COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Engineering and Technology

Curriculum Structure

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

Materials Engineering

Department of Metallurgy and Materials Engineering

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

List of Abbreviations

Abbreviation	Title
PSMC	Program Specific Mathematics Course
PSBC	Program Specific Bridge Course
PCC	Program Core Course
PEC	Program Specific Elective Course
ELC	Experiential Learning Course (Dissertation Phase I & II, Summer Internships)
OE	Open Elective
SLC	Self-Learning Course
AEC	Ability Enhancement Course
RM & IPR	Research Methodology and Intellectual Property Rights
CCA	Co-curricular & Extracurricular Activities
LLC	Liberal Learning Course
Project	Dissertation

F. Y. M. Tech. Materials Engineering
Semester-I

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)			
									Theory			Laboratory
									MSE	TA	ESE	CIE
01	PSMC	MME-25001	Thermodynamics of Materials	3	1	-	1	4	30	20	50	-
02	PSBC	MME-25007	Composite Materials	2	-	2	1	3	30	20	50	100
03	PCC	MME-25004	Phase Transformation in Materials	3	1	-	1	4	30	20	50	-
04	PCC	MME-25002	Electronic Materials	3	-	-	1	3	30	20	50	-
05	PCC	MME-25003	Corrosion Engineering	3	-	-	1	3	30	20	50	-
06	PCC	MME-25005	Lab Practice-I	-	-	4	-	2	-	-	-	100
07	PEC-1	MME(PE)-25001	Ceramic Engineering	3	-	-	1	3	30	20	50	-
		MME(PE)-25002	Nanomaterials Engineering									
		MME(PE)-25003	Quantum Materials									
		MME(PE)-25004	Simulation and Modelling									
08	RM	SET-25001	Research Methodology	3	-	-	1	3	30	20	50	-
Total Credits								**25**				

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

F. Y. M. Tech. Materials Engineering
Semester-II

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

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

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

- Summer internship after semester II for two months and before semester III.
- Exit option to qualify for PG Diploma in Materials Engineering

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

S. Y. M. Tech. Materials Engineering

Semester -III

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

S. Y. M. Tech. Materials Engineering

Semester -IV

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

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

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

Semester-I

Course: Thermodynamics of Materials

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

Course Outcomes:

At the end of this course, students will be 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:

Thermodynamics systems, Classification, thermodynamic variables, State functions, Process variables, Extensive and intensive properties, Energy and laws of thermodynamics, Heat capacity, Enthalpy, Heat of reactions, Hess's law, Kirchoff's equation, Adiabatic flame temperature of the reactions, Thermochemistry, Entropy, , Effect of temperature on entropy, Statistical nature of entropy, 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, 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, Free energy-temperature diagrams, oxygen potential and oxygen dissociation pressure, Gibb's phase rule and its applications, Free energy composition diagram, Ellingham diagrams. 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 equilibria, excess thermodynamic quantities. Electrochemical cell, Determination of thermodynamic quantities using reversible electrochemical cell, EMF cell, electrode potential-pH diagrams and their applications. Thermodynamics of crystalline defects, surfaces and interfaces of solids, vacancies and interstitials in solid metals, Reaction kinetics: Arrhenius equation, order of reactions.

Textbooks:

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.

Course: Composite Materials

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

Course Outcomes:

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

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

Syllabus:

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

Textbooks/ Reference Books:

1. Principles of Materials Science and Engineering, William F. Smith, Third Edition, 2002, McGraw-Hill.
2. Composite Materials: Engineering and Science, Matthews F.L., and Rawlings R. D., 1999, Woodhead Publishing Limited, Cambridge England.

3. Composite Materials - Functional Materials for Modern Technology, DDL Chung, Springer-Verlag Publications, London.
4. The Nature and Properties of Engg. Materials, Jastrzebaski, John Wiley & Sons, New York.
5. Composite Materials Handbook, Mel M. Schwartz (R), 2nd Edition, 1992, McGraw-Hill, New York.
6. Mechanics of Composite Materials, Autar K. Kaw, 1997, CRC Press, New York.
7. Fundamentals of Fiber Reinforced Composite Materials, A. R. Bunsell, J. Renard, 2005, IOP Publishing Ltd.
8. Composite Materials Science and Engg., Chawla K.K., Second Edition, 1998, Springer Verlag.

COMPOSITES LABORATORY

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

Course Outcome:

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

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

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

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

Course - Phase Transformations in Materials

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

Course Outcomes:

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

1. Utilize the knowledge of phase transformation in industries & research organizations.
2. Analyze, interpret and present observations on heat treatment.
3. Function in engineering units and science laboratory teams, as well as on multidisciplinary projects.

Syllabus Contents:

Basics of solution thermodynamics, concept of excess free energy, regular solution model, Binary and ternary phase diagrams and interpretations of tie line in ternary isotherms, Kinetics of phase transformation, Classification of phase transformations, Mechanism of diffusion in solids, steady state and non-steady state diffusion, factor affecting diffusion rate, Kirkendall effect. Energy aspects of homogeneous and heterogeneous nucleation, Fraction transformed at constant rates of nucleation and growth, Nucleation in solids. Austenite to pearlite transformation, temperature effect on pearlite transformation, austenite to bainite transformation. Martensitic transformation: Crystallographic aspects and mechanism of atom movements, comparison between twinning and martensitic transformation, Effect of grain size, Plastic deformation, arrested cooling on kinetics. Order-Disordered transformations: Common structures in ordered alloys, variation of order with temperature, Determination of degree of ordering. Effect of ordering on properties and applications. Precipitation hardening: Structural changes, Mechanism and integration of reactions, Effect of retrogression, Double peaks, Spinodal decomposition. Recovery, Recrystallization and grain growth: Property changes, Driving forces, N-G aspects, Annealing twins, textures in cold worked and annealed alloys, polygonization, Phase transformations in ceramics.

Textbooks/ Reference Books:

1. Solid State Phase Transformations by V. Raghavan, Prentice-Hall of India (P) Ltd., N. Delhi, 1987.
2. Phase Transformation in Metals and Alloys by David A. Porter, Kenneth E. Easterling, and Mohamed Y. Sherif, CRC Press, 3rd Ed. (Indian reprint), 2009.
3. Materials Science and Engineering, An introduction, by William D. Callisters, Jr., 7th Edition, John Wiley & Sons, Inc, 2011.
4. Modern Physical Metallurgy and Materials Enginering by R. E. Smallman and R.J. Bishop, 6th Edition, Butterworth Heinemann, 1999.
5. Recovery Recrystallization & Grain Growth in Metals – P. Cotterill& P. R. Mould- Surrey University Press. Physical Metallurgy – Cahn, Haasen, North Holland Physics Publication.

Course: Electronic Materials

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

Course Outcome:

At the end of course students will be able to

1. Understand the role of crystal structure and defects in determining electrical properties of the materials.
2. Understand theoretical basis of electrical, dielectric, semiconducting, optical, and thermal properties of device materials.
3. Analyze the effect of process parameters on the structure-property correlations in electronic materials.
4. Solve the numerical based on fundamental principles.
5. Select the materials for device fabrication.

Syllabus:

Crystal Structure, Defects and Electrical Properties of Materials: Role of defects in electronic properties, Classical and quantum theories of conduction, Electrical conductivity in metals and semiconductors, Temperature dependence of conductivity, Electrical Characterisation. Conducting Materials & Semiconductors: Brushes, lamp filaments, fuses and solders, Resistors, Varistors, Capacitors, and Inductors, Types of semiconductors, Density of carriers in intrinsic semiconductors, Hall Effect - compound semiconductors, Amorphous and organic semiconductors. Dielectric and Ferroelectric Materials: Polarization mechanisms, Dielectric constant and loss, Dipolar relaxation, Ferroelectricity, Piezoelectricity, Pyroelectricity, Spontaneous Polarizations (PE curve), Capacitor materials, Inorganic and Organic materials, Resins and varnishes, Liquid insulators, Gaseous insulators. Superconductors and Magnetic Materials: Fundamentals and classification, Type-I and Type-II superconductors, London equations, Josephson effect, Applications of superconductors, Meissner effect, Curie temperature, Ferromagnetic domains, Magnetic alloys. Optical Materials: Interaction of light with materials, Snell’s law, Photoconductivity and luminescence, Optical lenses, waveguides, optical fiber, LASER, and optoelectronic devices. Emerging Materials and Applications: 2D materials (graphene, MoS_2), Organic electronic materials, Transparent conductors, Materials for photovoltaics and thermoelectric, Transition metal dichalcogenides (TMDs) and Nanowires.

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).

Course: Corrosion Engineering

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

Course Outcomes:

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

1. Understand corrosion types, mechanisms, and influencing factors like temperature and velocity.
2. Analyze corrosion processes, including galvanic coupling and industrial diagnostic tools.
3. Identify various corrosion forms and their prevention methods, such as pitting and intergranular corrosion.
4. Conduct corrosion testing and data analysis using methods like exposure and NACE tests.
5. Apply corrosion control techniques, including material selection, coatings, and industry standards.

Syllabus:

Introduction to corrosion, types (wet and dry), electrochemical mechanisms, and factors like temperature, velocity, and oxidizers. Galvanic coupling, metallurgical and economic aspects, corrosion inspection, industrial scope, and emerging diagnostic tools. Introduction to two-metal corrosion, EMF, galvanic series, and area-distance principle; pitting corrosion characteristics, mechanism, and velocity. Intergranular corrosion (weld decay, knife-line attack), selective leaching, erosion corrosion, stress corrosion cracking, hydrogen embrittlement, and prevention methods. Introduction, classification, and purpose of corrosion testing; methods include exposure, electrochemical, NACE test, and material-specific tests with data analysis. Corrosion in natural environments (atmosphere, water, soil) and industries including aerospace, automotive, electronics, and power plants. Corrosion control through material selection, design, alternate environments, metallic coatings (anodic/cathodic), galvanizing, cladding, electroplating (nickel, chromium), cleaning methods, metal spray coatings, and corrosion control standards.

Textbooks:

1. Mars G. Fontana, Corrosion Engineering (Third edition), McGraw Hill Education (India) Private Limited, Chennai, India.
2. P.C. Jain & Monika Jain, Engineering Chemistry, Dhanpat Rai & Sons, Delhi, India.

References Books:

1. Pierre R. Roberge, Handbook of Corrosion Engineering, McGraw Hill Professional (1999).
2. Volkan Cicek, Corrosion Engineering, John Wiley & Sons (2014).
3. Volkan Cicek, Bayan Al-Numan, Corrosion Chemistry, John Wiley & Sons (2011).

Course: Laboratory Practice-I

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

Laboratory Outcome:

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

List of Experiments/Assignments:

Wherever possible refer to BIS or ASTM standards.

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

Course: Ceramics Engineering

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

Course Outcomes:

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

1. Know the importance of chemistry/stoichiometry, bonding, crystal structure and microstructure of ceramic materials in arriving at the final properties,
2. Learn the ceramic processing techniques starting from powder making to fabrication the finished products
3. Analyse and solve the problems related to ceramics engineering
4. Comprehend microstructures of advanced ceramics
5. Understand and evaluate the important properties and applications of ceramics

Syllabus:

Introduction to ceramics: electronegativity, important ceramics structures, coordination, ionic radii, Kroger Vink notation of point defects, defect reactions, stoichiometry calculations, density-theoretical and experimental density calculations, concept of energy well and its applications. Phase equilibria: displacive and reconstructive transformation, eutectic & incongruent melting, phase separation, solid solutions, free energy composition and temperature diagram. Zirconia phase diagram study and its transformation toughening. Ceramic powder processing methods: Ball milling, Chemical vapour deposition, Sol-gel, Polymer pyrolysis, Coprecipitation, Spray Drying/pyrolysis, Powder characterization methods: Laser particle size analyzer, BET surface analysis, introduction to XRF and XRD methods. Forming methods: Conventional compaction route (ceramics route) and Novel processing techniques to finished products - Slip and Tape casting, gel casting, CIP, HIP ping, extrusion, injection moulding and spray forming, DMO and RBAO. Sintering theory and microstructure development: Different mass transport mechanisms, Sintering parameters- materials and processing, Role of defects during sintering, Solid and liquid phase sintering, grain growth and ostwald ripening, pore-grain boundary interactions, Reaction sintering, sintering of nanomaterials, characterization methods like dilatometry to determine sintering temperature, compressive strength, 3-4 point bend test and weibull modulus.

Textbooks/ Reference Books:

1. C. Barry Carter, M. Grant Norton, Ceramic Materials- Science and Engineering, Second Edition, Springer New York, 2013.
2. M. N. Rahaman, Ceramic Processing and Sintering, 2nd edition, Marcel Dekker Inc., NY, 2003.
3. W.D. Kingery, H.K. Bowen and D.R. Uhlman, Introduction to Ceramics, Ceramic Science and Technology, John Wiley and Sons, Singapore, 1991.
4. M.W. Barsoum, Fundamentals of Ceramics, 2nd edition, IoP Publications, UK, 2003.

5. C.J. Brinker, D. E. Clark, and D.R. Ulrich, Better Ceramics through Chemistry, North Holland,1984.
6. F.F.Y. Wang, Ceramic Fabrication Processes, Academic Press, 1976.
7. J. Reed, Introduction to Principles of Ceramic Processing, 2nd Ed., John Wiley & Sons, 1995.

Course: Nanomaterials Engineering

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

Course Outcomes:

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

1. Know the length scale, surface area to volume ratio and properties of nanomaterials.
2. Know the effect of particles size on mechanical, thermal, optical and electrical properties of nanomaterials.
3. Know the synthesis and applications of nanomaterials/nanocomposites.
4. Apply the knowledge to prepare and characterize nanomaterials using various tools.
5. Understand the theoretical concepts useful for structural, electronics, optical, magnetic and bio-medical fields, nanocomposites etc.

Syllabus:

Introduction: Definition, length scales, classification of nanomaterials, effect of particle size on thermal, mechanical, electrical, magnetic, and optical properties of the nanomaterials, Inspiration from Nature about nanotechnology (or Nanobiotechnology). Synthesis of nanomaterials: Top-down approaches like ball milling, severe plastic deformation, lithography (optical, UV-visible, Deep-UV visible, X-ray, e-beam), soft lithography etc., Bottom-up approaches like inert gas condensation, chemical vapor deposition, colloidal method, sol-gel method, and atomic layer deposition (ALD) and Laser nanomanufacturing. Characterization of Nanomaterials; X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning microscopy (SPM), Raman spectroscopy, UV-visible spectroscopy, and specific surface area analyzer (BET), Synthesis and applications of nanowires, carbon nanotube (CNT), and expanded graphite (EG)/graphene. Fabrication of nanocomposites and their types, Applications of nanomaterials in nanocomposites, electrical/electronics, biomaterials and Energy devices. Pros and cons of nanomaterials and nanotechnology for human beings.

Textbooks:

1. Textbook of Nanoscience and Nanotechnology by B.S. Murty and P. Shankar, Universities Press (India) Private Limited, 2012, 1st Edition.
2. Nanostructures and Nanomaterials: Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press, 2004, 2nd Edition.
3. Introduction to Nanoscience and Nanotechnology by Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, 2008, ISBN-13: 978-1420047790.
4. Introduction to Nanotechnology by Charles P. Poole, Jr., Frank J. Owens, Wiley, 2003, ISBN: 978-0-471-07935-4.

5. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects by Daniel L. Schodek, Paulo Ferreira, and Michael Ashby, Butterworth-Heinemann, 2009, 1st Edition.
6. Nanomaterials: An Introduction to Synthesis, Properties and Applications by Dieter Vollath, Wiley-VCH, 2ndEdn, 2013, ISBN: 978-3-527-33379-0.
7. Introduction to Nanoscience. Oxford: OUP Oxford, 2009 by Stuart Lindsay, Oxford University Press.

Reference Books:

1. Nanoscale Materials in Chemistry edited by Kenneth J. Klabunde and Ryan M. Richards, 2ndedn, John Wiley and Sons, 2009.
2. Nanocrystalline Materials by A I Gusev and AARempel, Cambridge International Science Publishing, 1st Indian edition by Viva Books Pvt. Ltd. 2008.
3. Springer Handbook of Nanotechnology by Bharat Bhushan, Springer, 3rdedn, 2010.
4. Carbon Nanotubes: Synthesis, Characterization and Applications by Kamal K. Kar, Research Publishing Services; 1stedn, 2011, ISBN-13: 978-9810863975.

Course: Quantum Materials

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

Course Outcomes:

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

1. Demonstrate knowledge of quantum mechanics in relation to crystal materials and understanding of wave mechanics in one and three dimensions.
2. Understand the purely quantum mechanical idea of spin, and how to represent and visualize it.
3. Understand the basic properties of quantum magnetism and some initial knowledge in exotic quantum materials, such as superconducting materials.

Syllabus:

The foundational principles of quantum mechanics and their application to modern materials, failure of classical theories and the development of quantum theory, including the photoelectric effect, Compton scattering, and wave-particle duality. The Schrödinger equation in one and three dimensions, wave functions, eigenvalues and eigenfunctions, the uncertainty principle, quantum tunneling, and potential wells. The quantum theory - solids through the free electron model, lattice periodicity, Bloch's theorem, reciprocal lattices, Brillouin zones, and energy band formation. Quantum statistics including Fermi-Dirac and Bose-Einstein distributions, along with the concept of density of states and k-space. The quantum mechanical treatments of lattice vibrations (phonons), and their role in electrical, thermal, and optical properties of materials. Examine semiconductors, insulators, and conductors from a quantum perspective. Quantum magnetism is covered, including diamagnetism, paramagnetism, ferromagnetism, exchange interactions, and spin systems. Introduction to superconductivity, the Josephson effect, quantum wells, band-gap engineering, and emerging topics such as topological materials and quantum entanglement in condensed matter systems.

Textbooks/ Reference Books:

1. Eisberg, Robert M., and Robert Resnick. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles. Wiley, 1985. ISBN: 9780471873730.
2. Liboff, Richard L. Introductory Quantum Mechanics. Addison Wesley, 2002. ISBN: 9780805387148.
3. Gasiorowicz, Stephen. Quantum Physics. John Wiley & Sons, 2003. ISBN: 9780471429456.
4. Shankar, Ramamurti. Principles of Quantum Mechanics. Springer, 2008. ISBN: 9780306447907.
5. Dirac, Paul Adrien Maurice. The Principles of Quantum Mechanics. Clarendon Press, 2011. ISBN: 9780198520115.

6. Griffiths, David J. Introduction to Quantum Mechanics. Upper Saddle River, Pearson Prentice Hall, 2005. ISBN: 9780131118928.
7. Feynman, Richard P., Robert B. Leighton, and Matthew L. Sands. The Feynman Lectures on Physics. Addison Wesley, 1989. ISBN: 9780201500646.

Course: Simulation and Modelling

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

Course Outcomes:

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

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

Syllabus:

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

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

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

Textbooks:

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

References Books:

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

Course: Research Methodology

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

Course Outcome:

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

1. Formulate research problems by defining objectives, hypotheses, variables, and feasibility.
2. Synthesize literature using reproducible search and screening strategies.
3. Apply research ethics, authorship norms, compliance rules, and FAIR data practices.
4. Produce research outputs through ethical analysis, documentation, and dissemination.

Syllabus:

Unit	Contents	Lecture
01.	**Introduction to Research:** What is scientific research, objectives of research, motivation, types of research, research approaches, research methodology, significance of research, indications of good research	**04**
02.	**Designing a Problem:** Research problems, literature review, formulation of feasible problems, hypothesis, errors in problem selection, selection of variables	**06**
03.	**Methods- Simulations and Experiments:** Conventional approaches, selection of tools, setting up production, validation of results, performance analysis, sensitivity analysis, errors in measurements	**07**
04.	**Statistics and Uncertainty Quantification:** Data, importance of analyzing data, types of analyses, selection practices, statistics, sampling techniques, uncertainty quantification, errors analysis	**07**
05.	**RCR and Ethics:** Responsible conduct of research, IEC compliance, what is plagiarism, QRPs, generative A.I. in research	**05**
06.	**IPR, Research Ethics and Publishing:** Introduction to IPR, significance of IPR, types of IPR, recent developments, technical writing	**08**

Suggested learning resources:

1. Melville, S., & Goddard, W. (1996). Research methodology: An introduction for science & engineering students. Juta & Co.
2. Kothari, C. R. (2009). Research methodology: Methods and trends. New Age International Publishers.
3. Goddard, W., & Melville, S. (2001). Research methodology: An introduction (2nd ed.). Juta Academic.
4. Kumar, R. (2005). Research methodology: A step-by-step guide for beginners (2nd ed.). Sage Publications.
5. Sharma, S. D. (2001). Operational research. Kedar Nath Ram Nath & Co

SEMESTER – II

Course: Design and Selection of Materials (Open Elective)

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

Course Outcomes:

At the end of course, students will be able to

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

Syllabus:

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

Text Books:

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

Reference Books:

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

Course: Thermo-Mechanical Processing

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

Course Outcome:

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

1. Analyze and compare cold working methods and hot working methods for its impact on microstructure and mechanical properties.
2. Assess the impact of microstructure evolution during TMP on material properties.
3. Describe and apply SPD methods and evaluate their effects on material microstructure and mechanical properties.
4. Interpret workability, power dissipation, and instability maps for determining optimal TMP processing conditions.

Syllabus:

Introduction to Thermo-mechanical processing (TMP); importance in materials engineering. Stress-strain behavior and strain hardening. Slip and/or twinning, dislocation multiplication during deformation. Stored energy of cold work. Cold working methods and effects on properties. Hot working techniques (Forging, Rolling, Extrusion). Recovery, recrystallization, types of recrystallizations and grain growth. Severe plastic deformation methods (SPDs): Equal channel angular pressing (ECAP), Accumulated roll bonding, friction stir processing (FSP), high pressure torsion (HPT), microstructure evolution during SPDs, case studies. TMP effects on mechanical properties (strength, ductility). Industrial applications. Processing map: workability, power dissipation map, Instability map, processing map.

Reference Books:

1. Humphreys, F. J., and M. Hatherly. Recrystallization and Related Phenomena. Pergamon Press, 2004.
2. Prasad, Y.V.R.K., Rao, K.P., and Sasidhara, S. Hot Working Guide: A ompendium of Processing Maps. 2nd ed. Materials Park, OH: ASM International, 2015.
3. Callister, William D., and David G. Rethwisch. Materials Science and Engineering: An Introduction. 10th ed. Hoboken, NJ: Wiley, 2018.
4. Mishra, Rajiv S., Zonghua Liu, and Xueyun Zhang. Severe Plastic Deformation: Advances in Nanostructured Materials. CRC Press, 2014.
5. Verlinden, Bert, Julian Driver, Indradev Samajdar, and Roger Doherty. 2007. Thermo-Mechanical Processing of Metallic Materials. Vol. 11. Elsevier Science.

Course: Thermo-Mechanical Processing (Laboratory)

Course Code	MME-25008	**Scheme of Evaluation**	Weightage %
Teaching Plan	0-0-2-0=1	**CIE**	100
Credits	1		

Course Outcome:

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

1. Understand deformation behaviour of metals through tensile, cold working, and hot working experiments.
2. Analyze microstructural changes due to TMP using optical/SEM techniques.
3. Evaluate mechanical property variations using hardness mapping and tensile data.
4. Correlate thermo-mechanical processing routes with resulting microstructure and properties.

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

1. Tensile Testing and Determination of Stress–Strain Behaviour of Metals
2. Cold Rolling of Metal Sheets and Evaluation of Percentage Cold Work
3. Microstructural Examination of Cold-Worked Metals
4. Annealing Studies: Recovery, Recrystallization, and Grain Growth Analysis
5. Observation of Slip and Twinning in Deformed Metals Using Optical/SEM Techniques
6. Hardness Profiling and Mapping After Thermo-Mechanical Processing
7. Comparative Analysis of Mechanical Properties After Different TMP Routes
8. Hot Working Study: Hot Rolling/Hot Forging and Associated Property Changes
9. Industrial visit.

Course: Surface Coating Technology

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

Course Outcomes:

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

1. Understand the role of surface engineering in enhancing product performance.
2. Explain surface-dependent properties like mechanical, thermal, and optical behavior.
3. Describe major surface coating methods such as CVD, PVD, and electroplating.
4. Analyze how process parameters influence coating quality and performance.
5. Select appropriate coating methods based on application requirements.
6. Evaluate coating properties using standard testing and characterization techniques.

Syllabus Contents:

Significance of Surface engineered materials in modern engineering application, surface dependent engineering properties (mechanical, chemical, thermal, electrical, electronic, optical). Role of surface coating and surface modification technologies in obtaining required surface characteristics of a product. Various surface modification techniques (mechanically modified, thermally modified). Scope of their application. Different surface coating technologies: chemical vapour deposition, physical vapour deposition, electro deposition, electroless deposition, thermal spray process, coating deposition by wetting. Various process parameters controlling the yield of the coating and various surface properties of the coating. Criteria for selection of surface coating technology. Product oriented surface coating technology. Different coating systems and function of various elements of coating system. Substrate technology and its significance in obtaining high performance coating. Physical and mechanical characterization of the coating. Various methods for evaluating the performance of the coating.

Textbooks/ Reference Books:

1. J. R. Davis, Surface Engineering for Corrosion and Wear Resistance, 3rd ed. Materials Park, OH: ASM International, 2017.
2. P. M. Martin, Introduction to Surface Engineering and Functionally Engineered Materials. Hoboken, NJ: Wiley, 2009.
3. K. G. Budinski and M. K. Budinski, Surface Engineering, 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2010.
4. J. C. Riviere and S. Myhra, Eds., Handbook of Surface and Interface Analysis: Methods for Problem-Solving, 2nd ed. Boca Raton, FL: CRC Press, 2009.
5. E. Lugscheider, Ed., Surface Engineering of Materials: Principles, Equipment, Technologies. Boca Raton, FL: CRC Press, 1998.
6. S. Bose, Surface Engineering: Science and Technology. Boca Raton, FL: CRC Press, 2017.
7. L. Pawlowski, The Science and Engineering of Thermal Spray Coatings, 2nd ed. Hoboken, NJ: Wiley, 2008.

8. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd ed. Hoboken, NJ: Wiley, 2013.
9. R. Chattopadhyay, Advanced Surface Coating Techniques for Modern Industrial Applications. Berlin: Springer, 2011.
10. L. S. Newman, Electroplating and Electroforming: A Guide for the Craftsman. Bradley, IL: Lindsay Publications, 2005

Course: Fracture Mechanics

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

Course Outcome:

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

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

Syllabus:

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

Reference Books:

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

Course: Light Metals and Alloys

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

Course Outcome:

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

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

Syllabus:

Introduction: Definition, Characteristics, production of aluminum, production of magnesium, production of titanium, usage and economics, Recent trends, Thermodynamics and kinetics of solidification: homogeneous and heterogeneous nucleation, dendritic growth, solid/liquid Interface stability, Heat flow, heat evolution, shrinkage, macro and micro segregation, Recent advances in processing: Semi solid processing (SSP), Thixographic processing, Aluminum Alloys: Wrought Al Alloys: Designation and Tempers heat treatable and non-heat treatable alloys, Li containing alloys, joining. Special products- aircraft alloys, automotive alloys, packaging alloys, electrical conductor alloys, Cast Aluminium Alloys: Designations, tempers and characteristics, alloys based on Al-Si, Al-Cu, Al-Mg, Al-Zn-Mg systems, modification in Al-Si alloys, joining, Physical Metallurgy of Al Alloys: Work hardening and annealing, forming limit curves, textures, principles of age hardening, microalloying effects, hardening mechanisms, aging processes, mechanical behavior, corrosion behavior, Magnesium Alloys: Introduction to alloying behavior, alloy designations, Zr-free and Zr-containing alloys, wrought magnesium alloys, extrusion alloys, forging alloys, trends in applications of Mg alloys, electrochemical aspects, Titanium Alloys: Introduction and classification, basic principles of heat treatments, wrought and cast commercial titanium alloys, texture effects, surface treatments, engineering performance- tensile, creep, and fatigue behaviour, Applications- general application of Titanium Alloys, aerospace, power generation, automotive, marine, biomaterials.

Textbooks/ Reference Books:

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

Course: Amorphous Materials

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

Course Outcomes:

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

1. Distinguish between amorphous and crystalline materials.
2. Develop correlations between structure and properties.
3. Use the subject knowledge to fabricate application specific materials.

Syllabus:

Network structure of various oxide glasses, Stevel's parameters and kinetic criterion of glass formation, Role of oxides in glass composition, Melting, refining and forming of oxide glasses, Viscoelastic behaviour and mechanical properties, Thermal, dielectric and optical properties of glasses, Coloured and photosensitive glasses, glass fibre technology, Glass-ceramics and glasses for electronic applications, Preparation of metallic glasses by rapid solidification, Synthesis of amorphous alloys by mechanical alloying, Properties and applications of amorphous alloys, Microcrystalline and nanocrystalline materials.

Textbooks/ Reference Books:

1. H. Scholze, Glass: Nature, Structure and Properties, Springer-Verlag, New York, 1991.
2. J. Zarzycki, Glasses and the Vitreous State, Cambridge Univ. Press, 1991.
3. S.J. Schneider Jr., Ceramics and Glasses, Engineered Materials Handbook, Vol. 4, ASM Intl.,Ohio, 1991.
4. F.H. Froes and S.J. Savage (Eds.), Processing of Structural Metals by Rapid Solidification, ASMPub., Ohio, 1987.
5. H.H. Liebermann (Ed), Rapidly Solidified Alloys, Marcel Dekker Inc., New York, 1993.

Course: Crystallographic Texture in Materials

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

Course Outcome:

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

1. Understand the fundamentals of crystallographic texture and its representation.
2. Explain texture formation during various metal processing methods.
3. Analyze the effects of texture on anisotropy in materials properties.
4. Apply texture characterization techniques like XRD and EBSD.

Syllabus:

Concepts of texture in materials, their representation by pole figure and orientation distribution functions. Macro and Micro Texture measurement by X-ray diffraction, EBSD. Origin and development of textures during materials processing stages: solidification, deformation, annealing, phase transformation. Deformation microstructure and texture in FCC, BCC and HCP metals and alloys. Texture evolution during annealing, Influence of texture on mechanical, chemical and physical properties: Yield strength, ductility, fatigue, corrosion, stress corrosion cracking, magnetic and dielectric properties. Introduction to Grain boundaries in polycrystalline materials: LAGB, HAGB, cell/subgrain structure. Role of grain boundary character on interface-controlled properties (segregation, creep, fracture, sensitization). Concept of grain boundary engineering. Case studies.

Textbooks/ Reference Books:

1. M. Hatherly and W. B. Hutchinson, An Introduction to Texture in Metals (Monograph No. 5), The Institute of Metals, London
2. V. Randle, and O. Engler, Introduction to Texture Analysis: Macrotexture, Microtexture and Orientation mapping, Gordon and Breach Science Publishers
3. S. Suwas, and R. K. Ray, Crystallographic Texture of Materials, Springer-Verlag
4. F. J. Humphreys, and M. Hatherly, Recrystallization and Related Phenomenon, Pergamon Press
5. P. E. J. Flewitt, and R. K. Wild, Grain Boundaries

Course: High Temperature Corrosion

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

Course Outcomes:

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

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

Syllabus:

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

Textbooks/ Reference Books:

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

Course: Semiconductor Materials

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

Course Outcome:

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

1. Understand the fundamental crystal structures and electronic band theory of various semiconductor materials.
2. Explain the behavior of charge carriers and different transport mechanisms in intrinsic and extrinsic semiconductors.
3. Analyze the role of defects and doping in controlling semiconductor properties.
4. Describe various techniques used for growing semiconductor crystals and processing wafers.
5. Apply key characterization techniques to analyze the electrical, structural, compositional, and optical properties of semiconductors.
6. Discuss the applications of semiconductors in electronic and optoelectronic devices and explore emerging semiconductor technologies.

Syllabus:

Basics of Semiconductors: Crystal structures: Zinc blende, Wurtzite, Diamond structures, Classification: Elemental (Si, Ge), Compound (GaAs, InP, ZnO), Organic semiconductors, Band theory, band gap (direct vs indirect), Fermi level, effective mass, Charge Carriers and Transport: Intrinsic and extrinsic semiconductors, Carrier generation and recombination, Carrier mobility and conductivity, Hall effect and measurement of carrier concentration, Defects and Doping: Point defects, dislocations, and their effect on semiconductor properties, Diffusion and implantation doping techniques, Compensation and degenerate semiconductors, Material Growth and Processing: Crystal growth techniques: Czochralski, Bridgman, MBE, MOCVD, Wafer preparation, slicing, polishing, cleaning, Thin film deposition: sputtering, evaporation, ALD, Characterization Techniques: Electrical: 4-point probe, Hall measurement, Structural: XRD, TEM, SEM, AFM, Compositional: EDS, SIMS, XPS, Optical: UV-Vis, photoluminescence, Applications and Emerging Topics, Semiconductors in electronic and optoelectronic devices, Photovoltaic materials and solar cells, Wide band gap semiconductors (GaN, SiC), 2D semiconductors (MoS_2, graphene), nanostructured semiconductors

Textbooks:

1. S. M. Sze and K. K. Ng, Physics of Semiconductor Devices, 3rd ed., Wiley, 2007.
2. B. G. Streetman and S. K. Banerjee, Solid State Electronic Devices, 7th ed., Pearson, 2014.
3. U. Mishra and J. Singh, Semiconductor Device Physics and Design, Springer, 2008.

Reference Books:

1. S. O. Kasap, Principles of Electronic Materials and Devices, 4th ed., McGraw-Hill, 2017.
2. J. Singh, Semiconductor Devices: Basic Principles, Wiley, 2000.
3. C. Kittel, Introduction to Solid State Physics, 8th ed., Wiley, 2004.
4. R. F. Pierret, Semiconductor Device Fundamentals, Addison Wesley, 1996.

Course: Smart Materials and Structures

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

Course Outcome:

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

1. Analyze smart materials properties for vibration control and sensing applications.
2. Develop models to simulate smart composites.
3. Create smart actuator/sensor designs for active shape control and sensing.

Syllabus:

Overview of smart materials, Piezoelectric Ceramics, Piezo-polymers, Magnetostrictive Materials, Electroactive Polymers, Shape Memory Alloys, Electro and Magneto Rheological Fluids, Modelling of smart materials, introduction to composite smart materials, Mechanics of smart composite materials, Smart sensors based on high bandwidth low strain smart materials, Low-bandwidth high strain smart actuators, Micro-electro mechanical Smart Systems, Intelligent devices based on smart materials, Applications of Smart Actuators: Active and Hybrid Vibration Control, Active Shape Control, Distributed Sensing and Control of Smart Beams.

Textbooks/ Reference Books

1. Brian Culshaw, Smart Structures and Materials, Artech House, 2000
2. Gauenzi, P., Smart Structures, Wiley, 2009
3. Cady, W. G., Piezoelectricity, Dover Publication

Course: Laboratory Practice-II

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

Laboratory Outcome:

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

List of Experiments/Assignments: (Any 8 to be performed)

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

Course: Technical Communication Skills

Course Code	SET-25002	Scheme of Evaluation	Weightage %
Teaching Plan	1-0-2-1 = 2	**CIE**	100
Credits	2		

Course Outcomes (COs):

After successful completion of the course, students will be able –

1. To produce effective dialogue for business related situations.
2. To use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively.
3. To analyze critically different concepts / principles of communication skills.
4. To demonstrate productive skills and have a knack for structured conversations.
5. To appreciate, analyze, evaluate business reports and research papers.

Syllabus:

Fundamentals of Communication: 7 Cs of communication, common errors in English, enriching vocabulary, styles and registers. Aural-Oral Communication: The art of listening, stress and intonation, group discussion, oral presentation skills. Reading and Writing: Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers.

Reference Books:

1. Raman Sharma, "Technical Communication", Oxford University Press. Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press.
2. Mark Hancock "English Pronunciation in Use" Cambridge University Press.
3. Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentise Hall.
4. Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non- native speakers of English", McGraw Hill.

SEMESTER – III

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

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

Dissertation Phase-I

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

Course Outcome:

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

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

Guidelines:

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

SEMESTER – IV

Dissertation Phase-II

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

Course Outcome:

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

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

Guidelines:

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