd>	Electronic waste management	3	0	0	1	3	30	20	50	--	--
08	VSEC	MT-24010	Micro Project	0	0	4	0	2	--	--	--	50	50
09	HSMC	HS-24001	Principles of Entrepreneurship	2	0	0	1	2	30	20	50	--	--
10	VEC-II	AS-24001	Environmental Studies	1	0	0	1	1	CIE: 100			--	--
11	HSMC	HS-24007	Communication Skills	1	0	2	0	2	CIE:100			CIE:100	
			Total	**17**	**00**	**14**	**09**	**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

Exit option to qualify for Diploma in Materials Engineering:

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	Exit Course	<tbd>	Materials Process Laboratory (Powder Metallurgy, Casting, Materials Joining, Rolling, Forging)	0	0	6	1	3	--	--	--	CIE: 100	
02	Exit Course	<tbd>	Materials Testing Software and Microstructure Analysis Laboratory	0	0	6	1	3	--	--	--	CIE: 100	
			Total	**00**	**00**	**12**	**02**	**06**					

S. Y. B. Tech in Metallurgy and Materials Technology

Course: PRINCIPLES OF PHYSICAL METALLURGY

Course Code	MT-24001	**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 the fundamentals of physical metallurgy.
2. Illustrate the binary phase diagrams and analyze the various phases present on it.
3. Create microstructure- properties correlation for ferrous and light weight alloys
4. Apply the knowledge of physical metallurgy to select proper ferrous material for specific applications.

Syllabus:

Unit	Contents	Lecture
01.	**Metallography:** Specimen preparation for microscopic examination, Quantitative Metallography, volume fraction of phases by area, linear analysis, point counting methods for grain size and phase measurements, grain size significance and measurement, macroscopic examination methods. **Self-Study:** Metallurgical microscopes	**06**
02.	**Solidification:** Solidification, nucleation and growth, dendrites, surface energy & interfacial phenomena, interfacial phenomena in liquid-solid interface. **Solid Solutions and Phase diagrams:** Solid solution and intermediate phases, Gibb's phase rule, phase equilibria, alloy phases and compounds, Cooling curves, Hume Rothery's rule of solid solution formation, Binary equilibrium diagrams and related microstructures, Lever rule application, Non equilibrium cooling of alloys.	**06**
03.	**Iron-Carbide system:** Allotropic Transformation of Iron, Iron-Iron carbide phase diagram, critical temperatures, plain carbon steels, slow cooling of steels, Effect of Carbon on Microstructure and Mechanical Properties of Plain Carbon Steel. Transformation Products of Austenite : Pearlite, Bainite, Martensite.	**06**

	TTT and CCT diagrams: Plotting of Time Temperature Transformation (TTT) Diagram, Continuous Cooling Transformation (CCT) diagram, Effect of carbon, grain size and alloying elements on TTT and CCT Curves. Importance of IT and CCT diagrams for heat treatment. **Self-Study:** Effect of Impurities (S, P, Si, Mn) on Properties of Plain Carbon Steel, Classification, and specifications of steels. Properties and Applications of Plain Carbon Steel.	
04.	**Cast Irons:** Fe-Graphite diagram, Factors controlling microstructure, Types of cast irons: gray, White, malleable cast, Nodular (SGCI), Chilled and Mottled cast iron, Alloy cast irons: Ni hard, Ni resist, Silal, Austempered Ductile Iron (ADI). **Self-Study:** Step bar Test, Properties and Applications of Various Types Cast Irons	**06**
05.	**Copper and Copper Base Alloys:** Phase diagrams and microstructure of Cu based alloys: brasses – Single Phase, Two Phase Brass. Bronzes - Sn Bronzes, Si Bronzes, Al Bronzes, Be Bronzes,. Cupronickel and nickel silvers. **Self-Study:** Properties and applications of various types of brasses and bronzes	**06**
06	**Light metal alloys:** Classification, Properties, and Applications: Aluminium, Magnesium and Titanium alloys. Precipitation hardening of Al-Cu system, Modification treatment of Al-Si system. **Self-Study:** Classification and Temper designation of Aluminium and, Magnesium alloys.	**06**

Suggested learning resources:

Text Books:

1. S. H. Avner, Introduction to Physical Metallurgy, Tata McGraw-Hill Education, 1997.
2. Askeland & Phule, Material science & Engineering of materials,4th edition, Thomson Publication,2003.
3. R. A. Higgins, Engineering Metallurgy: Applied Physical Metallurgy Volume -I, R.E. Krieger Publishing Company, 1983.
4. Vijendra Singh, Physical Metallurgy, Standard Publishers Distributors, 2005.

5. V. Raghvan, Physical Metallurgy, PHI learning Pvt. Ltd., Second edition 2006.
6. W.F.Smith, Principles of Material Science and Engineering, 2nd edition, McGraw-Hill Companies;1990.

Reference Books:

1. Robert E. Reed Hill, Physical Metallurgy Principles, 2nd edition, Van Nostrand, 1972.
2. ASM Handbook Volume 9: Editor George F. Vander Voort, ASM International, 2004.
3. ASM Handbook Volume 3: Alloy Phase diagram, ASM International, 1992.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: PRINCIPLES OF PHYSICAL METALLURGY LABORATORY

Course Code	MT-24001	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-0 = 1	**CIE**	100
Credits	1		

Course Outcome:

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

1. Prepare the samples for microscopic examination and understand the concepts of quantitative metallography.
2. Analyze and interpret the microstructures of various plain carbon steels and cast irons.
3. Draw conclusions related to grain size, manufacturing process or heat treatment related to microstructures of ferrous alloys.

List of Experiments: (Any 08 experiments)

1. Preparation of specimens for microscopic examination: Plain carbon steels and Cast irons.
2. Preparation of specimen for microscopic examination by hot mounting and cold mounting method.
3. Study of etching mechanism of single phase and two phase alloys and preparation of etching reagents for plain carbon steel, cast iron, copper base alloys and aluminium alloys.
4. Study of Metallurgical microscope.
5. Observation and drawing of different morphologies of grains: equiaxed dendrites, columnar dendrites, cellular structure, equiaxed grains, polygonal grains, elongated grains.
6. Estimation of grain size by: i) ASTM comparison method, ii)Heyn's Intercept method and iii) Jefferies planimetric method.
7. Observation and interpretation of microstructures of annealed plain carbon steels.
8. Observations and interpretation of microstructures of various cast irons.
9. Quantitative analysis of microstructures using image analyzer software for grain size, shape, phases distribution and porosity.
10. Students will bring unknown metallic sample, prepare it for metallographic observation; observe and describe the microstructure with identification of phases present in it.
11. Industrial Visit to relevant industry.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: MATERIALS THERMODYNAMICS AND KINETICS

Course Code	MT-24002	**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 Outcomes:
At the end of this course, students will able to

1. Understand applications of laws of thermodynamics in metallurgy and material science
2. Determine the heat of reaction using Kirchhoff's equation, calculate change of internal energy, entropy and enthalpy and determine the adiabatic flame temperature of the reactions
3. Determine the activity of solute in dilute as well as concentrated solutions and understand the meaning of ideal, regular and real solutions.
4. Determination of thermodynamic quantities using reversible electrochemical cell and calculate the potential of electrolytic cells.
5. Understand reaction kinetics in metallurgical reactions.

Syllabus:

Unit	Contents	Lectures
01.	Thermodynamics systems, Classification, thermodynamic variables, State functions, Process variables, Extensive and intensive properties, Energy and first law of thermodynamics, Heat capacity, Enthalpy, Heat of reactions, Hess's law, Kirchoff's equation, Adiabatic flame temperature of the reactions, Thermochemistry.	**07**
02.	Second law of thermodynamics, Entropy, Effect of temperature on entropy, Statistical nature of entropy, Combined statements of first and second law of thermodynamics, Gibbs' free energy, Helmholtz's free energy, Maxwell's equations, Gibbs-Helmholtz equation, Clausius-Clapeyron's equation, and its application to phase changes, Free energy as criterion for equilibrium and its applications to metallurgical reactions, Third law of thermodynamics.	**07**
03.	Activity, Equilibrium constant, Le –Chatelier's principle, Chemical potential, Law of mass action, Effect of temperature and pressure on equilibrium constant, Vant Hoff's isotherm, Sigma function, Free energy-temperature diagrams, oxygen potential and oxygen dissociation pressure, Gibb's phase rule and its applications, Free energy composition diagram, Ellingham diagrams.	**07**

04.	Solutions, Partial molar quantities, Ideal solutions, Raoult's law, Non ideal solutions, Gibbs-Duhem equation, Free energy of formation of solution, Regular solutions, application to phase equiibria, excess thermodynamic quantities	**07**
05.	Electrochemical cell, Determination of thermodynamic quantities using reversible electrochemical cell, EMF cell, electrode potential, Electrode potential-pH diagrams and their applications.	**07**
06.	Thermodynamics of crystalline defects: surfaces and interfaces of solids, vacancies and interstitials in solid metals Reaction kinetics: Arrhenius equation, order of reactions	**07**

TEXT BOOKS:

1. D.R.Gaskell, Introduction to Thermodynamics of Materials, III Edition, McGraw Hill Book Co.Inc.
2. Ahindra Ghosh, Textbook of Materials & Metallurgical Thermodynamics, Prentice Hall India.
3. S.K. Bose and S.K. Roy, Principles of Metallurgical Thermodynamics, 1st Edition, Universities Press, Hyderabad.

REFERENCE BOOKS:

1. L.S.Darken and R.W.Gurry, Physical Chemistry of Metals, McGraw- Hill, 1958.
2. R.H.Parker, An Introduction to Chemical Metallurgy: Pergamon Press, Inc.
3. G.S.Upadhya and R.K.Dube, Problems in Metallurgical Thermodynamics and Kinetics, Pergamon Press, Inc. 1977.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: FURNACE TECHNOLOGY

Course Code	MT-24003	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	2-0-0-1 = 2	**MSE and TA**	30 and 20
Credits	2	**ESE**	50

Course Outcome:
At the end of course, students will be able to

1. Relate selection of Furnace, Fuels, and Refractory with working conditions.
2. Select Thermocouple and Atmosphere as per customer requirement.
3. Utilize knowledge of various Furnaces used in industry as per applications like Heat Treatment, Iron Making, Steel Making etc.

Syllabus:

Unit	Contents	Lecture
01.	**Furnaces:** Classification of furnaces, construction, working & application of various fuel fired heating furnaces, materials for industrial furnace construction, accessories such as burners, blowers, pumps, exhaust systems. Combustion calculations, efficient combustion of fuels, excess air requirement, operation, and control of industrial furnaces. Furnace atmospheres, gas flow and heat transfer in furnaces, Wall Losses, Radiation Heat Loss from Surface of Furnace Thermal efficiency. Environmental controls and safety measures. **Self-Study:** methods of waste heat utilization- regeneration, recuperators, waste heat boilers.	**06**
02	**Fuels:** Introduction to conventional fuels, Classification, and characteristics of various fuels. **Refractories:** Definition, classification, important properties, Materials, and factor affecting selection of refractories, manufacturing of refractories, Phase diagrams of oxide systems and their applications, types and properties of refractories, special refractories, testing of refractories. **Self-Study:** Testing of fuels. Applications of Refractories.	**06**
03	**Arc furnaces:** direct and indirect arc furnaces, constructions, working and applications, numerical. **Induction furnace:** principle, core and coreless types, skin effect, calculation of minimum frequency, power generation, depth of penetration, numerical. Electric resistance heating, direct and indirect resistance heating, melting of glasses and electric salt bath furnace, calculations of power requirement, design of Muffle furnace.	**08**

	Self-Study: Construction of muffle furnace, types of heating elements, coil dimensions.	
04	Heat treating furnaces: Salt bath furnace, Sealed Quench furnace etc. Blast furnace construction and raw material., Sintering Furnace and its atmosphere. Temperature measurement, thermocouple principle, calibration and types, optical and radiation pyrometers, temperature controllers- main types of temperature control systems. **Self-study:** Fluidized bed furnace, fixtures, Cupola construction, raw material.	**04**

Suggested learning resources:

1. O. P. Gupta, Elements of Fuels, Furnaces & Refractories, 5th Edition, 2009, Khanna Publishers.
2. W. Trinks & M. H. Mawhiney, Industrial Furnaces, 6th Edition, 2004, Wiley New York.
3. J. D. Gilchrist, Fuels, Furnaces and Refractories, International Series on Materials Science and Technology, Elsevier Science, 2013.
4. F.P.Edneral, Electrometallurgy of Steel and Ferro-alloys,1st Edition, 1979, MIR Publishers.
5. S. Sarkar, Fuels & Combustion, 3rd Edition,2009, Universities Press.
6. A. Rashid Chesti, Refractories- Manufacturing, Properties & Applications, 2nd Edition,1991, Prentice Hall of India Pvt. Ltd.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: MATERIALS TESTING LABORATORY

Course Code	MT-24004	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-1=1	**CIE**	100
Credits	1	**Oral**	--

Course Outcome:
At the end of course, students will be able to

1. Demonstrate the basic understanding of various testing methods.
2. Select and apply appropriate testing method for analysis of materials.
3. Compare and evaluate the results of different testing methods for various materials.

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

1. Tensile Test: to conduct tensile test on standard of M.S./C.I., Plotting of stress- Strain curves and comparison of test results.
2. Study the effect of gauge length on percent elongation.
3. Evaluation of hardness by Brinell hardness Testing Machine.
4. Evaluation of hardness by Rockwell testing machines.
5. Evaluation of hardness by Vickers Hardness Testing Machine.
6. Evaluation of compressive strength by UTM.
7. Effect of L/D ratio on the compressive strength of Brass / aluminium
8. Determination of Impact strength by impacting testing machine.
9. Evaluation of torsion strength by torsion testing machine.
10. Evaluation of Bending strength by UTM.
11. Study of dye penetrant, magnetic particles, eddy current, radiography, ultrasonic methods.
12. Industrial Visit to relevant industry.

Suggested learning resources:

1. ASM handbook Vol. 08, Mechanical Testing and Evaluation.
2. Relevant applicable standards for above experiments.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: DEVICE MATERIALS (OE - I)

Course Code	OEC-24005	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	2-0-0-1 = 2	**MSE and TA**	30 and 20
Credits	2	**ESE**	50

Course Outcome:
At the end of the course, students will be able to:

1. Understand theoretical basis of electrical, dielectric, semi conducting, magnetic, optical, and thermal properties of device materials.
2. Analyze the effect of process parameters on the structure-property correlationship in device materials.
3. Solve the numerical based on fundamental principles
4. Select the materials for device fabrication

Syllabus:

Unit	Contents	Lectures
01.	**Conducting Materials:** Resistivity range, Free electron theory, Drift velocity, Zone theory, Energy/Band gap theory, Conductors, Insulators, and Semiconductors, Fermi-Dirac Equation, Electrical and thermal conductivity, Wiedemann-Franz law, Classical theory: Significance and Limitations, Quantum free electron theory, Temperature and composition dependance of conductivity, Brushes (electrical machines), lamp filaments, fuses and solders, Resistors, Varistors, Capacitors, and Inductors	**06**
02.	**Semiconductors:** Types of semiconductors: Intrinsic and Extrinsic, Density of carriers in intrinsic semiconductors, Hall Effect - compound semiconductors, Amorphous and organic semiconductors	**03**
03.	**Dielectric and Insulating Materials:** Dielectric polarization under static fields, Types of polarization in dielectrics: electronic, ionic, and dipolar, Various dielectric constants, Dipolar relaxation, Dielectric losses, Polarizations under alternating fields – key mechanisms, breakdown in gases, liquids and solids, Influencing factors for dielectric strength, Materials for capacitor, Piezo and Ferroelectric Materials, Inorganic and Organic materials, Resins and varnishes, Liquid insulators,	**06**

	Gaseous insulators, Temperature dependance of insulating properties and ageing of insulators	
04.	**Superconductors:** Superconductors: Fundamentals and classification, Type-I and Type-II superconductors, Effect of magnetic field, Meissner effect, London equations, Josephson effect, Applications of superconductors in device fabrications	**03**
05.	**Magnetic Materials:** Concept of magnetic dipoles and ferromagnetism, Hysteresis (loop) curve, Magnetostriction, Concept of hard and soft magnetic materials, Applications of magnetic materials in electrical machines instruments and relays, Permanent magnets (or magnetic materials) and their applications in various electrical devices, Superconductors: Type-I and Type-II superconductors, Effect of magnetic field, Meissner effect, London equations, Josephson effect, Applications of superconductors in device fabrications	**06**
06.	**Optical, Energy, Battery Materials, and Plastic Electronics:** Refractive index, Reflectance, Transparency, Translucency, Snell's law, Luminescence, Optical lenses, waveguides, optical fibre, LASER, and opto-electronics devices, Mechanical and functional properties of energy materials, functional materials, functional ceramics, and 2D materials, Transition metal dichalcogenides (TMDs) and Nanowires, Battery materials: cathode, anode, separator materials, and electrolyte, Conducting polymers	**06**

Suggested learning resources:

Textbooks:

1. V. Raghavan, Materials Science and Engineering: First Course, Fifth Edition, PHI Learning Pvt Ltd., New Delhi (2011).
2. W.D. Callister, J.D. Rethwisch, Materials Science and Engineering: An Introduction, 10th Ed., Wiley (2018).
3. William F. Smith, Javad Hashemi, Francisco Presuel-Moreno, Fundamentals of Materials Science and Engineering, McGrow Hill, 6th Ed., (2022).

Reference Books:

1. S.O. Kasap, Principles of Electronic Materials and Devices, Tata McGrow Hill, Second Edition, (2002).
2. Electronic Materials Handbook, ASM International, Materials Park (1989).

S. Y. B. Tech in Metallurgy and Materials Technology

Semester IV

Course: FUNDAMENTALS OF METAL WORKING

Course Code	MT-24005	**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 the mechanism of plastic deformation.
2. Classify and compare various metal forming processes and evaluate load-torque requirement for metal forming operations.
3. Analyze the defects in various metal forming operations and suggest remedial solution.
4. Compute stresses developed in component of different shapes under variety of loading condition.
5. Evaluate principal stresses in 2 Dimension and 3 Dimension state of stress to understand yielding criterion.

Syllabus:

Unit	Contents	Lecture
01.	**Metal Forming:** Classification of forming processes, cold, hot and warm working processes, True Stress-True Strain Curve, flow curve, friction and lubrication, hydrostatic pressure and workability. **Rolling:** Classification of Rolling Processes and Rolling Mills, Forces and geometrical relations in rolling, Angle of contact and angle of friction, Material, Projected length of contact, Neutral point, Forward slip and backward slip, Analysis of Rolling force, load, Torque. spread in rolling, Problems in Rolling and defects in rolled products. **Self-Study:** Plastic deformation: Slip System, Slip, Twining, Pierls-Nabbaro stress, Schmid's Law, Resolved Shear Stress (RSS) and Critical Resolved Shear Stress (CRSS), Strain Hardening in Single Crystal and Polycrystalline Material.	**06**

02.	**Forging** Classification of forging processes, forging in plane strain, Open and closed die forging, Calculations of forging loads in closed die forging, Residual forces in forging. **Wire Drawing:** Drawing of rods wires and tubes, Analysis of tube drawing, Temperature increase in wire drawing, Die wear, Water-cooling of dies. Residual stresses in drawn products. **Self-Study:** Forging equipment, Significance of flow lines, Forging defects. Defects in Drawn Products.	**06**
03.	**Extrusion:** Classification of extrusion processes, Hot and Cold extrusion. Analysis of extrusion process, Hydrostatic extrusion. Extrusion of tubing, **Sheet Metal Forming:** Sheet metal forming and forming methods, Shearing, and blanking, Bending, stretch forming of Sheet Metals, Deep drawing, Forming limit criteria, **Self-Study:** Extrusion equipment, Deformation and lubrication in extrusion, Extrusion defects. Defects in sheet Metal Forming.	**06**
04.	**Stress and Strain on Engineering Components:** Types of loading in materials used in engineering, Basic ideas about stress, direct stress, and shear stress, Hooke's law for three dimensions, Stresses and strains in compound section, Tapered section, Thin cylinders under pressure, Hoop stress and longitudinal stress. Thermal Stresses. Bending stresses in beams, Torsion of shafts and springs.	**06**
05.	**2D State of Stress:** Concept and determination of two-dimensional principal planes and principal stresses, maximum shear stress, Mohr's circle of stress-two dimensions, numerical problems based on analytical and Mohr's circle method.	**06**
06	**3D State of Stress:** System of a body under three dimensional stresses. Matrix representation of the state of stress under three dimensions, principal planes, and maximum shear stress for three-dimensional state of stress, Yielding criteria. **Self-Study:** Determination of Principles Stresses by Eigen Values and Eigen Vector.	**06**

Suggested learning resources:

Text Books:

1. George E. Dieter, Mechanical Metallurgy, SI Metric Edition,1988, McGraw-Hill Book Company.
2. Mechanical Behavior of Materials, Thomas H. Courtney, Second Edition, 2005, Waveland Press Inc.
3. Serope kalpakjian, Steven R. Schmid, Manufacturing Engineering and Technology, International Edition, Fourth Edition, 2001, Prentice Hall International.
4. Ghosh A., Mallik A.K., Manufacturing Science, 1985, Affiliated East-West Press (P) Ltd., New Delhi.

REFERENCE BOOKS:

1. Mechanical Working of Metals, Harris J. N., 1983 Jan 01, Pergamon Press, Elmsford, NY.
2. ASM Metals Handbook Vol. 14A: Metal Working: Bulk Forming, Materials Park, Ohio.
3. Hosford W.F Caddell, Metal Forming Mechanics and Metallurgy, Prentice Hall, 1983.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: FUNDAMENTALS OF METAL WORKING LABORATORY

Course Code	MT-24005	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-0=1	**CIE**	100
Credits	1		

Course Outcome:

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

1. Perform various metal working operations such as rolling, forging, extrusion, wire drawing, sheet metal forming and analyze the data.
2. Evaluate the effect of cold working and hot working on microstructure and mechanical properties of steel and copper base alloys
3. Correlate the structure property relationship associated with different metal working processes.
4. Solve numerical based on strength of materials, plastic deformation and metal working processes.

List of Experiments/Assignments: (Any 08 experiments)

1. Assessment of non metallic inclusions in steels as per ASTM E 45.
2. Effect of cold rolling and process annealing on microstructure and mechanical properties of Copper base alloys, Plain carbon steel and Stainless steel.
3. Effect of hot working on microstructure and mechanical properties of Copper base alloys, Plain carbon steel and Stainless steel.
4. Study of open die and closed die forging processes. To perform open die forging of Aluminium samples.
5. Observations of flow line pattern of forged part.
6. Study of rolling mills, effect of rolling parameters on final product, defects in rolled products and their remedial measures.
7. To study and perform sheet metal forming operations like deep drawing, stretch forming, shearing, blanking and bending.
8. To determine formability of sheet metal using cupping test.
9. Study of extrusion of aluminium and its alloys.
10. Numerical based on strength of material, plastic deformation and metal working processes.
11. Industrial Visit to relevant industry.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: NON-FERROUS LABORATORY

Course Code	MT-24006	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-1=1	**CIE**	100
Credits	1		

Course Outcome:
At the end of **laboratory** course, the students will demonstrate the ability to:

1. Understand phase diagrams of Copper, Aluminum, Nickel, Magnesium and Titanium base alloys.
2. Understand the method of describing and reporting of observed microstructure.
3. Classify Various types of nonferrous alloys based on microstructure and
4. Interpret results of heat treatment given to nonferrous alloys and draw structure property relationship.

List of Experiments/Assignments: (Any 08 experiments)

1. Preparation of specimen of nonferrous alloys using metallographic techniques and Phase analysis using Image Processing (ImageJ Software).
2. To study phase diagrams of aluminium alloys and observe microstructure of cast and wrought aluminium alloys, and correlation of observed results with at least one peer reviewed Research Paper. (preferably separate research article for every student.)
3. To study Cu-Zn phase diagram and observe the microstructure of brasses.
4. To study phase diagrams of Cu-Sn, Cu-Al, Cu-Ni, Cu-Si alloys and observe the microstructure of various bonzes. and correlation of observed results with at least one peer reviewed Research Paper. (preferably separate research article for every student.)
5. To study microstructures of Ni-based or/and Co-based superalloys with at least one peer reviewed Research Paper. (preferably separate research article for every student.)
6. To study modification treatment of Al-Si alloys.
7. To study the heat treatment of titanium alloys.
8. To study heat treatment of magnesium alloys.
9. Study of effect of alloy composition, heat treatment cycles, thermo-mechanical treatments on the microstructure and Properties of non-ferrous metals through various peer reviewed Research Papers.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: EXTRACTIVE METALLURGY

Course Code	MT-24007	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	2-0-0-1 = 2	**MSE and TA**	30 and 20
Credits	2	**ESE**	50

Course Outcome:

At the end of course students will be able to

1. Choose appropriate Mineral Processing Techniques for the type of ore and subsequent extraction methods for various non ferrous metals.
2. Assess hydro, pyro and electro metallurgical methods of extraction used for extraction of Metals.
3. Select Post extraction Refining methods as per the requirement of end use.
4. Demonstrate understanding of metal recycling methods.

Syllabus:

Unit	Contents	Lecture
01.	**Mineral Processing:** Sources of Metals, Introduction to ore dressing, crushing and grinding, Sizing and sorting, Magnetic and electrostatic separation processes, Principles of floatation, Factors affecting floatation, **Self-Study:** Locations of ore deposits of non-ferrous metals in India and abroad, historical, and current production of nonferrous metals, Sizing and sorting Equipment.	**04**
02.	**Main approaches in extractive metallurgy:** Reactivities of Metals, Principles and Important unit operations of Pyrometallurgy, Hydrometallurgy and Electrometallurgy. Thermodynamic considerations and process selection in extraction of metals, Application of Ellingham Diagram and Predominance Area Diagram. Study of Leaching and precipitation of metals. Basic approaches and methods of Metal Refining: Preparation of Pure compounds and Purification of Bulk Crude Metal. **Self-Study :** Bioleaching, reduction by gases.	**07**
03.	**Metals for Electric Vehicles:** Pyrometallurgical extraction of copper- Roasting, Smelting, Converting, Refining, Copper loss in slag. Imperial smelting process. Principle of electrolysis in winning, fused	**06**

	salt electrolysis, Hall-Heroult process, Refining of Aluminium. Dow's process of extraction of Mg. **Self-Study:** Bayer's process for production of alumina, newer routes of Aluminium Extraction. Extraction of titanium.	
04.	**Hydrometallurgical Extraction and Recycling of Metals :** Hydrometallurgical extraction of Zinc, Production of Secondary metals, Recovery of metals from scrap and other secondary sources by pyro-, hydro- and electrometallurgy. Metal Recovery from E-waste.	**07**

Suggested learning resources:

1. H. S. Ray, R. Shreedhar and K.P. Abraham, Extraction of Non-Ferrous Metals, Affiliated East West press pvt. Ltd, Oscar Publications, New Delhi, 2011.
2. W. G. Davenport, M. King, M. Schlesinger, and A. K. Bishwas, Extractive metallurgy of Copper, 4th edition, Pergamon Press, 2002.
3. H. S. Ray, A. Ghosh, Processes in Extractive Metallurgy, New age international pvt. Ltd, New Delhi, 2001.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: MODERN CHEMICAL ANALYSIS LABORATORY (MCAL)

Course Code	MT-24008	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-1 = 1	**CIE**	100
Credits	1		

Course Outcomes

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

1. Demonstrate basic understanding of different methods for chemical analysis.
2. Perform elemental analysis experiments from different materials.
3. Perform and interpret results of analytical techniques.

List of Experiments/Assignments: (Any 08 experiments)

1. Estimation of carbon in steels by colorimeter.
2. Analysis of Fe from steel sample.
3. Analysis of Mn in steels & cast iron.
4. Analysis of Ni in steels & stainless steels
5. Analysis of Cr in steels & stainless steels
6. Analysis of Cu & Pb by Electro-gravimeter
7. Analysis of Carbon in steel and Cast iron by using Strohlien's apparatus
8. Analysis of Ni / Cu by Atomic Absorption Spectroscope
9. Analysis of compounds by using FTIR/ UV Spectroscopy.
10. Chemical analysis by EDS method.
11. Estimation of mass of Zinc on steel plate.
12. Study of FIVE Indian Standards related to chemical analysis of Elements.
13. Industrial Visit to relevant industry.

Suggested learning resources:

1. Metallurgical Analysis – B.C.Agarwal and S.P. Jain
2. Instrumental Methods of Chemical Analysis – G.R.Chatwal, S.K.Anand

S. Y. B. Tech in Metallurgy and Materials Technology

Course: POLYMERS AND COMPOSITES

Course Code	MT-24009	**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, students will be able to;

1. Understand the basic structures of polymers, their properties and applications.
2. Select appropriate techniques for processing of polymers.
3. Distinguish between metal, ceramic and polymer matrix composites along with advantages and limitations of each of these.
4. Correlate the microstructure of composite materials to their properties.

Syllabus:

Unit	Contents	Lectures
01.	**Polymers:** Introduction, Classification of Polymers, Degree of Polymerization, Polymerization Reactions, Polymerization Mechanisms: Addition Polymerization, Copolymerization, Condensation Polymerization, Polymer Structures and Shapes, Cross Linking and Branching, Crystallinity and Stereo-Isomorphism in Polymers. **Self Study:** Differentiate between Polymer, Metal, Ceramic and their Composites.	**06**
02.	**Thermoplastics and Thermoset Polymer:** General-Purpose Thermoplastics, Engineering Thermoplastics, Thermosetting Plastics (Thermoset), Elastomer (Rubbers), Structure-Property Relationship in Thermoplastics, Characteristics and Applications of Polymers, Processing of Plastic Materials: Processes Used for Thermoplastic and Thermosetting Materials. **Self Study**: Applications of Thermoplastic Polymer, Thermoset Polymer and Elastomers etc.	**06**
03.	**Mechanical Properties of Polymers:** Deformation and Strengthening of Plastic Materials, Mechanical Properties: Creep and Fracture of Polymeric Materials, Visco-elasticity, Stress Relaxation,	**06**

	Glass Transition Temperature and Polymer Degradation **Self Study**: High Performance Polymer, their Characteristics and Applications.	
04.	**Composite Materials:** Introduction, Reinforcements: Natural Fibers, Synthetic Fibers, Synthetic Organic and Inorganic Fibers, Particulate and Whiskers Reinforcements, Reinforcement-Matrix Interface. **Self Study:** Hybrid and Advanced Composites	**06**
05.	**Particle and Fiber Reinforced Composites:** Large Particle Composites, Dispersion Strengthened Composites, Fiber Reinforced Composites: Influence of Fiber Length, Orientations and Concentrations, Fiber Phase, Matrix Phase, Processing of Fiber Reinforced Composites, Structural Composites, Rule of Mixture, Fracture Mechanics and Toughening Mechanisms. **Self Study:** Applications of Particle and Fiber Reinforced Composites	**06**
06.	**Composites with Polymer/Metal/Ceramic Matrix:** Introduction, Metal Matrix Composite Processing, Interface Reactions and Properties of MMCs, Polymer Matrix Composites: Introduction, Polymer Matrices, Processing of PMCs, Ceramic Matrix Composites: Introduction, Processing and Structure of Monolithic Materials, Processing of CMCs. **Self Study:** Applications of PMC, MMC and CMC composites.	**06**

Suggested learning resources:

Text Books:

1. V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, Polymer Science, New Age International (P) Limited Publishers, New Delhi, 1996.
2. Premamoy Ghosh, Polymer Science and Technology of Plastics and Rubbers, Tata McGraw-Hill Publishing Company Limited, New Delhi,1990.
3. F.L.Matthews, and R. D. Rawlings, Composite Materials, Engineering and Science, Woodhead Publishing Limited, Cambridge, England,1999.

Reference Books:

1. Mel M. Schwartz (R), Composite Materials Handbook, Vol. II, Processing, fabrication and applications, 2nd Edition, McGraw-Hill, New York, 1992.

2. K.K. Chawla, Composite Materials Science and Engg., 2nd Edition, Springer Verlag, 1998.
3. D. R. Askland and P. P. Phule, The Science and Engineering of Materials, 4th Edition, Pacific Grove Publication, 2003.
4. William F. Smith, Principles of Materials Science and Engineering, 3rd Edition, McGraw-Hill, 2002.
5. William D. Callister, Jr, Materials Science and Engineering – An introduction, sixth edition, John Wiley & Sons, Inc. 2004.
6. ASM Handbook, Vol. 21, ASM International, OH, USA.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: POLYMERS AND COMPOSITES LABORATORY

Course Code	MT-24009	**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 Tes
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. Numericals Based on rule of mixture and inverse rule of mixture.
15. Industrial Visit to relevant industry.

S. Y. B. Tech in Metallurgy and Materials Technology

Course: MANUFACTURING OF ELECTRONICS DEVICES (OE - II)

Course Code	OEC-24012	**Scheme of Evaluation**	MSE, TA and ESE
Teaching Plan	2-0-0-1 = 2	**MSE and TA**	30 and 20
Credits	2	**ESE**	50

Course Outcome:

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

1. Understand manufacturing aspects of electrical engineering device devices.
2. Analyze the effect of process parameters on the manufacturing of electrical engineering device materials.
3. Understand cause-effect relationship in failure of the electrical engineering devices.
4. Select the materials and manufacturing processes for device fabrication.

Syllabus:

Unit	Contents	Lectures
01.	**Single crystal growth techniques:** Classification of single crystal growth techniques (Growth from solid, solution, melt, vapour), Czochralski process, Bridgeman technique, Vernuil method, Zone melting method, Kyropoulos technique, Skull melting, Floating zone technique, Temperature dependent growth of single crystals, Gel growth.	**06**
02.	**Semiconductor, FET and MOSFET Manufacturing Techniques:** Si and Si wafer preparation techniques, Zone refining, Mono crystallization, Floating zone method, Alloy-junction crystals, Growth junctions, Solid diffusion, Gaseous diffusion, Point contact	**06**
03.	**Printed and Integrated circuit fabrication techniques:** Metallization, Lithography, Ion implantation	**02**
04.	**Thin film growth/deposition techniques:** Physical and chemical vapour deposition (PVD and CVD), Plasma CVD, Thermal CVD, Sputtering, Atomic layer deposition (ALD), Molecular beam epitaxy, Epitaxial growth, Chemical bath deposition, Plating, Vacuum evaporation	**06**
05.	**Lithography and Etching techniques:** Overview and applications of various electronic devices/materials	**06**

	fabrication techniques such as Photolithography: Vapour prime to soft bake, Alignment, Exposure, Photoresist development, and Advanced Lithography, Etching: Wet etching, Plasma etching, and Ion beam etching	
06.	**Fabrication related aspects, system reliability, and maintenance:** Productivity and process yield, Processes and device evaluation, Applications to electronic packaging, Micro/nanoelectromechanical systems (M/NEMS devices), E-mobility, and Nanoelectronics	**04**

Suggested learning resources:

Textbooks:

1. V. Raghavan, Materials Science and Engineering: First Course, Fifth Edition, PHI Learning Pvt Ltd., New Delhi (2011).
2. William F. Smith, Javad Hashemi, Francisco Presuel-Moreno, Fundamentals of Materials Science and Engineering, McGrow Hill, 6th Ed., (2022).
3. S.M. Dhir, Electronic components and materials: Principles, Manufacture, and Maintenance

Reference Books:

1. S.O. Kasap, Principles of Electronic Materials and Devices, Tata McGrow Hill, Second Edition, (2002).
2. Electronic Materials Handbook, ASM International, Materials Park (1989).

S. Y. B. Tech in Metallurgy and Materials Technology

Course: ELECTRONIC WASTE MANAGEMENT (MDM-I)

Course Code	MDM-I	**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:

1. Describe and explain the national and global e-waste scenario, including sources, composition, generation trends, and associated environmental and health impacts.
2. Analyze the roles and responsibilities of individuals, organizations, producers, and regulatory bodies in the governance and implementation of e-waste management systems.
3. Apply principles of safe handling, segregation, storage, and recycling of e-waste in compliance with Indian regulations and occupational safety standards.
4. Evaluate existing and emerging e-waste management practices and propose sustainable and innovative technological or policy-based solutions aligned with circular economy principles.

Syllabus:

Unit	Contents	Lecture
01.	**National and Global Scenario:** Definition and scope of e-waste, classification of electronic waste, composition and material constituents of e-waste, global e-waste generation trends, major e-waste generating regions and countries, Indian e-waste generation scenario, sources of e-waste in India, urban and metropolitan concentration of e-waste, informal and formal e-waste sectors, environmental impacts of improper e-waste disposal, public health implications of e-waste pollution, overview of global conventions and international initiatives on e-waste management	**06**
02.	**Role of Individuals and Organizations:** Role of consumers in responsible electronics use, household-level e-waste segregation and disposal practices, awareness and behavioral change for sustainable consumption, role of educational institutions in e-waste awareness, contribution of non-governmental organizations, corporate social responsibility in e-waste management, sustainable product design and green electronics, take-back and collection initiatives, interaction between consumers and recycling systems	
03.	**Environmental and Health Impacts:** Role of government agencies in e-waste management, functions of MoEFCC, CPCB, and SPCBs, Extended Producer	**06**

	Responsibility (EPR) concept and implementation, producer, manufacturer, refurbisher, and recycler responsibilities, monitoring and compliance mechanisms, public–private partnerships in e-waste management, role of urban local bodies and municipalities, integration of e-waste management with national initiatives such as Swachh Bharat Mission and Smart Cities Mission, case studies of institutional e-waste management practices in India	
04.	**Safety and Handling of E-Waste:** Hazardous components of e-waste including heavy metals and toxic substances, exposure pathways through air, water, soil, and occupational contact, health impacts on recycling workers and nearby communities, environmental risks associated with informal recycling, safe collection and segregation methods, storage and transportation of e-waste, occupational health and safety practices, use of personal protective equipment, administrative and engineering controls for risk reduction	**06**
05.	**Current E-Waste Management Practices:** Principles of e-waste management hierarchy, reduction and reuse strategies, formal recycling processes and dismantling practices, mechanical separation and material recovery techniques, recovery of metals and valuable resources, existing e-waste recycling infrastructure in India, challenges associated with informal recycling systems, overview of E-Waste (Management and Handling) Rules 2011, salient features of E-Waste Management Rules 2016 and 2022, comparison with international regulations such as WEEE and RoHS directives	**06**
06.	**Innovative Approaches and Technologies:** Circular economy concepts applied to electronics, eco-design and sustainable electronics manufacturing, green materials and substitution of hazardous substances, advanced recycling and automation technologies, urban mining and recovery of critical and rare earth elements, application of life cycle assessment in electronic products, digital tools for tracking and compliance, emerging research trends and future directions in e-waste management	**06**

Textbooks:

1. Johri, R., *E-Waste: Implications, Regulations, and Management in India and Current Global Best Practices*, TERI Press, New Delhi
2. Hester, R. E. and Harrison, R. M., *Electronic Waste Management*, Royal Society of Chemistry / Science, 2009

Reference Books

1. Fowler, B., *Electronic Waste: Toxicology and Public Health Issues*, Elsevier, 2017
2. Rajagopalan, R., *Environmental Studies – From Crisis to Cure*, Oxford University Press
3. Miller, G. T., *Environmental Science – Working with the Earth*, Thomson Brooks/Cole
4. Dubey, B. K., *Electronic Waste Management – Issues and Challenges*, NPTEL, IIT Kharagpur

S. Y. B. Tech in Metallurgy and Materials Technology

Course: MICRO PROJECT

Course Code	MT-24010	**Scheme of Evaluation**	ISE & ESE
Teaching Plan	0-0-4-0 = 2	**ISE**	50
Credits	2	**ESE**	50

Course Outcome:

1. Identify and formulate real-life engineering problems related to Metallurgy and Materials Engineering through literature review and problem analysis.
2. Apply fundamental concepts of materials science, metallurgical processes, and engineering sciences to design feasible solutions for defined problems.
3. Create, select, and effectively use appropriate tools such as CAD software, simulation tools, basic laboratory equipment, and modern IT resources for problem-solving and prototyping.
4. Demonstrate effective teamwork, communication skills, ethical responsibility, and project management while working individually or in multidisciplinary teams.

Syllabus:

The Micro-Project course is designed as an experiential, activity-based learning component in alignment with the National Education Policy (NEP) 2020, to strengthen the connection between theoretical knowledge and practical application in Metallurgy and Materials Technology. In this course, small groups of students undertake a mini project based on reworking an established concept, improving an existing solution, or developing a new idea derived from the fundamental courses studied up to the third semester and those being pursued in the fourth semester. The micro-project may involve the design and fabrication of a simple physical model, component, or assembly; experimental investigation or material characterization; process analysis related to metallurgical and materials engineering; CAD-based design and modeling; rapid prototyping using modern fabrication techniques; or participation in interdisciplinary, laboratory-based, or industry-collaborated activities. Students are expected to define a clear problem statement, carry out a basic literature review, plan and execute the work systematically, apply appropriate engineering principles and modern tools, analyze the results, and draw meaningful conclusions. The course emphasizes teamwork, communication skills, ethical practices, and project management, and the student's performance is evaluated through continuous assessment and an end-semester oral examination.