BACHELOR OF TECHNOLOGY

METALLURGICAL ENGINEERING / METALLURGY & MATERIALS ENGINEERING

THIRD YEAR (SIXTH SEMESTER)

W.E.F. ADMISSION BATCH 2023-24

Sl. No.	Category	Course Code	Course	Contact Hrs. L-T-P	Credit	University Marks	Internal Evaluation
			Subject (Theory)				
1	PC	MTPC3004	Joining of Metals	3-0-0	3	100	50
2	PC	MTPC3005	Characterization of Materials	3-0-0	3	100	50
3	PE	MTPE3004	Corrosion and Environmental Degradation of Materials	3-0-0	3	100	50
		MTPE3005	High Temperature Materials				
		MTPE3006	Mechanical Working of Materials				
		-	-				
		-	-				
		-	-				
		-	-				
4	PE	MTPE3007	Metallurgical Failure : Detection and Analysis	3-0-0	3	100	50
		MTPE3008	Composite Materials				
		MTPE3009	Nano-Structured Materials				
		-	-				
		-	-				
		-	-				
		-	-				
5	HS	HSHS3002	Entrepreneurship Development	3-0-0	2	100	50
		HSHS3001	Business Management				
6	MC	MCMC3002	Industrial Safety Engineering	3-0-0	2	100	50
		MCMC3001	Environmental Engineering				
			Subject (Sessional / Practical)				
7	PSI	CSPS3202	Project for Product Development - I	0-0-6	3	-	100
8	PC	MTPC3204	Joining of Metals Laboratory	0-0-3	1.5	-	100
9	PC	MTPC3205	Characterization of Materials Laboratory	0-0-3	1.5	-	100
			Total	**18-0-12**	**22**	**600**	**600**

NB : Minimum 4 weeks of Summer Internship and Research Experience-II (SIRE-II) after 6th Semester during the vacation.

Click here to view/download the syllabus of the subjects.

MCMC3002 INDUSTRIAL SAFETY ENGINEERING (3-0-0)

Course Objectives:
1. Students will be able to recognize and evaluate occupational safety and health hazards in the workplace, and to determine appropriate hazard controls following the hierarchy of controls.
2. Students will furthermore be able to analyze the effects of workplace exposures, injuries and illnesses, fatalities and the methods to prevent incidents using the hierarchy of controls, effective safety and health management systems and task-oriented training.

Course Outcomes:
By the end of this course, a student should:
CO1: Evaluate workplace to determine the existence of occupational safety and health hazards
CO2: Identify relevant regulatory and national consensus standards along with best practices that are applicable.
CO3: Select appropriate control methodologies based on the hierarchy of controls
CO4: Analyze injury and illness data for trends

Module-I: (07 hrs)
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Module-II: (07 hrs)
Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Module-III: (07 hrs)
Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Module-IV: (07 hrs)
Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault-finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Module-V: (08 hrs)
Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Books:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, McGraw Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

HSHS3001 BUSINESS MANAGEMENT (3-0-0)

Course Objectives

By the end of this course, students will be able to:

- Understand fundamental management principles
- Learn project management techniques and its application
- Understand the financial aspects of engineering decisions
- Demonstrate leadership, communication, and team management skills
- Understand the basics of entrepreneurship and innovation management

Module-I: Management Foundations and Organizational Dynamics

Introduction to Management: Functions of Management; Evolution of management thought and its relevance to engineering; Management vs. Leadership: Key distinctions; Decision-making processes; Organizational design and structure; Team dynamics and group behaviour; Motivation theories and their application to technical teams; Organizational Communication; Cultural considerations in global business environment

Module-II: Project Management and Financial Decision Making

Project lifecycle and phases; Work breakdown structure and scheduling; Resource allocation and budgeting; Risk management in engineering projects; Quality management and control; Basic financial statements and their interpretation; Time value of money; Budgeting and cost control; Return on investment (ROI) and net present value (NPV); Funding sources for engineering projects; Cost-benefit analysis for technical decisions

Module-III: Leadership, Innovation and Entrepreneurship

Leadership styles and their effectiveness; Managing technical teams and professionals; Performance management and feedback; Recruitment and selection in engineering roles; Training and development of technical staff; Ethical leadership in engineering; Innovation management; Technology transfer and commercialization; Startup fundamentals; Intellectual property basics; Business model development

Course Outcomes

CO1: Recall fundamental management principles, organizational theories, and project management methodologies, key financial concepts used in engineering decision-making.

CO2: Explain the relationship between management functions (planning, organizing, leading, controlling) and their application.

CO3: Demonstrate project management skills and apply financial analysis techniques for decision making.

CO4: Analyse organizational behaviour patterns, team dynamics, and performance issues in engineering management contexts.

CO5: Judge ethical implications of management decisions and leadership actions in professional engineering practice.

CO6: Create integrated management solutions for solving complex business problems.

Reference Books:

1. Management Theory and Practice" by C.B. Gupta
2. Essentials of Management" by Koontz, Weihrich, and Aryasri (Indian Edition)
3. Project Management for Engineering and Technology" by N.K. Sharma
4. Financial Management: Theory and Practice" by Prasanna Chandra
5. Organizational Behaviour" by Aswathappa K.
6. Human Resource Management" by V.S.P. Rao
7. Entrepreneurship Development" by S.S. Khanka
8. Operations Management" by R. Panneerselvam

MTPE3009 NANO-STRUCTURED MATERIALS (3-0-0)

Objectives of the Course:
The course aims to introduce students to the science, synthesis, characterization, and applications of nanostructured materials. It focuses on understanding how materials behave differently at the nanoscale due to their high surface-to-volume ratio, quantum effects, and unique mechanical, electrical, and optical properties. Students will learn about bottom-up and top-down fabrication methods, characterization techniques, and industrial applications of nanomaterials in metallurgy, electronics, energy, and biomaterials.

Module – I: (06 hours)
Introduction to Nanostructured Materials
Historical background and evolution of nanoscience. Definition and classification of nanomaterials — nanoparticles, nanowires, nanotubes, thin films, and nanocomposites. Significance of nanoscale dimensions and surface phenomena. Thermodynamic and kinetic considerations at nanoscale. Applications and challenges in the synthesis and utilization of nanomaterials.

Module – II: (06 hours)
Synthesis and Fabrication Techniques
Top-down approaches: mechanical attrition, high-energy ball milling, lithography, etching. Bottom-up approaches: sol-gel process, chemical vapor deposition (CVD), physical vapor deposition (PVD), electrodeposition, and self-assembly. Gas-phase synthesis: inert gas condensation, laser ablation, and plasma methods. Biological synthesis of nanoparticles. Thin film deposition and nanocoating technologies.

Module – III: (06 hours)
Characterization of Nanomaterials
Particle size and surface area analysis — BET method, dynamic light scattering (DLS). Structural analysis — X-ray diffraction (XRD) and Rietveld refinement. Electron microscopy — SEM, TEM, HRTEM, and AFM for morphological and lattice imaging. Compositional analysis — EDS, XPS, AES. Raman spectroscopy, UV–Vis spectroscopy, and photoluminescence for optical characterization.

Module – IV: (06 hours)
Properties and Behavior of Nanostructured Materials
Mechanical properties — hardness, strength, ductility, and deformation mechanisms in nanomaterials. Electrical and magnetic behavior — conductivity, tunneling, giant magnetoresistance (GMR), and superparamagnetism. Optical properties — absorption, photoluminescence, and colour variations. Thermal stability and sintering characteristics of nanomaterials. Diffusion, grain growth, and coarsening at the nanoscale.

Module – V: (06 hours)
Applications, Challenges, and Future Prospects
Nanostructured coatings and thin films for wear and corrosion resistance. Nanocomposites for lightweight and high-strength applications. Nanomaterials in catalysis, sensors, energy storage (Li-ion batteries, supercapacitors), and hydrogen storage. Biomedical applications — drug delivery, implants, and biosensors. Environmental and safety concerns in nanomaterials handling. Recent developments: graphene, carbon nanotubes (CNTs), and 2D materials.

Course Outcomes:
After completing this course, the student will be able to:
CO1: Explain the fundamental concepts, structure, and unique properties of nanostructured materials.
CO2: Compare different synthesis routes and evaluate their influence on material characteristics.
CO3: Select appropriate characterization tools for nanoscale structure and property analysis.
CO4: Correlate nanoscale phenomena with macroscopic material behavior.
CO5: Identify applications and challenges of nanomaterials in engineering, energy, and healthcare fields.

Books:

1. C. P. Poole Jr. & F. J. Owens. Introduction to Nanotechnology, Wiley.
2. B. S. Murty, P. Shankar, B. Raj, B. B. Rath & J. Murday. Textbook of Nanoscience and Nanotechnology, Springer.
3. M. A. Ratner & D. Ratner. Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson Education.

Reference Books:

1. G. Cao & Y. Wang. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, World Scientific.
2. S. K. Kulkarni. Nanotechnology: Principles and Practices, Springer.
3. Rodney S. Ruoff & David C. Lorents. Fullerenes and Carbon Nanotubes, Academic Press.
4. Mark Ratner & Daniel Ratner. Nanotechnology: The Science of the Small, Oxford University Press.

Digital Learning Resources:

Course Name: Introduction to Nanomaterials and Nanotechnology
Course Link: https://nptel.ac.in/courses/118/104/118104008
Course Instructor: Prof. Tapas Kumar Mandal, IIT Kharagpur
Course Name: Nanostructured Materials: Synthesis, Properties, and Applications
Course Link: https://nptel.ac.in/courses/113/106/113106098
Course Instructor: Prof. K. Chattopadhyay, IISc Bangalore

MTPE3008 COMPOSITE MATERIALS (3-0-0)

Objectives of the Course:
This course aims to introduce students to the principles, fabrication methods, properties, and applications of composite materials used in advanced engineering systems. It focuses on the structure–property relationships, reinforcement mechanisms, and processing techniques of fiber-reinforced, particle-reinforced, and laminated composites. Emphasis is given to metal, polymer, and ceramic matrix composites, their mechanical behavior, testing, and industrial relevance in aerospace, automotive, marine, and defense sectors.

Module – I: (06 hours)
Introduction and Fundamentals
Definition and classification of composite materials. Historical development and importance of composites in modern engineering. Comparison between composites and conventional engineering materials (metals, ceramics, polymers). Components of a composite: matrix, reinforcement, and interface. Role of reinforcement and matrix — load transfer, stiffness, and toughness improvement. Advantages, limitations, and areas of application.

Module – II: (06 hours)
Reinforcements and Matrices
Types of reinforcements: fibers, whiskers, and particles. Fiber materials — glass, carbon, aramid, boron, silicon carbide, alumina fibers. Fiber properties, orientation, and aspect ratio effects. Matrices: polymer, metal, and ceramic matrices — properties and selection criteria. Interface characteristics — bonding, wettability, and chemical stability.

Module – III: (06 hours)
Processing and Fabrication Techniques
Polymer Matrix Composites (PMCs): hand lay-up, spray-up, filament winding, pultrusion, resin transfer molding (RTM), and compression molding. Metal Matrix Composites (MMCs): powder metallurgy route, stir casting, squeeze casting, diffusion bonding, and infiltration methods. Ceramic Matrix Composites (CMCs): sol-gel, slurry infiltration, hot pressing, and chemical vapor infiltration (CVI). Fabrication of laminated composites. Processing parameters, defects, and quality control.

Module – IV: (06 hours)
Mechanical Behavior and Testing
Stress–strain behavior and failure modes of composites. Rule of mixtures and micromechanical analysis. Longitudinal and transverse modulus and strength of unidirectional composites. Mechanical testing — tensile, flexural, impact, hardness, and interlaminar shear strength tests. Environmental effects — temperature, humidity, and radiation.

Module – V: (06 hours)
Applications and Recent Developments
Hybrid composites and sandwich panels. Tribological behavior and wear resistance. Applications in aerospace, marine, automotive, defense, and biomedical fields. Nanocomposites and smart composites — concept and future trends.

Course Outcomes:
After completing this course, the student will be able to:
CO1: Explain the structure, classification, and roles of various components in composite materials.
CO2: Analyze the mechanical behavior of composites using micromechanical and macromechanical models.
CO3: Evaluate different fabrication methods for polymer-, metal-, and ceramic-matrix composites.
CO4: Perform testing and analysis to determine the strength, stiffness, and durability of composites.

Books:

1. K. K. Chawla. Composite Materials: Science and Engineering, Springer.
2. M. F. Ashby & D. R. H. Jones. Engineering Materials Vol. II: An Introduction to Microstructures, Processing and Design, Elsevier.
3. D. Hull & T. W. Clyne. An Introduction to Composite Materials, Cambridge University Press.

Reference Books:

1. R. M. Jones. Mechanics of Composite Materials, Taylor & Francis.
2. A. Kelly & C. Zweben. Comprehensive Composite Materials, Elsevier.
3. Bhattacharya, S. K. Metal Matrix Composites, Narosa Publishing House.
4. Agarwal, B. D., Broutman, L. J., & Chandrashekhara, K. Analysis and Performance of Fiber Composites, Wiley.

Digital Learning Resources:

Course Name: Introduction to Composite Materials
Course Link: https://nptel.ac.in/courses/112/104/112104319
Course Instructor: Prof. K. Gopalakrishnan, IIT Madras
Course Name: Composite Materials
Course Link: https://nptel.ac.in/courses/112/107/112107292
Course Instructor: Prof. S. Suwas, IISc Bangalore

MTPE3007 METALLURGICAL FAILURE: DETECTION AND ANALYSIS (3-0-0)

Objectives of the Course:

The course aims to familiarize students with the principles, methodologies, and tools used to detect, analyze, and interpret metallurgical failures in engineering components and structures. It emphasizes the relationship between material properties, manufacturing processes, service conditions, and failure mechanisms. Students will learn the systematic approach to failure analysis, covering fracture, fatigue, creep, corrosion, and wear-related failures, along with modern characterization and preventive design techniques used in industries.

Module – I: (06 hours)

Introduction to Failure Analysis

Importance and scope of failure analysis in engineering practice. Classification of failures — ductile, brittle, fatigue, creep, corrosion, and wear. General procedure for failure analysis — data collection, visual inspection, and background study. Steps in a systematic failure investigation.

Module – II: (06 hours)

Fracture Mechanisms and Fractography

Principles of fracture mechanics — stress intensity factor (K), critical stress, and fracture toughness. Ductile fracture — nucleation, growth, and coalescence of voids. Brittle fracture — cleavage, intergranular, and transgranular fracture modes. Transition temperature and impact testing (Charpy, Izod). Fractography: optical and electron microscopic examination of fracture surfaces. Identification of overload, fatigue, and stress-corrosion features using fractography.

Module – III: (06 hours)

Fatigue and Creep Failures

Fatigue — mechanisms, crack initiation and propagation, S–N curves, and mean stress effects. Low-cycle and high-cycle fatigue behavior. Surface and environmental effects on fatigue life. Creep — time-dependent deformation, stages, and fracture. Stress-rupture and Larson–Miller parameter analysis. Creep-fatigue interaction and metallurgical changes under prolonged service. Case studies of fatigue and creep failures in aerospace and power plant components.

Module – IV: (06 hours)

Corrosion, Wear, and Environmental Failures

Corrosion-induced failures: stress-corrosion cracking (SCC), hydrogen embrittlement, intergranular attack. Hot corrosion and oxidation failures. Wear failures — adhesive, abrasive, erosive, and fretting wear. Synergistic effects of wear and corrosion. Case studies: pipelines, marine structures, turbine blades, and chemical process equipment. Preventive measures — material selection, coatings, and environmental control.

Module – V: (06 hours)

Failure Detection Techniques and Prevention

Non-destructive testing (NDT): radiography, ultrasonic, magnetic particle, dye penetrant, eddy current, and acoustic emission methods. Metallographic examination — optical microscopy, SEM, and microhardness analysis. Chemical and compositional analysis — EDS, XRD, and spectroscopy. Residual stress measurement and hardness mapping. Industrial case studies — aircraft components, pressure vessels, and welded joints.

Course Outcomes:

After completing this course, the student will be able to:

CO1: Explain the systematic procedure for detecting and analyzing metallurgical failures.
CO2: Identify various failure mechanisms such as fatigue, fracture, creep, corrosion, and wear.
CO3: Apply appropriate testing and characterization techniques to determine root causes of failure.
CO4: Interpret fractographic and metallographic evidence to correlate microstructure with failure behavior.
CO5: Recommend preventive measures through improved material selection, design, and maintenance practices.

Books:

1. ASM Handbook, Volume 11. Failure Analysis and Prevention, ASM International.
2. S. A. Bradford. Failure Analysis and Prevention, McGraw-Hill Education.
3. Dieter, G. E. Mechanical Metallurgy, McGraw-Hill Education.

Reference Books:

1. Colangelo, V. J. & Heiser, F. A. Analysis of Metallurgical Failures, Wiley-Interscience.
2. J. E. Hatch. Aluminum: Properties and Physical Metallurgy, ASM International (for case examples).
3. Boyle, G. & Xu, W. Forensic Engineering: Damage Assessment and Failure Analysis, Elsevier.
4. Broek, D. Elementary Engineering Fracture Mechanics, Springer.

Digital Learning Resources:

Course Name: Failure Analysis of Engineering Components
Course Link: https://nptel.ac.in/courses/113/105/113105099
Course Instructor: Prof. A. K. Ghosh, IIT Kanpur
Course Name: Fracture and Fatigue of Materials
Course Link: https://nptel.ac.in/courses/113/106/113106068
Course Instructor: Prof. K. Bhanu Sankara Rao, IIT Madras

MTPE3006 MECHANICAL WORKING OF MATERIALS (3-0-0)

Objectives of the Course:
The course aims to provide students with a comprehensive understanding of the principles, mechanisms, and technologies involved in the mechanical working and deformation of materials. It focuses on plastic deformation behavior, hot and cold working processes, and the relationship between processing parameters, microstructure, and mechanical properties. The objective is to develop an understanding of how industrial forming operations — such as rolling, forging, extrusion, drawing, and sheet-metal forming — are designed and optimized for various materials.

Module – I: (06 hours)
Fundamental of metalworking
Classification of forming process, mechanics of metalworking, Flow stress deformation, temperature in metalworking, strain rate effect, metallurgical structure, friction and lubrication, deformation zone geometry, hydrostatic pressure, workability, residual stress, experimental technique for metalworking process, computer-aided metalworking

Module – II: (06 hours)
Forging
Classification of forging process, forging equipment, forging in plain strain, open die forging, closed die forging, calculation of loads in closed die forging. Forging defects, powder metallurgy forging, residual stress in forging.

Module – III: (06 hours)
Rolling and Extrusion Process
Classification of rolling process, rolling mills, Hot and cold rolling , Rolling bars and shape, forces and geometrical relationship in rolling, simplified analysis of rolling load: rolling variables, problem and defects in rolling products, rolling mill control, theories of cold rolling, theories of hot rolling, torque and horsepower, Classification of extrusion, extrusion equipment, hot extrusion, deformation, lubrication and defects, cold extrusion and cold forming, hydrostatic extrusion, extrusion of tubing, production of seamless of pipe and tubing.

Module – IV: (06 hours)
Drawing and Sheet Metal Forming
Wire drawing and tube drawing processes — principle, mechanics, and die design. Sheet metal forming operations: bending, deep drawing, stretching, spinning, and shearing. Forming limit diagrams and spring back behaviour. Deep drawing defects and remedies. Hydroforming and superplastic forming. Influence of material anisotropy and strain rate on formability.

Module – V: (06 hours)
Advanced Working Processes and Industrial Applications
High strain rate forming — explosive, electrohydraulic, and electromagnetic forming. Thermo-mechanical processing (TMP) — concept, objectives, and benefits. Hot working of steels, aluminium, copper, and titanium alloys. Modern metal forming equipment and automation defects, and inspection in worked materials.

Course Outcomes:
After completing this course, the student will be able to:
CO1: Explain the fundamentals of plastic deformation and the principles of metal forming.
CO2: Analyze the process parameters influencing rolling, forging, extrusion, and drawing operations.
CO3: Evaluate the effects of working temperature, strain rate, and microstructure on mechanical behavior.
CO4: Identify and prevent defects in formed products through proper process design.
CO5: Apply advanced and thermo-mechanical forming methods in industrial contexts.

Books:

1. Dieter, G. E. Mechanical Metallurgy, McGraw-Hill Education.
2. H. J. Avner. Introduction to Physical Metallurgy, McGraw-Hill Education.
3. K. L. Narayan. Metal Forming Technology, New Age International Publishers.

Reference Books:

1. Hosford, W. F. & Caddell, R. M. Metal Forming: Mechanics and Metallurgy, Cambridge University Press.
2. Polakowski, N. N. & Ripling, E. J. Strength and Structure of Engineering Materials, McGraw-Hill.
3. Kalpakjian, S. & Schmid, S. R. Manufacturing Processes for Engineering Materials, Pearson.
4. Ghosh, A. & Mallik, A. K. Manufacturing Science, Affiliated East-West Press.

Digital Learning Resources:

Course Name: Metal Forming
Course Link: https://nptel.ac.in/courses/112/105/112105125
Course Instructor: Prof. S. K. Biswas, IIT Kanpur
Course Name: Principles of Metal Forming
Course Link: https://nptel.ac.in/courses/112/107/112107297
Course Instructor: Prof. N. S. Das, IIT Kharagpur

MTPE3005 HIGH TEMPERATURE MATERIALS (3-0-0)

Objectives of the Course:
This course aims to provide students with a comprehensive understanding of materials used in high-temperature environments, such as aerospace, power generation, nuclear reactors, and metallurgical processing industries. It focuses on the mechanical behavior, oxidation, corrosion, and design principles of materials that retain strength and stability at elevated temperatures. The course also emphasizes the thermodynamic and kinetic principles governing high-temperature degradation, and the development of superalloys, ceramics, and composites for advanced engineering applications.

Module – I: (06 hours)
Introduction to High-Temperature Materials
Importance of high-temperature materials in engineering applications. Classification: metals, ceramics and composites. Temperature regimes and stress conditions for high-temperature operation. Phenomena at elevated temperatures: creep, diffusion, and oxidation.

Module – II: (06 hours)
Creep and Deformation Mechanisms
Definition and significance of creep. Stages of creep — primary, secondary, and tertiary. Creep curve analysis and mechanisms: dislocation creep, diffusion creep, and grain boundary sliding. Stress and temperature dependence of creep rate. Creep testing methods and data interpretation. Creep-resistant materials.

Module – III: (06 hours)
High-Temperature Alloys and Composites
Steels for high-temperature service: ferritic, austenitic, and heat-resistant steels. Superalloys — classification (Ni-based, Co-based, Fe-based) and composition. Dispersion-strengthened alloys and oxide-dispersion-strengthened (ODS) materials. High-temperature ceramics: SiC, Si_3N_4, ZrO_2 — structure, properties, and limitations. Ceramic–matrix composites for high-temperature applications.

Module – IV: (06 hours)
Oxidation and Hot Corrosion
Fundamentals of oxidation — thermodynamics, kinetics, and rate laws. Parabolic and linear oxidation behavior. Mechanisms of protective and non-protective oxide formation. Factors affecting oxidation resistance. Hot corrosion in gas turbines and boilers — Type I and Type II corrosion.

Module – V: (06 hours)
Protective Coatings and Applications
Types of protective coatings: metallic, ceramic, and diffusion coatings. Thermal barrier coatings (TBCs). Physical vapor deposition (PVD) and chemical vapor deposition (CVD) processes. Case studies: jet engine turbine blades, reformer tubes, and nuclear reactor components.

Course Outcomes:
After completing this course, the student will be able to:
CO1: Explain the mechanical and thermodynamic principles governing materials behavior at high temperatures.
CO2: Analyze creep mechanisms and high-temperature deformation processes.
CO3: Describe the composition, structure, and strengthening mechanisms of superalloys and ceramics.
CO4: Evaluate oxidation and hot corrosion phenomena and propose prevention techniques.
CO5: Select suitable materials and coatings for high-temperature engineering applications.

Books:
1. Raj, R. & Ashby, M. F. Processing and Design for High Temperature Materials, Pergamon Press.
2. Courtney, T. H. Mechanical Behavior of Materials, McGraw-Hill Education.
3. R. Viswanathan. Damage Mechanisms and Life Assessment of High Temperature Components, ASM International.

Reference Books:
1. P. Kofstad. High Temperature Oxidation of Metals, Wiley-Interscience.
2. C. T. Sims, N. S. Stoloff, & W. C. Hagel. Superalloys II: High-Temperature Materials for Aerospace and Industrial Power, Wiley.
3. Boyer, H. E. Atlas of Creep and Stress-Rupture Curves, ASM International.
4. Dieter, G. E. Mechanical Metallurgy, McGraw-Hill Education.

Digital Learning Resources:
Course Name: High Temperature Materials

Course Link: https://nptel.ac.in/courses/113/106/113106097
Course Instructor: Prof. G. P. Tiwari, IIT Roorkee
Course Name: Creep, Fatigue and Fracture of Materials
Course Link: https://nptel.ac.in/courses/113/107/113107151
Course Instructor: Prof. K. Bhanu Sankara Rao, IIT Madras

MTPE3004 CORROSION AND ENVIRONMENTAL DEGRADATION OF MATERIALS (3-0-0)

Objectives of the Course:
The course aims to familiarize students with the fundamental principles of corrosion and environmental degradation of materials. It emphasizes the thermodynamic and kinetic aspects of corrosion, types and mechanisms of degradation, and methods for prevention and control. The course also focuses on industrial corrosion issues, corrosion testing, and materials selection for enhanced durability and sustainability in engineering applications.

Module – I: (06 hours)
Introduction to Corrosion and Thermodynamics of Corrosion
Definition and importance of corrosion in engineering applications. Electrochemical nature of corrosion; distinction between chemical and electrochemical corrosion. Thermodynamics of corrosion: free energy changes, electromotive force series, Pourbaix (potential–pH) diagrams. Concept of corrosion rate and its measurement. Factors influencing corrosion rate: temperature, medium, and metal composition.

Module – II: (06 hours)
Kinetics and Mechanisms of Corrosion
Electrochemical kinetics: polarization, activation, and concentration polarization. Mixed potential theory. Types of corrosion: uniform, galvanic, pitting, crevice, intergranular, selective leaching, erosion-corrosion, stress corrosion cracking, and hydrogen embrittlement. Corrosion under different environments — atmospheric, aqueous, soil, and high-temperature oxidation.

Module – III: (06 hours)
Corrosion Testing and Evaluation
Laboratory methods for corrosion rate measurement. Potentiodynamic polarization and electrochemical impedance spectroscopy. Weight loss tests. Surface examination and analysis techniques.

Module – IV: (06 hours)
Prevention and Control of Corrosion
Material selection and design considerations. Protective coatings: metallic, inorganic, and organic coatings. Cathodic and anodic protection methods. Inhibitors and environmental modification. Surface engineering techniques: carburizing, nitriding, cladding, and thermal spraying.

Module – V: (06 hours)
Environmental Degradation and Case Studies
High-temperature oxidation and scaling of metals and alloys. Corrosion in specific environments — marine, industrial, and biological. Corrosion in power plants, chemical industries, and refineries. Sustainability and corrosion economics.

Course Outcomes:
After completing this course, the student will be able to:
CO1: Explain the thermodynamic and kinetic principles governing corrosion and oxidation processes.
CO2: Identify and analyze different types of corrosion and environmental degradation mechanisms.
CO3: Evaluate corrosion testing methods and interpret results for material performance.
CO4: Recommend suitable prevention and protection techniques for industrial applications.
CO5: Analyzing environment degradation mechanism

Books:

1. Fontana, M. G. Corrosion Engineering, McGraw-Hill Education.
2. Uhlig, H. H., and Revie, R. W. Corrosion and Corrosion Control, Wiley.
3. Raj Narayan. An Introduction to Metallic Corrosion and Its Prevention, Oxford & IBH.

Reference Books:

1. Trethewey, K. R., and Chamberlain, J. Corrosion for Students of Science and Engineering, Longman.
2. Jones, D. A. Principles and Prevention of Corrosion, Prentice Hall.
3. Schweitzer, P. A. Corrosion and Corrosion Protection Handbook, CRC Press.

Digital Learning Resources:

Course Name: Corrosion Failures and Control
Course Link: https://nptel.ac.in/courses/113/106/113106152
Course Instructor: Prof. K. Balasubramanian, IIT Madras
Course Name: Environmental Degradation of Materials
Course Link: https://nptel.ac.in/courses/113/107/113107151
Course Instructor: Prof. S. K. Bhaumik, IIT Kanpur

MTPC3004 JOINING OF METALS (3-0-0)

Objectives of the Course:

This course aims to introduce students to the science and technology of material joining processes used in engineering and manufacturing industries. It focuses on the fundamental principles, metallurgical aspects, process parameters, and joint performance of various joining techniques. Emphasis is given to welding, brazing, soldering, and adhesive bonding — along with advancements in solid-state and fusion joining technologies. The objective is to enable students to select suitable joining methods for specific materials and applications while ensuring quality, safety, and cost efficiency.

Module – I: (06 hours)

Introduction to Material Joining and Welding Fundamentals

Importance and classification of joining processes. Comparison between mechanical fastening, welding, brazing, and adhesive bonding. Basic welding terms and definitions. Fundamental principles of fusion welding: heat source, energy transfer, and cooling rates. Welding metallurgy — microstructure evolution, heat-affected zone (HAZ), and residual stresses.

Module – II: (06 hours)

Fusion Welding Processes

Arc welding processes: Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW/MIG), Gas Tungsten Arc Welding (GTAW/TIG). Submerged Arc Welding (SAW), Electroslag, and Plasma Arc Welding. Power sources and current characteristics. Oxy-fuel gas welding principles and applications. Defects in welded joints – causes, types, and preventive measures.

Module – III: (06 hours)

Solid-State Welding and Other Joining Techniques

Principles of solid-state welding: Friction welding, Friction Stir Welding (FSW), Diffusion bonding, Ultrasonic welding, Cold pressure welding. Resistance welding – spot, seam, projection, and flash butt welding. Thermite welding and explosion welding. Metallurgical aspects and applications of solid-state processes. Comparison between fusion and solid-state joining.

Module – IV: (06 hours)

Brazing, Soldering, and Adhesive Bonding

Principles of brazing and soldering; differences and similarities. Filler materials, fluxes, and joint design. Capillary action and wetting phenomena. Surface preparation and cleaning. Adhesive bonding – classification, surface treatment, curing, and bonding mechanisms. Applications in electrical, aerospace, and automotive industries.

Module – V: (06 hours)

Inspection, Testing, and Modern Developments in Joining

Destructive testing: tensile, bend, impact, and hardness tests of welded joints. Non-destructive testing (NDT): radiography, ultrasonic testing, magnetic particle, and dye penetrant methods. Automation and robotics in welding. Laser and Electron Beam Welding. Safety in welding and environmental aspects.

Course Outcomes:

After completing this course, the student will be able to:

CO1: Explain the principles, classifications, and mechanisms of various material joining processes.
CO2: Analyze the metallurgical phenomena occurring during fusion and solid-state welding.
CO3: Select appropriate joining methods and parameters for different materials and service conditions.
CO4: Evaluate joint integrity using destructive and non-destructive testing techniques.
CO5: Understand modern developments and automation in welding and joining technologies.

Books:

1. R. S. Parmar. Welding Engineering and Technology, Khanna Publishers.
2. S. V. Nadkarni. Modern Arc Welding Technology, Oxford & IBH Publishing.
3. Linnert, G. E. Welding Metallurgy, AWS.

Reference Books:

1. Little, R. L. Welding and Welding Technology, McGraw-Hill.
2. Kou, Sindo. Welding Metallurgy, Wiley-Interscience.
3. Balasubramanian, V. Welding Technology and Design, Universities Press.
4. Lancaster, J. F. Metallurgy of Welding, Elsevier.

Digital Learning Resources:

Course Name : Welding Technology

Course Link : https://nptel.ac.in/courses/112/105/112105238
Course Instructor: Prof. Pradeep Kumar, IIT Guwahati
Course Name : Joining of Materials
Course Link : https://nptel.ac.in/courses/112/106/112106295
Course Instructor: Prof. K. Balasubramanian, IIT Madras

MTPC3005 CHARACTERIZATION OF MATERIALS (3-0-0)

Objectives of the Course:
The course aims to introduce students to the fundamental principles and practical applications of various material characterization techniques. It focuses on crystallographic, microstructural, and chemical analysis using diffraction, microscopy, and spectroscopy. The objective is to enable students to select the appropriate characterization tools for analyzing metals, ceramics, and polymers.

Module - I: (06 hours)
Introduction and Optical Microscopy:
Importance of material characterization, classification of techniques. Principles of Optical Microscopy: Resolution, magnification, depth of field, numerical aperture. Lens defects and corrections. Techniques: Bright field, Dark field, Polarized light, and Phase contrast microscopy. Sample preparation for metallography (grinding, polishing, etching).

Module - II: (06 hours)
X-Ray Diffraction (XRD):
Production and properties of X-rays. Bragg's Law and diffraction conditions. Structure factor and intensity of diffracted beams. Diffractometer geometry and instrumentation.

Module - III: (06 hours)
X-Ray Diffraction (XRD Application):
Applications: Crystal structure determination, phase identification, and residual stress measurement.

Module - IV: (06 hours)
Electron Microscopy (SEM):
Interaction of electron beam with matter: Secondary electrons, Backscattered electrons, Characteristic X-rays. Scanning Electron Microscopy (SEM): Construction, electron gun sources (Thermionic vs. Field Emission), resolution, and depth of focus. Contrast mechanisms in SEM.

Module - V: (06 hours)
Transmission Electron Microscopy (TEM) and Microanalysis:
Transmission Electron Microscopy (TEM): Basic principle, construction, and imaging modes (Bright field/Dark field). Selected Area Diffraction (SAD) patterns. Chemical Analysis: Energy Dispersive Spectroscopy (EDS) and Wavelength Dispersive Spectroscopy (WDS) – principles and quantitative analysis.

Course Outcomes:
CO1: Understand the fundamental principles of optical microscopy and apply metallographic techniques for proper sample preparation and microstructural examination.
CO2: Interpret X-ray diffraction (XRD) patterns to identify crystal structures, phases, and lattice parameters of crystalline materials.
CO3: Explain the working principles of Scanning Electron Microscopy (SEM) and utilize electron-matter interactions to analyze surface morphology.
CO4: Analyze internal microstructures and chemical compositions at the nanoscale using Transmission Electron Microscopy (TEM) and Energy Dispersive Spectroscopy (EDS).

Books:

1. Elements of X-Ray Diffraction by B.D. Cullity, Pearson Education.
2. Microstructural Characterization of Materials by D. Brandon and W.D. Kaplan, Wiley.
3. Materials Characterization by Yang Leng, Wiley.

Reference Books:

1. Scanning Electron Microscopy and X-Ray Microanalysis by J. Goldstein et al., Springer.
2. Transmission Electron Microscopy by D.B. Williams and C.B. Carter, Springer.
3. Characterization of Materials by E.N. Kaufmann, Wiley-Interscience.

Digital Learning Resources:
Course Name: Materials Characterization Course Link: https://nptel.ac.in/courses/113/106/113106034/ Course Instructor: Prof. S. Sankaran, IIT Madras
Course Name: Modern Instrumental Methods of Analysis Course Link: https://nptel.ac.in/courses/103/108/103108100/ Course Instructor: Prof. J.R. Mudakavi, IISc Bangalore

HSHS3002 ENTREPRENEURSHIP DEVELOPMENT (3-0-0)

Course Objectives –

1.To explain concept of entrepreneurship and build and understanding about business situation in which entrepreneurs act.
2.To explain classification and type of entrepreneurs and the process of entrepreneurial project development
3.To discuss the steps in venture development and new trends in entrepreneurship.
4.The more focus is given on creativity and innovation.

Module-I: (10 hours)
Entrepreneurship: Concept of entrepreneurship and intrapreneurship, Types of Entrepreneurs, Nature and Importance, Entrepreneurial Traits and Skills, Entrepreneurial Motivation and Achievement, Entrepreneurial Personality

Module-II: (08 hours)
Entrepreneurial Environment, Identification of Opportunities, Converting Business Opportunities into reality. Start-ups and business incubation, Setting up a Small Enterprise. Issues relating to location, Environmental Problems and Environmental pollution Act, Industrial Policies and Regulations

Module-III: (10 hours)
Need to know about Accounting, Working capital Management, Marketing Management, Human Resources Management, and Labour Laws. Organizational support services - Central and State Government, Incentives and Subsidies.

Module-IV: (12 hours)
Sickness of Small-Scale Industries, Causes and symptoms of sickness, cures of sickness, Role of Banks and Governments in reviving industries.

Course Outcomes
After completion of this course, students
CO1: will aware about foundation of entrepreneurship development and its theories
CO2: will identify the type of entrepreneur and the steps involved in a entrepreneurial venture.
CO3: will understand various steps involved in starting a venture and to explore marketing methods & new trends in entrepreneurship.
CO4: Think creative and innovative

Books:

1. Entrepreneurship Development and Management, Vasant Desai, HPH
2. Entrepreneurship Management, Bholanath Dutta, Excel Books
3. Entrepreneurial Development, Sangeeta Sharma, PHI
4. Entrepreneurship, Rajeev Roy, Oxford University Press

CSPS3202 PROJECT FOR PRODUCT DEVELOPMENT - I (0-0-6)

Course objectives:

Learning outcomes Upon completing the course, students are expected to be able to:

- Plan and execute independently projects aimed at collecting, systematize and analyze information about markets and customer contexts as fundamental supporting elements for product development in specific sectors and industrial fields,
- Apply the most important models for organizing and managing product development and its implementation in concrete commercial setting,
- Analyze complex product development situations and, based on such analysis, suggest relevant strategies, plans and action programs for various types of companies and organizations,
- Identify the need of further knowledge and tools (both analytics and computer-based) to conduct product development tasks,
- Evaluate critically the result of a product development project and, based on such an evaluation, reflect on uncertainty and risks in execution, so to be able to suggest alternative conclusions.

Instruction

The course is organized as an independent project conducted in teams of 4-5 students with the aim of developing an idea all the way to a product ready for launch for a specific firm. This work is supported by methodological lectures. The project work is presented during a series of seminars with oppositions acting as ”control gates” and leading to a final seminar where a decision on launching or not the product is taken by an opponent group.

MTPC3204 JOINING OF METALS LABORATORY (0-0-3)

List of Experiments (Student Activities):

1. Study of Various Welding Machines and Equipment Identification and understanding of components used in arc, gas, and resistance welding setups.
2. Preparation of Butt Joint by Shielded Metal Arc Welding (SMAW) Practice bead-on-plate and butt joint welds on mild steel plates.
3. Preparation of Lap and T-Joint by Gas Metal Arc Welding (GMAW / MIG Welding) Use of inert gas shielding and understanding of wire feed mechanism.
4. Preparation of Weld Joint by Gas Tungsten Arc Welding (GTAW / TIG Welding) Welding of stainless steel or aluminium sheet using tungsten electrode and argon gas.
5. Demonstration and Practice of Oxy-Acetylene Gas Welding and Cutting Manual operation and observation of flame characteristics and cutting speed.
6. Resistance Spot Welding of Low Carbon Steel Sheets Study of nugget formation and influence of welding current and time.
7. Preparation of Joint by Friction stir Welding (Demonstration/Practice) Joining of rods through solid-state frictional heat generation.
8. Brazing of Two Metal Pieces Using Copper or Silver Alloy Filler Observation of capillary action and surface cleaning importance.
9. Soldering of Electrical or Thin Sheet Components Soft soldering using lead–tin solder and flux selection.
10. Metallographic Examination of Weld Zone and Heat-Affected Zone (HAZ) Sample preparation, polishing, etching, and optical microscopy of welded joints.
11. Mechanical Testing of Welded Joints Tensile test or bend test of welded specimens and interpretation of fracture location.
12. Non-Destructive Testing (NDT) of Welded Samples Dye penetrant, magnetic particle, and ultrasonic testing to detect surface and subsurface defects.
13. Study of Welding Defects and Their Causes Identification of porosity, slag inclusion, cracks, undercut, and lack of fusion from sample specimens.
14. Demonstration of Advanced Welding Techniques Observation of laser, plasma, or electron beam welding (through videos or industrial visit).

MTPC3205 CHARACTERIZATION OF MATERIALS LABORATORY (0-0-3)

List of Experiments (Student Activities):

1. Study and Familiarization with Optical Microscope and Image Analyzer
2. Micro structural Examination of Metallic Samples using Optical Microscope
3. Quantitative Metallography using Image Analyzer
4. Grain size determination of a given microstructure by using different methods.
5. Study and Familiarization with X-ray Diffraction (XRD) Instrumentation
6. Phase Identification of Metallic Samples using XRD
7. Determination of Crystallite Size and Residual Stress using XRD
8. Study and Familiarization with Scanning Electron Microscope (SEM)
9. Micro structural Analysis of Samples using SEM
10. Elemental Analysis using Energy Dispersive X-ray Spectroscopy (EDS)