College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Metallurgy and Material Science

Curriculum Structure & Detailed Syllabus (UG Program)

Third Year B. Tech.

(Revision: A.Y. 2020-21, Effective from: A.Y. 2021-22)

INDEX

Program Education Objectives (PEOs):

I. Graduate will have in-depth knowledge of Metallurgy and Materials Science aspects such as scientific principles of fabrication, phase transformations, mechanical treatment, heat treatment, structure-property correlations and service behavior of various types of materials necessary to formulate, solve and analyze critical engineering problems.

II. Graduate will be able to make a successful career in metallurgical and manufacturing industry, academics, research and development that meet the needs of Indian and multinational companies.

III. Graduate will be capable of solving unfamiliar problems through literature survey, deciding a suitable research methodology and conducting interdisciplinary/collaborative-multidisciplinary scientific research as per the need.

IV. Graduate will achieve the art of reflective learning, build hands-on experimental skills, and become familiar with modern engineering software tools and equipments and able to work independently or as a part of a team for successful project implementations in his/her professional life.

V. Graduate will acquire leadership qualities, techno-economical and social considerations, an aptitude for life-long learning, and get introduced to professional ethics and codes.

VI. Graduate will develop the ability to effectively communicate technical information in both written and oral form.

Program Outcomes (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

On completion of the B.Tech.(Metallurgical Engineering) degree, the graduates will be able to:

1. Design, develop and select new materials and processes to produce products with desired end properties, within optimum time and resources.
2. Apply modern software tools and quality control techniques to observe and understand the underlying mechanisms to perform structure - properties correlation, failure analysis, and provide solutions towards betterment of industry, R&D and society at large.

Correlation between the PEOs and the Pos

PO / PEO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO 2
I	✓	✓	✓		✓		✓							✓
II	✓	✓	✓	✓	✓	✓	✓					✓		✓
III	✓	✓	✓	✓	✓	✓						✓	✓	
IV				✓	✓				✓	✓	✓	✓	✓	
V							✓		✓	✓	✓			✓
VI	✓	✓	✓					✓						✓

Note: The cells filled in with✓indicate the fulfilment/correlation of the concerned PEO with the PO.

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
BSC	Basic Science Course	1	3	6
MLC	Mandatory Learning Course	2	0	0
IFC	Interdisciplinary Foundation Course	1	2	4
HSMC	Humanities/Social Sciences/Management Course	3	5	10
SBC	Skill Based Course	2	3	6
PCC	Program Core Course	8	27	54
LC	Laboratory Course	5	5	10
IOC	Interdisciplinary Open Corse	1	2	4
DEC	Department Elective Course	1	3	6

Curriculum Structure
Third Year Metallurgical Engineering
Semester V

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	MLC	ML-21002	Environmental Studies	1	0	0	0
2	IFC	ETC(IF)-21001	Internet of Things and Applications	1	0	2	2
3	HSSC	AS(HS)-21005 AS(HS)-21006 AS(HS)-21007 AS(HS)-21008	Humanities and Social Sciences Open Course-I • Industrial Psychology • Personnel Psychology • Engineering Economics • Finance for Engineers Etc.	2	0	0	2
4	SBC	MT-21001	Heat Treatment Technology Lab	0	0	2	1
5	PCC	MT-21002	Heat Treatment Technology	3	0	0	3
6	PCC	MT-21003	Mineral Processing and Extractive Metallurgy	4	0	0	4
7	PCC	MT-21004	Iron Making	3	0	0	3
8	PCC	MT-21005	Materials Characterization	3	0	0	3
	PCC	MT-21006	Transport Phenomena	3	1	0	4
9	LC	MT-21007	Mineral Processing and Extractive Metallurgy Lab	0	0	2	1
11	LC	MT-21008	Materials Characterization Lab	0	0	2	1
12	LC	MT-21009	Materials Software Tools Lab	0	0	2	1
			Total lectures -Tutorials-Practicals (L-T-P)	**20**	**1**	**10**	**25**
			Total Academic Engagement and Credits				**Max. 25**

No.	Semester	Minor Course	Honors Course	Lectures	Credits
1	V	MT(MI)-21001 Heat Treatment Technology	Materials Engineering: MT(HO)-21001 Advances in Ceramic Engineering **/** Process Metallurgy: MT(HO)-21002 Advanced Composites	3	3

Third Year Metallurgical Engineering

Semester VI

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	BSC	MA 21001	Probability and Statistics for Engineers	2	1	0	3
2	MLC	ML-21001	Constitution of India	1	0	0	0
3	HSSC	AS(HS)-21001 AS(HS)-21002 AS(HS)-21003 AS(HS)-21004	Humanities and Social Sciences Open Course - II • English Language Proficiency • German Language • Japanese Language • Spanish Language	2	0	0	2
4	HSMC	HS-21001	Entrepreneurship Principles and Process	1	0	0	1
5	SBC	MT-21010	Mini project ["D-S-P-T: Design-Simulate-Prototype-Test "]	0	0	4	2
6	IOC		Interdisciplinary Open Course-I	2	0	0	2
7	DEC	MT(DE)-21001 MT(DE)-21002 MT(DE)-21003	Department Elective-I • Wire Drawing and Sheet Metal Forming • Tribology of Materials • Non Destructive Testing	3	0	0	3
8	PCC	MT-21011	Foundry Technology	3	0	0	3
9	PCC	MT-21012	Structural Metallurgy	3	1	0	4
11	PCC	MT-21013	Steel Making	3	0	0	3
12	LC	MT-21014	Foundry Technology Lab	0	0	2	1
14	LC	MT-21015	Non Ferrous Metallurgy Lab	0	0	2	1
			Total Lectures -Tutorials-Practicals (L-T-P)	**20**	**2**	**8**	**25**
			Total Academic Engagement and Credits				**Max. 25**

No.	Semester	Minor Course	Honors Course	Lectures	Credits
1	VI	MT(MI)-21002 Foundry Technology	Materials Engg. and Process Metallurgy both: MT(HO)-21003 Mechanical Behavior of Materials	3	3

Semester-V

[ML-21002] Environmental Studies

(Adopted from the 'Ability Enhancement of Compulsory Courses: Environmental Studies' as prescribed by the Expert Committee of University Grants Commission as per directives of Hon'ble Supreme Court)

Teaching Scheme:
Lectures : 1 hrs/week

Evaluation Scheme:
Periodic Assignments & Tests
Assignments: 2 hrs/week

Course Outcomes:

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

1. Comprehend Sustainable Development Goals for present generation
2. Appreciate environmental resources, functioning of an ecosystem, significance of biodiversity and environmental challenges
3. Analyze the current status of environment with respect to precautionary mechanisms and control measures
4. Appreciate the role of an engineer for better tomorrow

Unit 1 **[2 hrs]**

Multidisciplinary nature of environmental studies

Definition, scope and importance, Need for public awareness.

Unit 2 **[8 hrs]**

Natural Resources

Renewable and non-renewable resources:

Natural resources and associated problems.

Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies. Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.

Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

Unit 3 **[6 hrs]**

Ecosystems

Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of

the following ecosystem: -Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 4 **[8 hrs]**

Biodiversity and its conservation

Introduction – Definition : genetic, species and ecosystem diversity, Bio geographical classification of India, Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, India as a mega-diversity nation, Hot-sports of biodiversity, Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity.

Unit 5 **[8 hrs]**

Environmental Pollution

Definition, Cause, effects and control measures of:-Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards, Solid waste Management : Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management : floods, earthquake, cyclone and landslides.

Unit 6 **[7 hrs]**

Social Issues and the Environment

From Unsustainable to Sustainable development, Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rehabilitation of people; its problems and concerns. Case Studies, Environmental ethics: Issues and possible solutions, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies, Wasteland reclamation, Consumerism and waste products. Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, Public awareness.

Unit 7 **[6 hrs]**

Human Population and the Environment

Population growth, variation among nations, Population explosion – Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.

Unit 8 **[5 hrs]**

Field work

Visit to a local area to document environmental assets river/forest/grassland/hill/mountain. Visit to a local polluted Site-Urban/Rural/Industrial/Agricultural, Study of common plants, insects, birds, Study of simple ecosystems-pond, river, hill slopes, etc.

Reference Books

- Agarwal, K.C. 2001 Environmental Biology, Nidi Publ. Ltd. Bikaner.
- Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd.,Ahmedabad – 380 013, India, Email:mapin@icenet.net (R)
- Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480p
- Clark R.S., Marine Pollution, Clanderson Press Oxford (TB)
- Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001,
- Environmental Encyclopedia, Jaico Publ. House, Mumabai, 1196p
- De A.K., Environmental Chemistry, Wiley Eastern Ltd.
- Down to Earth, Centre for Science and Environment (R)
- Gleick, H.P. 1993. Water in crisis, Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute Oxford Univ. Press. 473p
- Hawkins R.E., Encyclopedia of Indian Natural History, Bombay NaturalHistory Society, Bombay (R)

[ETC(IF)21001] Internet of Things and Applications

Teaching Scheme:
Lectures: 1 hr/week
Lab: 2 hrs/Week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Understand the concepts of Internet of Things.
2. Analyze basic communication protocols.
3. Implement basic IoT applications using IoT platforms.
4. Design IoT applications in diverse domain and analyze their performance.

Unit 1 **[10 hrs]**

Fundamentals of Internet of Things: Introduction to IoT, Basics of Networking, Sensors (transducers) Actuators, Communication Protocols, Arduino and Raspberry Pi, Cloud Computing, SDN - Network requirements, SDN for IoT, Data management and Analytics, Challenges in IOT implementation.

Unit 2 **[4 hrs]**

IoT Applications: Case study: Smart Grid, Smart Agriculture, Smart Environment, Smart Health Care, Smart Transportation.

List of Experiments:

Experiments based on Python Programming:

1. a) Study and Install Python in Linux and WAP for data types in python.

b) Write a program for arithmetic operation in Python.
c) Write a program for looping statement in Python.

2. Write a program for Encryption in python
3. Write a program for Decryption in Python

Experiments based on Hardware:

1. Install IDE of Arduino and different types of Arduino.
2. Write program using Arduino IDE for a) Blink LED. b) Implementing RFID, NFC.
3. Write program for monitor temperature using Arduino.
4. Implement MQTT protocol using Arduino.
5. Configure Raspberry Pi and WAP for LED blink.
6. Implement Zigbee Protocol using Arduino / Raspberry Pi.
7. IoT case study implementation.

Text Books:

1. Bahga, Arshdeep, and Vijay Madisetti, “Internet of Things: A hands-on approach.” Vpt, 2014.
2. Misra, Sudip, Anandarup Mukherjee, and Arijit Roy. Introduction to IoT. Cambridge University Press, 2021.

Reference Books:

1. David, Etter, "IOT (Internet of Things) Programming A Simple and Fast Way of Learning IOT." Kindle Edition (2016).
2. S. Misra, C. Roy, and A. Mukherjee, “Introduction to Industrial Internet of Things and Industry 4.0." CRC Press, 2020.
3. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016.

Humanities and Social Sciences Open Course

[AS(HS)-21005] Industrial Psychology

Teaching Scheme:
Lectures : 2 Hrs/week

Examination Scheme:
Assignment/Test: 40 Marks
End-Sem Exam: 60 marks
Field Visit/Expert lecture report-20 Marks
Mini project report-40 marks

Course Outcomes (CO)

At the end of the course, student will be able to

1. Determine the psychological factors that influence individual differences at work and appraise the role of research.
2. Explain the concepts of motivation and job satisfaction at work and Utilize the elements of organizational culture for enhancing group/team behavior.

3. Evaluate the relevance & functioning of leadership & diversity in workforce and acknowledge the multicultural factors influencing workplace behavior.
4. Illustrate the process of recruitment & selection and Experiment with the information required to sustain employability.
5. Interpret the nuances of Human Factors in Engineering and Analyze its role in their disciplines.
6. Measure the behavioral findings from self-lead projects and Propose corrective actions to improve quality of workplace behavior.

Unit 1: Basics of Industrial Psychology (IP) [6 hrs]

Difference between IP & Business Programs; Major fields & Employment in IP

Brief History- Scientific Management, Time and Motion Study, Hawthorne Studies, World War I & II

Research in Social Sciences

Individual Differences at Work: Personality, Intelligence, Emotional Intelligence, Creativity & Innovation, Perception & Attitudes

Unit 2: People at Work [8 hrs]

Motivation & Job Satisfaction- Employee Predisposition, Expectations, Goals, Incentives& Equity; Job Characteristic Theory (Diagnostic Model)

Understanding Groups & Teams- Group dynamics, Factors affecting Group performance; Understanding work teams, Types of teams, Team development, Issues with teamwork

Leadership (Co-Teaching 4 hrs)- Leader characteristics, Leader & situation, Leader & follower; Specific leadership skills, Introduction to Organizational Development (OD)

Diversity- Multiculturalism- Hofstede's theory, Diversity dynamics

Unit 3: Human Factors Engineering (HFE) [8 hrs]

Introduction & Brief History of HFE; Essentials of HFE

Person-Machine Systems- Basic Human Factors: Sensory systems, Perception, Cognition, Information Processing approach, Memory, Decision Making

Workspace Designs- General Principles, Designing work areas; Machine Displays &Controls; Physical work environment & Anthropometry; Managing workplace strain through Ergonomics (Self-study)

Current trends in HFE- Use of artificial intelligence, cognitive engineering, sociotechnical systems, etc.

Unit 4: Managing People at Work [6 hrs]

Job Analysis- Brief Background, Types & Importance; Job description

Recruitment & Selection- Overview, Process, Evaluation

Gearing for Selection- Interviews & Job Search Skills

Performance Appraisal (Co-Teaching 2 hrs): Steps in the Evaluation Process; Appraisal Interview

Text Books:

1. Aamodt, M.G. (2013). Industrial Psychology. Cengage Learning: Delhi.
2. Wickens, C. D.; Lee, J. D., Liu, Y. & Gordon Becker, S. E. (2015). An Introduction to Human Factors Engineering. 2nd Edition. Pearson Education: New Delhi.
3. Landy, F. J. & Conte, J. M. (2010). Work in the 21st Century: An Introduction to Industrial and Organizational Psychology. 2nd Edition. Wiley India: New Delhi.

References:

1. Matthewman, L., Rose, A. & Hetherington, A. (2009). Work Psychology. Oxford University Press: India.
2. Schultz, D. & Schultz, S. E. (2013). Psychology and Work Today: An Introduction to Industrial and Organizational Psychology. 7th Edition. Pearson Education: New Delhi.
3. Schultz, D. & Schultz, S. E. (2002). Psychology and Work Today. Pearson Education: New Delhi.

[AS (HS)-21006] Personnel Psychology

Teaching scheme
Lectures: 2 hrs / Week

Evaluation scheme
Assignments – 60 marks
End Semester- 40 marks

Course Outcomes:

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

1. Acquire organizational concepts and will recognize their own personality attributes suitable for corporate world.
2. Realize the importance of motivation and apply motivational principles to their lives
3. Experience group dynamics and apply those principles in their lives
4. Grasp and apply different techniques to maintain mental health.

Unit 1 **[6 Hrs]**

Introduction- Understanding own personality and corporate world

Basic concepts in Organizational set up and its importance, Know own personality attributes. Preparing for corporate world, work ethics, and self- management.

Unit 2 **[6 Hrs]**

Motivation

Motivational theories for self- motivation and motivating others at work place, Approaches to work

Unit 3 **[8 Hrs]**

Group dynamics

Group behavior and leadership, Effective group behavior, Leadership and management

principles, virtual teams and Performance appraisal

Unit 4 **[6 Hrs]**

Mental health at work place

Occupational stress and conflict and strategies for its management, Emotional Intelligence, spiritual Intelligence

Text Books

- Khana S.S.- (2016) Organizational Behaviour(Text and Cases) Chand and company Pvt.Ltd.Delhi.
- Rae Andr'e:- (2008) organizational behavior. Dorling Kindersley (India) Pvt. Ltd.
- Wallace H.and Masters L.- (2008) Personality development. Cengage Learning India Pvt. Ltd.

Reference books:

- Robbins S, JudgeA, Vohra N:- (2013)Organizational behavior.(15thed) Pearson Education,Inc.
- Singh Kavita:- (2010) Organizational behavior-Text and cases. Dorling Kindersley

[AS(HS)-21007] Engineering Economics

Teaching Scheme:
Lectures : 2 hrs/week

Examination Scheme:
Assignment/Test: 40 Marks
End-Sem Exam: 60 Marks

Course Outcome (CO)

At the end of the course, student will be able to

1. Demonstrate understanding of economic theories and policies.
2. Identify economic problems and solve it by applying acquired knowledge, facts and techniques in the available framework.
3. Categorize, classify and compare economic situations and draw inferences and conclusions.
4. Adapt to changing economic atmosphere and propose alternative solutions to the problems.

Unit 1: Introduction to Economics: **[6 hrs]**

Definitions, basic concepts of economics: Cost, efficiency and scarcity, Opportunity Cost
Types of economics: Micro Economics, Macroeconomics and Managerial Economics.
Difference between micro economics and macroeconomics. Application of Managerial economics

Unit 2: Micro Economics Analysis: **[8 hrs]**

Demand Analysis, Supply Analysis, Theories of Utility and Consumers Choice, Cost analysis, Competition and Market Structures. Application of micro economics theories

Unit 3: Macro Economic Analysis: **[8 hrs]**

Aggregate Demand and Supply, Economic Growth and Business Cycles, inflation,
Fiscal Policy, National income, theory of Consumption, savings and investments, Commercial and Central banking. Use of macroeconomic theories.

Unit 4: International Economics: **[8 hrs]**

Balance of Trade and Balance of Payments, Barriers to Trade, Benefits of Trade/Comparative Advantage, Foreign Currency Markets/Exchange Rates, Monetary, Fiscal and Exchange rate policies, Economic Development.
Application of exchange rate policies

Reference Books:

1. Macroeconomics: N. Gregory Mankiw, 2018
2. Managerial Economics: Economic Tools for Today's Decision Makers: by Paul Keat (Author), Philip Young (Author) 2013
3. Principles of Macro Economics: Misra and Puri.2009, Himalaya publishing house, New Delhi.
4. Modern Microeconomics, A. koutsoyiannis , Macmillan , London
5. Microeconomics Robert S. Pindyck and Daniel L. rubinfeld:, Pearson education Inc. New Delhi
6. Micro economics: K. N. Verma

[AS(HS)-21008] Finance for Engineers

Teaching Scheme:
Lectures : 2 hrs/week

Examination Scheme:
Assignment: 40 Marks
End-Sem Exam: 60 Marks

Course Outcome (CO)

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

1. Comprehend basics of accounting, cost concepts, will be able to read Financial statements of companies
2. Enable them to understand critical financial principles and to enable them to integrate & analyze financial information necessary for Business Decision Making.
3. Establish relationship between Risk & Return, time value of money, sources of finance & working capital
4. Appreciate the digital platform of future finance, cryptocurrency, understand the terms associated with Financial Markets such as Money market, capital market, SEBI & other Regulatory authorities

Unit 1: Introduction to Accounting & Finance [6 hrs]
Basic elements of financial accounting, cost concepts, preparation of Profit & Loss Account & Balance Sheet & concept of Budgetary control

Unit 2: Read & interpret Financial Statements [6 hrs]
As per Schedule III of Companies Act 2013, Financial statement analysis, concept of cash flow statement

Unit 3: [8 hrs]
Break-even analysis, Risk & Return relationship, time value of money, sources of finance & working capital

Unit 4: [4 hrs]
Digital Platform such as Net Banking, Cryptocurrency, Algorithm based stock exchange trading, Basics of Money market, capital market, Commodities market, IPO & Regulatory authorities

****Pedagogy:** Lectures and PPTs, Use of basic Excel tools for preparation of final accounts, Annual Reports of companies.

Reference Books:

1. Accounting for Managers – C Rama Gopal (2012), Accounting for Management, New Age International Publishers
2. Financial Management – Theory and Practice - Prasanna Chandra [Mc Graw Hill] publication.

[MT-21001] Heat Treatment Technology Laboratory

Teaching Scheme:
Laboratory: 2 hrs/week

Examination Scheme:
Continuous evaluation - 50 Marks
End Sem exam - 50 Marks

Course Outcomes:
At the end of course students will be able to
1. Interpretation of microstructures and various phases.
2. Design of heat treatment cycles using TTT/CCT diagram.
3. Analyzing and comparing hardening and tempering, austempering and QP heat treatments

List of Experiments: (Any 08 from the given below)
1. Performing annealing, normalizing and hardening heat treatment of steel samples; observation of microstructures and hardness.
2. Designing of Spheroidizing annealing cycle for eutectoid steel.
3. Design of isothermal heat treatment cycle using TTT/CCT diagram using fluidized bed and salt bath furnace.

4. Hardenability determination by Jominy End Quench test as per ASTM standard; estimation of hardenability using composition of steel.
5. Performing hardening and tempering on high strength steel
6. Performing hardening and multiple tempering of High Speed Steel.
7. Performing surface heat treatments like carburizing, nitriding on steels; estimating resultant case depth.
8. Performing maraging heat treatment on maraging grade steels
9. Case Study of defects due to heat treatment and remedial design changes
10. Determination of prior austenite grain size for a heat treatment
11. Comparison of austempering and QP heat treatments

[MT-21002] Heat Treatment Technology

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

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

1. Understand the basic principles of various heat treatments.
2. Analyse the effect of heat treatment processes on the micro-structure and properties of materials
3. Design of various heat treatment cycles using phase diagrams, TTT, CCT diagrams
4. Design of thermo-mechanical treatment for micro-alloy steel, dual phase steel, tool steel Maraging steel and stainless steel
5. Compare various surface heat treatments given to steels
6. Analyse effect of furnace atmospheres on heat treatment processes and reasons behind defects after heat treatments

Unit I: **[6 hrs]**

Heat treatment of plain carbon steels: Annealing, Isothermal and subcritical Annealing types, Normalizing, Hardening Heat Treatment: Quenching process, characteristics and kinetics of martensitic transformation, Bain model, Retained austenite and its effect, Tempering and subzero treatment. Hardenability: Mass effect, Grossman method, Critical and ideal critical diameter, Jominy End Quench method, Use and Significance of Hardenability data, Effect of grain size and composition, Residual stresses, Quench cracking, Case studies of design changes for hardening.

Unit II: **[6 hrs]**

Classification of alloying elements and their effects on Iron–Iron carbide phase diagram, TTT Diagram and CCT Diagram, General Heat treatments such as Annealing, Normalizing,

Hardening, Tempering, Austempering, Martempering, Hardenability concept, Stages of Quenching and their effects, Types of quenching media such as oils, polymers; Cooling characteristics of quenching media, Control of quenching parameters, quenching fixtures, Dimensional changes during hardening and tempering.

Unit III: [6 hrs]

Heat treatment to commercial alloys steels-1: Heat treatment of Low alloy steels, Free cutting steels, Spring steels; bearing steel, Tool Steel: Selection criteria and properties of Tool steels, Classification of Tool Steels: Cold work, Hot Work Tool Steels, High Speed Steels and Stellites; Heat treatments of Die and Tool steels, Secondary hardness and Red Hardness, Subzero treatment, Super High Speed Steels, TRIP Steels.

Unit IV: [7 hrs]

Heat treatment to commercial alloys steels-2: Stainless Steels: Fe-Cr, Fe-Ni Phase Diagram, Schaeffler Diagram and its modifications, Classification of Stainless Steels, sensitization, Heat treatment of stainless steels, Precipitation Hardening Stainless Steels, Marageing Steels, Superalloys and their heat treatment.

Unit V: [6 hrs]

Thermomechanical Processing of Steels: Basics of thermomechanical processing, Controlled rolling of low alloy steels, DP steels, TRIP steels and TRIP assisted Steels, QP steel TWIP steels, Industrial steel subjected to thermomechanical treatments.

Unit VI: [6 hrs]

Surface hardening: Carburizing, Carburizing atmosphere and Heat treatment after Case Hardening, Bainite control in case, Case depth measurement, ASTM E1077-01 Depth of carburization, Drip Feed Carburizing, dimensional changes during case hardening; Nitriding, Carbonitriding, Tufftriding, Nitrocarburising, Plasma Nitriding; Induction Hardening, Flame Hardening, Laser Hardening, Selection of steels for these treatments and their applications. Classification of atmospheres for heat treatments, Generation of atmospheres and their applications. In situ atmosphere generation, Thermodynamics and Kinetics of atmospheres, Control and monitoring of Furnace Atmospheres: Infrared controller, Gas chromatography, Dew point analyzer and Oxygen probe analyzer Heat treating furnaces: Salt bath furnace, Fluidized bed furnace, Sealed Quench furnace, Vacuum furnace, Heat Treatment Defects such as Distortion, Residual stresses, quench cracks and Design for Heat treatment.

Text Books:

- Heat Treatment of Metals, Vijendra Singh, 2007, Standard Publishers and Distributors, New Delhi
- R.A. Higgins, Engineering Metallurgy, Part I, App. Physical Met, ELBS, 5th ed., 1983
- H. K. D. H. Bhadeshia, Robert Honeycombe, Steels:Microstructure and Properties,Third edition, Publisher Elsevier Ltd., UK

Reference Books:

- Steel and its Heat Treatment -K.E Thelning, Butterworth, London
- Handbook of Heat Treatment of Steels – Prabhudev-Tata McGraw Hill. New Delhi, 1988
- Heat Treatment of Ferrous Alloys, Brooks, Washington: Hemisphere Pub., 1979
- ASM Metals Handbook – Heat treatment, Metals Park Ohio Pub.
- ASM Metals Handbook – Steels, Metals Park Ohio Pub.

[MT-21003] Mineral Processing and Extractive Metallurgy

Teaching Scheme:
Lectures : 4 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Choose appropriate Mineral Processing Techniques for the type of ore and its concentration required for subsequent extraction of various non ferrous metals such as Cu, Zn, Al, Pb, Zn etc.
2. assess hydro, pyro and electro metallurgical methods of extraction used for extraction of Metals.
3. Calculate and analyze thermodynamic aspects of the extraction of metals using hydro, pyro and electro metallurgical techniques.
4. Understand the application of various Refining techniques used post extraction of metals.

Unit I: Mineral Processing [8 hrs]

Locations of ore deposits of non-ferrous metals in India and abroad, historical and current production of nonferrous metals, Exploration for Mineral Deposits, Sources of Metals, Introduction to ore dressing, crushing and grinding, Crushers and Grinding mills, Comminution laws. Sizing: Industrial sizing units, Types of screen: Grizzlies, trammels, vibrating and shaking screens. Sorting using fluids: stokes and Newton's law, Terminal velocity and its relation with size. Sizing and sorting Equipments, Heavy media separation: Principles, flow chart, different media used. Magnetic and electrostatic separation processes. Floatation: Principles of floatation, Factors affecting floatation, Classification of collectors and frothers.

Unit II: Main approaches in extractive metallurgy [10 hrs]

Reactivities of Metals, Principles and Important unit operations of Pyro metallurgy, Hydrometallurgy and Electrometallurgy. Thermodynamic considerations and process selection in extraction of metals, Application of Ellingham Diagram and Predominance Area Diagram, Study of Leaching, bioleaching, precipitation of metals, reduction by gases. Basic approaches and methods of Metal Refining: Preparation of Pure compounds and Purification of Bulk

Crude Metal.

Unit III: Metals for Electric Vehicles [9 hrs]

Pyrometallurgical extraction of coppe- Roasting, Smelting, Converting, Refining, Copper loss in slag. Hydrometallurgical extraction of Copper and Newer routes. Extraction of Nickel, Lithium, Extraction of rare earth element neodymium.

Unit IV: Extraction of Light Metals [8 hrs]

Principle of electrolysis in winning, fused salt electrolysis, Bayer's process for production of alumina, Hall-Heroult process, Refining of Aluminium and Newer routes. Extraction of magnesium. Extraction of titanium.

Unit V: Extraction of Some Important Metals [7 hrs]

Lead smelting, Pyrometallurgical extraction of Zinc, Hydrometallurgical extraction of Zinc, Imperial smelting process. Extraction of, gold, zirconium.

Unit VI: Recycling of Metal [6 hrs]

Production of Secondary metals, Recovery of metals from scrap and other secondary sources by pyro-, hydro- and electrometallurgy. Metal Recovery from E-waste.

Text Books:

• H. S. Ray, R. Shreedhar and K.P. Abraham, Extraction of Non-Ferrous Metals, Affiliated East West press pvt. Ltd, Oscar Publications, New Delhi, 2011.

• R. D. Pehlke, Unit Processes in Extractive Metallurgy, American Elsevier pub. Co., Michigan, 1973.

• J. J. Moore, Chemical metallurgy, Butterworth-Heineman, 1981.

• J. D. Gilchrist, Extractive metallurgy, Pergamon Press, 1989.

Reference Books:

• W. G. Davenport, M. King, M. Schlesinger, and A. K. Bishwas, Extractive metallurgy of Copper, 4th edition, Pergamon Press, 2002.

• H. S. Ray, A. Ghosh, Processes in Extractive Metallurgy, New age international pvt.ltd, New Delhi, 2001.

[MT- 21004] Iron Making

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to:

1. Establish the flow chart to produce blast furnace iron starting from raw materials.

2. Select and design an appropriate process for treatment of ores depending on the ore characteristics.
3. Establish the thermodynamics and kinetics of reactions taking place in various zones of blast furnace.
4. Recommend measures to be taken for maximum utilization of various furnaces used in iron production and minimize operational irregularities.
5. Select appropriate alternate method for iron production and establish the physical chemistry for these methods.
6. Classify and compare various processes used for ferro- alloys production.

Unit I: **[6 hrs]**

Iron making: Historical, blast furnace process, Raw materials- iron ore, coke, fluxes, burden preparation.

Unit II: **[6 hrs]**

Treatment of iron ores: Agglomeration, sintering and pelletization, Low grade iron beneficiation Coke making, coke oven gas & BF flue Gas, Chemical by-products, gas cleaning system.

Unit III: **[6 hrs]**

Physical chemistry of blast furnace reactions, thermodynamic equilibria, chemical and thermal reaction zones, Reactions in stack, bosh and hearth, thermal efficiency, mass and enthalpy balances, gas flow, burden distribution and cohesive zone formation in BF.

Unit IV: **[6 hrs]**

Construction of Blast furnace and accessories, B.F. operation, performance, gas utilization, Irregularities in B.F. operation, products: metal and slag, Mini-blast furnace, COREX process- principles of operation, techno-economical considerations.

Unit V: **[6 hrs]**

Alternatives routes of iron production, low shaft furnace, electro thermal processes, Directly reduced iron (DRI) productions: Principles of operations, Physical chemistry of DRI processes, mechanism of sponge iron production, advantages and disadvantages, Processes such as – Rotary Kiln, MIDREX, advancement in blast furnace.

Unit VI: **[6 hrs]**

Ferro-alloys production: Methods of production, Electric submerged arc furnace, metallothermic processes, Ferrochrome, Ferrosilicon, Ferromanganese, Ca-Si, Si-Mn.

Text Books:

- R.H. Tupkary, V.R.Tupkary, An Introduction to modern Iron making, 3rd Edition, Khanna Publications, New Delhi, 2005.

- Ahindra Ghosh, Amit Chatterjee Iron and Steel making: Theory and practice, 2nd Edition, PHI learning Pvt. Ltd, New Delhi, 2011.
- A.K. Biswas: Principles of Blast Furnace Iron making, 1st Edition, SBA publications, Calcutta, 1984.
- F.P. Edneral, Electrometallurgy of Steel and Ferroalloys, Volume I and II, 4th Edition, Russia, 1979.

Reference Books:

- J.G. Peacey, W.G. Davenport, Daven Port, The iron Blast furnace: Theory and practice, Pregamon press, New York, 1979.
- Amit Chatterjee, Beyond the Blast furnace, CRC Press; 1st Edition, Boca Raton, 1993.
- National Steel Policy (NSP), Ministry of Steel, Government of India, 2012.

[MT-21005] Materials Characterization

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Understand the basic principles of optical microscopy, electron microscopy, X-ray diffractometry and thermal analysis techniques.
2. Apply the knowledge of characterization techniques to inspect the characterization need pertaining to material's structure –processing –property needs.
3. Analyze the outcome from various characterization techniques to interpret and present observations quantitatively and qualitatively.
4. Compare the various characterization techniques on the basis of advantages, limitations, specifications and applications.
5. Design the characterization flowchart for a process or system based on material's structure-process-property relationship.

Unit 1: Basics of optical microscopy and crystal structures [6 hrs]

Fundamentals of optical microscopy and its instrumentation, sample preparation, types of optical microscopes, bright and dark field image formation, phase contrast, polarized light, differential interference contrast, fluorescence microscopy, image analyzer, applications of optical microscopy, phase identification, Basics of crystal structures, statistical analysis of structural orientation data, stereographic projection, standard projection.

Unit 2: X-ray Diffraction [6 hrs]

Production and properties of x-rays, Absorption of x-rays and filters, diffraction of X- rays through crystals, Bragg's law derivation and the factors affecting the intensity, Laue equations

for 3D structure, structure factor calculations for SC, BCC, FCC crystal structures, Laue method, Rotating Crystal method and Powder method, Indexing of powder photographs, applications of X-rays to metallurgical problems such as determination of type of lattice and lattice parameter, lattice strains, crystallite size, and residual stresses.

Unit 3: Scanning electron microscope [6 hrs]

Advantages of imaging with electrons, interaction of electrons with matter, secondary electron generation, optics of Scanning electron microscope (SEM), image formation, resolving power, modes of operation: Secondary Electron Imaging, Backscattered Electron Imaging, magnification, depth of focus, methods of specimen preparation, Influence of applied potential on image quality, fractography, SEM analysis of nonconducting samples, SEM of fluids and biological specimen, limitations of SEM, applications of SEM.

Unit 4: Transmission electron microscope [6 hrs]

Transmitted electron generation, optics of Transmission electron microscope (TEM), techniques of specimen preparation, image formation, resolving power, contrast mechanism, bright field and dark field imaging, selected area diffraction, indexing and applications of TEM, interpretations of few selected TEM results like e.g. grains, subgrain, phases, nanoparticles, planes, etc. other types of TEM: STEM, HRTEM, HAADF.

Unit 5: Elementary Analysis [6 hrs]

Micro-analysis by EDX, WDX, EELS, and EPMA, Surface analysis by XPS, Auger Electron Spectroscopy (AES), Scanning probe microscope: Scanning-Tunneling Microscope (STM) and Atomic Force Microscope (AFM).X ray fluorescence spectroscopy, raman spectroscopy, secondary ion mass spectroscopy, Fourier-transform infrared spectroscopy (FTIR).

Unit 6: Thermal analysis [6 hrs]

Basic principles and applications of thermogravimetry analyzer (TGA)/differential thermogravimetry analysis (DTG), differential thermal analyzer (DTA), differential scanning calorimeter (DSC), dilatometer etc., Basic concept of electrical resistivity, effect of temperature, processing and strengthening on the resistivity of metals and alloys.

Text Books:

- P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, 3rdEdition, Taylor and Francis, London.
- Microstructure Characterization, Edited by E. Metcalfe, The Institute of Metals, USA.
- B.D. Cullity, Elements of X-ray Diffraction (For X-rays), 3rdedition, Prentice-Hall, Upper Saddle River 2001.
- Thomas & M.T. Goringe, Transmission Electron Microscopy of Materials, John Wiley, 1979.
- L.E. Murr, Electron and Ion Microscopy and Microanalysis, Marcel Dekker, 1991.

- Padmakar R. Khangaonkar, An Introduction to Materials Characterization, Penram International Publishing (India) Pvt. Ltd.
- Douglas B. Murphy and Michael W. Davidson, Fundamentals of Light Microscopy and Electronic Imaging, John Wiley & Sons, Inc.
- Williams, David B., Carter, C. Barry, Transmission Electron Microscopy - A Textbook for Materials Science, Springer, 2009.
- Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin, P., Lifshin, E., Sawyer, L., Michael, J.R., Scanning Electron Microscopy and X-Ray Microanalysis, Third Edition, Springer, 2003.

Reference Books:

- ASM Metals Handbook, 9thEdition, Vol.10 - Materials Characterization - ASM International Publication, 1980.
- P.E. Flewitt, R.K. Wild, Micro structural Characterization of Metals and Alloys, Institute of Metals, London, 1986.
- V. T. Cherepin and A.K. Mallik – Experimental techniques in Physical Metallurgy, Asia Publishing House.
- George L. Kehl - Principles of Metallographic Laboratory Practice - Eurasia Publishing house Pvt. Ltd. (For Dilatometry, Thermal analysis and resistivity).
- BL Gabriel - SEM - A User's Manual for Material Science - American Society for Metals.

[MT-21006] Transport Phenomena

Teaching Scheme:
Lectures: 3 Hrs/week
Tutorial : 1 Hr/Week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Classify different types of fluids and apply appropriate equations to solve fluid flow problems.
2. Distinguish between laminar and turbulent flow and compute various parameters in metallurgical processes.
3. Identify the processes in which steady state and unsteady state thermal conduction is prevalent and determine the rate of thermal conduction.
4. Differentiate between natural convection and forced convection and determine the rate of convective heat transfer.
5. Compute the rate of radiative heat transfer in different processes and assess the operative mode(s) of heat transfer in a process.
6. Determine various parameters of a chemical reaction such as rate, order molecularity and rank various theories applied to slag-metal interfacial mass transfer.

Unit 1 **[9 Hrs]**

Types of fluid flow, Classification of fluids, viscosity of liquid metals, slags, gases, molten salts and polymers, Momentum balance, Flow of falling film, Fully developed flow between parallel plates, Equation of continuity and the momentum equation, Navier - Stoke's equation, Application of Navier - Stokes's equation: Flow over a plate, Flow in inlet of circular tubes, Creeping flow around a solid sphere, Stoke's law and its application to inclusion and gas bubble removal.

Unit 2 **[9 Hrs]**

Turbulent and complex flows, Friction factors for flow in tubes, Dimensional analysis for friction factor, Experimental results for friction factor, Flow past submerged bodies, Flow through packed bed reactor, Flow through fluidized bed reactor, Energy balance applications in fluid flow, Bernoulli's theorem, Applications of Bernoulli's theorem: Flow through ladles, Flow measurements, Flow through piping networks.

Unit 3 **[10 Hrs]**

Introduction to various modes of heat transfer. Steady state thermal conduction - Fourier's law, Thermal Conductivity and thermal diffusivity, Effect of variables on thermal conductivity, Critical thickness of insulation, Steady state heat conduction with heat generation, Application of steady state conduction to the refractories in furnaces, Unsteady state thermal conduction: systems without internal temperature gradient and systems with internal temperature gradient, Lumped heat capacity approach to systems without internal temperature gradient, systems with internal temperature gradient: finite, semi-infinite and infinite systems, Use of Heisler charts in quenching of metals and alloys, Application of unsteady state thermal conduction in processing of powders and amorphous materials, Unsteady state conduction in moving sources: line and point sources.

Unit 4 **[9 Hrs]**

Convective Heat Transfer: Concept of velocity and thermal boundary layer, natural and forced convection of metallic materials with different configurations, Significance of various dimensionless numbers in quenching and their explanation with dimensionless analysis – Buckingham π theorem, Heat transfer coefficient in various metallurgical systems and processes e.g. quenching, forging, packed bed reactor, fluidized bed reactor, Convective heat transfer in solidification of melts and application of Chvorinov's rule.

Unit 5 **[10 Hrs]**

Radiation Heat Transfer: Principles of radiation heat transfer, Terms in radiation, laws of radiation, Emissivity, Radiation heat transfer between black bodies, non - black bodies, radiation shape factors, shape factor algebra, Interchange factor, Radiation heat transfer in furnaces, Few real life examples wherein all the modes of heat transfer are operative such as operation of fuel cells, curing of thermosetting polymers, heat loss through human body etc.

Unit 6 **[9 Hrs]**

Basic kinetics laws, order and molecularity of reactions, rate constant, elementary & complex reactions, Rate limiting steps and Arrhenius equation, Theories of reaction rates – simple collision theory, activated complex theory, Concept of activation energy, Unsteady state mass transfer, differential formulation of mass transfer, Convective mass transfer and concept mass transfer coefficient, Theories of mass transfer dealing with slag-metal interface.

Text Books

- D.R. Poirier, G.H. Geiger, Transport Phenomena in Materials Processing, 1st Edition, 1994, The Minerals, Metals and Materials Society (2016 Reprint by Springer Int. Publishers)
- T.L. Bergman, A.S. Lavine, F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, 7th Edition, 2011, John Wiley and Sons.
- A.K. Mohanty, Rate Processes in Metallurgy, 1st Edition, 2004, Prentice Hall of India.
- D.R. Gaskell, An introduction to Transport Phenomena in Materials Engineering, 2nd Edition, 2012, Momentum Press.

Reference Books

- R.B. Bird, W.E. Stewart, E.N. Lightfoot, Transport Phenomena, 2nd Ed., John Wiley & Sons.
- J. Welty, C.E. Wicks, R.E. Wilson, G.L. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 5th Edition, 2007, John Wiley and Sons.
- O. Levenspeil, Engineering Flow and Heat Exchanges, 3rd Edition, 2014, Springer.
- J.P. Holman, Heat Transfer, 10th Edition, 2010, McGraw Hill Higher Education.
- S. Kou, Transport Phenomena and Materials Processing, 1st Ed., 1996, John Wiley and Sons.
- J. Szekely, N.J. Themelis, Rate Phenomena in Process Metallurgy, 1st Ed., 1971, Wiley Inter science.

[MT-21007] Mineral Processing and Extractive Metallurgy Laboratory

Teaching Scheme:

Laboratory : 2 Hrs/week

Examination Scheme:

Continuous Evaluation – 50 marks
End Sem Exam – 50 marks

Course Outcomes:

At the end of course students will be able to

1. Prepare the ore concentrates
2. Manufacture the metal by reduction of ore using pyrometallurgy , hydrometallurgy and electrometallurgical techniques.
3. Calculate the temperature, energy required and yield of metal produced.

List of Experiments:

1. Performing Crushing of ores using Roll crusher and Jaw crusher.
2. Grinding of ore and its sieve analysis.
3. Study of Palletizing of Iron Ore

4. Study and perform Calcination of $CaCO_3$ and $MgCO_3$.
5. Study and perform Cementation process of Copper.
6. Study of Aluminothermic reduction of iron ore
7. Perform Hydrometallurgical extraction of copper and Zinc
8. Solving Numericals based on Extraction of nonferrous metals.
9. Assignments based on present scenario of nonferrous metals in India and Abroad.

[MT-21008] Materials Characterization Laboratory

Teaching Scheme:
Laboratory: 2 hrs/week

Examination Scheme:
Continuous evaluation - 50 Marks
End Sem Exam - 50 Marks

Course Outcomes:

At the end of course students will be able to

1. Understand, use and compare various characterization equipments for conducting microstructure and grain size evaluation.
2. Apply the knowledge of crystal structure and X ray diffraction to determine the lattice constant, crystal structure and quantify the retained austenite and residual stresses in a sample.
3. Determine the CTE of the metals, alloys and polymers using dilatometer.

List of Experiments:

1. To determine grain size of ferrous and nonferrous alloys using various techniques
2. Microhardness measurement of ferrous and nonferrous alloys
3. To study dilatometry to determine linear coefficient of thermal expansion (LCTE) of different materials
4. To study Simultaneous Thermal Analysis of various samples
5. Study of Different Types of Symmetry in Cubic Lattices
6. To study stereographic and standard projections to evaluate crystal orientation problems
7. To determine high temperature resistivity of various materials.
8. XRD: Indexing a diffraction pattern from cubic materials.
9. To study surface morphology and fractography by Scanning Electron Microscopy
10. X ray diffraction analysis to determine the retained austenite content in the sample.
11. X ray analysis to determine the residual stresses in formed sample.

[MT-21009] Materials Software Tools Laboratory

Teaching Scheme:
Laboratory : 2 hrs/week

Examination Scheme:
Continuous Evaluation – 50 marks
End Sem Exam – 50 marks

Course Outcome:

At the end of course students will be able to

1. Apply various software tools for plotting, analyzing and processing the data obtained from various experiments.
2. Use models and simulation tools to predict the results.
3. Correlate structure property relationship

List of Experiments

1. Use of ImageJ software for Calculation of Phase Fraction of at least 3 microstructure by Threshold Adjustment Method, Area measurement method in Microstructures of Cast Iron, Titanium Alloys, Plane Carbon steel, Alloy Steel, Copper alloys, for porosity in sintered alloy etc.
2. Use of ImageJ software for Counting of Pores, Carbides, second phase particles, Blow Holes in at least 3 Microstructures of As Cast, Sintered metals components, Heat Treated Alloy steels, Precipitation hardenable Al alloys, etc.
3. Use of ImageJ software to measure distances between atomic planes in high resolution transmission electron microscopy (TEM) images using Fast Fourier transform (FFTs). Also Measuring length and angle in TEM-SAD pattern.
4. Use of ImageJ software for Grain Size Measurement
5. Use of ATEX software for Plotting and Processing of X-Ray Data and Raman spectroscopy Data
6. Use of ATEX software for Plotting and analysis of EBSD Data and extracting micro structural information like – Grain Boundary Area, Grain Orientation Map, Grain Boundary Character Distribution
7. Use of ATEX software to simulate Sheet Rolling Process and study the effect of various process parameters
8. Use of ATEX software to simulate ECAP Process for given parameters and study the effect of various process parameters
9. Use of Matlab Modules to find Solution of Heat Transfer Problem.
10. Use of Matlab Modules to optimization of Multiobjective problems
11. Data Plotting, Curve Fitting, Regression analysis using suitable Software
12. Plotting of 2D and 3D data, Contour Maps, Pie Chart etc using Microsoft Excel or any suitable software
13. Simulation of Casting Processes using Click-to-Cast Software or any suitable software
14. Use of FEM Based Solver to simulate deformation/phase transformation of metals and alloys.

Course for B.Tech Minor (Metallurgical Engineering)

[MT(MI)21001] Heat Treatment Technology

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

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

1. Understand the basic principles of various heat treatments.
2. Analyse the effect of heat treatment processes on the micro-structure and properties of materials
3. Design of various heat treatment cycles using phase diagrams, TTT, CCT diagrams
4. Design of thermo-mechanical treatment for micro-alloy steel, dual phase steel, tool steel Maraging steel and stainless steel
5. Compare various surface heat treatments given to steels
6. Analyse effect of furnace atmospheres on heat treatment processes and reasons behind defects after heat treatments

Unit I: **[6 hrs]**

Heat treatment of plain carbon steels: Annealing, Isothermal and subcritical Annealing types, Normalizing, Hardening Heat Treatment: Quenching process, characteristics and kinetics of martensitic transformation, Bain model, Retained austenite and its effect, Tempering and subzero treatment. Hardenability: Mass effect, Grossman method, Critical and ideal critical diameter, Jominy End Quench method, Use and Significance of Hardenability data, Effect of grain size and composition, Residual stresses, Quench cracking, Case studies of design changes for hardening.

Unit II: **[6 hrs]**

Classification of alloying elements and their effects on Iron–Iron carbide phase diagram, TTT Diagram and CCT Diagram, General Heat treatments such as Annealing, Normalizing, Hardening, Tempering, Austempering, Martempering, Hardenability concept, Stages of Quenching and their effects, Types of quenching media such as oils, polymers; Cooling characteristics of quenching media, Control of quenching parameters, quenching fixtures, Dimensional changes during hardening and tempering.

Unit III: **[6 hrs]**

Heat treatment to commercial alloys steels-1: Heat treatment of Low alloy steels, Free cutting steels, Spring steels; bearing steel, Tool Steel: Selection criteria and properties of Tool steels, Classification of Tool Steels: Cold work, Hot Work Tool Steels, High Speed Steels and Stellites; Heat treatments of Die and Tool steels, Secondary hardness and Red Hardness, Subzero

treatment, Super High Speed Steels, TRIP Steels.

Unit IV: **[7 hrs]**

Heat treatment to commercial alloys steels-2: Stainless Steels: Fe-Cr, Fe-Ni Phase Diagram, Schaeffler Diagram and its modifications, Classification of Stainless Steels, sensitization, Heat treatment of stainless steels, Precipitation Hardening Stainless Steels, Marageing Steels, Superalloys and their heat treatment.

Unit V: **[6 hrs]**

Thermomechanical Processing of Steels: Basics of thermomechanical processing, Controlled rolling of low alloy steels, DP steels, TRIP steels and TRIP assisted Steels, QP steel TWIP steels, Industrial steel subjected to thermomechanical treatments.

Unit VI: **[6 hrs]**

Surface hardening: Carburizing, Carburizing atmosphere and Heat treatment after Case Hardening, Bainite control in case, Case depth measurement, ASTM E1077-01 Depth of carburization, Drip Feed Carburizing, dimensional changes during case hardening; Nitriding, Carbonitriding, Tufftriding, Nitrocarburising, Plasma Nitriding; Induction Hardening, Flame Hardening, Laser Hardening, Selection of steels for these treatments and their applications. Classification of atmospheres for heat treatments, Generation of atmospheres and their applications. In situ atmosphere generation, Thermodynamics and Kinetics of atmospheres, Control and monitoring of Furnace Atmospheres: Infrared controller, Gas chromatography, Dew point analyzer and Oxygen probe analyzer Heat treating furnaces: Salt bath furnace, Fluidized bed furnace, Sealed Quench furnace, Vacuum furnace, Heat Treatment Defects such as Distortion, Residual stresses, quench cracks and Design for Heat treatment.

Text Books:

- Heat Treatment of Metals, Vijendra Singh, 2007, Standard Publishers and Distributors, New Delhi
- R.A. Higgins, Engineering Metallurgy, Part I, App. Physical Met, ELBS, 5th ed., 1983
- H. K. D. H. Bhadeshia, Robert Honeycombe, Steels: Microstructure and Properties, Third edition, Publisher Elsevier Ltd., UK

Reference Books:

- Steel and its Heat Treatment -K.E Thelning, Butterworth, London
- Handbook of Heat Treatment of Steels – Prabhudev-Tata McGraw Hill. New Delhi, 1988
- Heat Treatment of Ferrous Alloys, Brooks, Washington: Hemisphere Pub., 1979
- ASM Metals Handbook – Heat treatment, Metals Park Ohio Pub.
- ASM Metals Handbook – Steels, Metals Park Ohio Pub.

Course for B.Tech Honors (Materials Engineering)

[MT(HO)21001] Advanced Ceramic Engineering

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Develop fundamental understanding of the advanced ceramics.
2. Understand the important properties and applications of advanced ceramics.
3. Select an appropriate ceramic composition-crystal structure and create desired microstructure and properties through appropriate processing methods.
4. Analyze and solve the problems related to advanced ceramics.
5. Evaluate performance of these ceramics for the desired end applications.

Unit I: [7hrs]

Dielectric materials, Basic Theory, Polarization (electronic, Ionic, dipolar, space charge), Dielectric constant and Loss, High-Q materials, high-ε_r materials, Capacitors and insulators, Frequency dependence of ε_r & tan δ, Temperature dependence of ε_r, resonant frequency; and tan δ, AC impedance & its measurement, ac conductivity, Debye equations, Dielectric Breakdown, factor affecting dielectric constant and loss, case studies, ceramic supercapacitor materials.

Unit II: [7 hrs]

Piezoelectric and ferroelectric materials, Crystallographic Considerations, Structural origin of the ferroelectric state, Hysteresis, Ferroelectric domains, Antiferroelectric Ceramics, Piezoelectric figures of merit (piezoelectric strain constant d, the piezoelectric voltage constant g, the electromechanical coupling factor k, the mechanical quality factor QM, and the acoustic impedance Z), Case studies on Piezoelectric materials (Single Crystals, Polycrystalline Materials), Morphotropic phase boundary, Relaxor Ferroelectrics, Piezoelectric Devices such as pressure sensors, resonators/filters and actuators.

Unit III: [7 hrs]

Ceramics for energy and environment technologies: Basic theory of Electrical and Ionic Conductivity in solids, fast ion conductors (FICs)/ solid electrolytes, Nernst-Einstein relationship, fuel cell : currently used materials: electrolytes, cathodes, anodes, interconnects, lithium and high energy batteries, production process of Li-ion battery , gas sensor and catalytic support, Ceramics in Electrochemical cells : Sodium sulphate cell (with β – alumina), Joncher's power law, Arrhenius equation, Activation energy, case studies on energy ceramics.

Unit IV: **[7 hrs]**

Magnetic Ceramics: Spinel Ferrites, Hexagonal Ferrites , Garnet , Processing , Single crystal ferrite, Applications . Critical parameters, Powder synthesis, case studies on magnetic ceramics.

Unit V: **[7hrs]**

Bioceramics: Biocompatibility, Structure of typical human bone, ceramics for artificial bone, requirement for artificial material to bond to living bone, apatite formation, Tissue attachment mechanism, Bio- active and biogenic materials, nearly inert crystalline ceramics, bioceramic implants for hip and knee prosthesis; hydroxyapatite related ceramics/composites; porous ceramics, bioactive glass and glass ceramics, Bioactive cements, calcium phosphate ceramics, carbon base implant materials, ceramics for dental applications.

Unit VI: **[7hrs]**

Glass and glass-ceramics: Definition of glass, Basic concepts of glass structure, theory of glass formation, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses. Application of glasses, Glass ceramics-controlled devitrification of a glass & fabrication, advantages of glass ceramic formation, properties and applications, Low temperature co-fired glass ceramics.

Text Books:

- C. Barry Carter, M. Grant Norton, Ceramic Materials- Science and Engineering, Second Edition, Springer New York, 2013
- W.D. Kingery, H.K. Bowen and D.R. Uhlman, Introduction to Ceramics, Ceramic Science and Technology, John Wiley and Sons, Singapore, 1991.
- M.W. Barsoum, Fundamentals of Ceramics, 2nd edition, IoP Publications, UK, 2003
- C.J. Brinker, D.E.Clark, and D.R. Ulrich, Better Ceramics through Chemistry, North Holland,1984.
- F.F.Y. Wang, Ceramic Fabrication Processes, Academic Press, 1976.
- J. Reed, Introduction to Principles of Ceramic Processing, 2nd Ed., John Wiley & Sons1995
- Van Vlack, Physical Ceramics for Engineers, Addison Wesley, 1964

Reference Books:

- Shigeyuki Somiya (Editor-in-Chief), Handbook of Advanced Ceramics, Volume II Processing and their Applications, Elsevier Academic Press, London, UK, 2003
- R.C. Buchanan, Ceramic Materials for Electronics, Processing, Properties and Applications
- S. Kumar: Hand book of ceramics; Vol – I & II
- M. N. Rahaman, Ceramic Processing and Sintering, 2nd edition, Marcel Dekker Inc., NY, 2003.

Course for B.Tech Honors (Process Metallurgy)

[MT(HO)-21002] Advanced Composites

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

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

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

Unit I: **[7 hrs]**

Composite materials in engineering, reinforcements and the reinforcement matrix interface - natural and synthetic fibers, synthetic organic and inorganic fibers, particulate and whisker reinforcements, reinforcement-matrix interface.

Unit II: **[7 hrs]**

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.

Unit III: **[7 hrs]**

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.

Unit IV: **[7 hrs]**

Structural Composites: Cement matrix composites, Steel Reinforced Concrete, Prestressed concrete, Thermal Control, Vibration reduction.

Unit V: **[7 hrs]**

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.

Unit VI: **[7 hrs]**

Composite materials for optical and magnetic applications, optical waveguide, optical filters and lasers, multilayer for magnetic applications.

Textbooks:

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

Reference Books:

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

Semester-VI

[MA - 21001] Probability and Statistics for Engineers

Teaching Scheme:
Lectures: 2 hrs/week
Tutorial : 1 hr/Week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

Students will be able to

1. Demonstrate number of methods of summarizing and visualizing data sets, evaluate probabilities of events.
2. Make use of concepts of random variables and associated probability distributions to solve problems, illustrate the central limit theorem.
3. Test for basic statistical inference (t-test, z-test, F-test, χ^2 –test, confidence interval, non-parametric tests).
4. Explain basic principles of regression analysis and perform the same.
5. Demonstrate use of R software for all the above.

Unit I: **[5 hrs]**

Descriptive statistics: Measures of location and variation. Visualization of data: Frequency tables, bar diagrams, histograms, heat maps, other visualization tools. Review on introduction to combinatorics and probability theory.

Unit II: **[5 hrs]**

Some of the basic probability distributions: Binomial, Poisson, Exponential, and Normal. Central limit theorem.

Unit III: **[4 hrs]**

Introduction to 'R': Introductory R language fundamentals and basic syntax, major R data structures, Using R to perform data analysis, creating visualizations using R.

Unit IV: **[6 hrs]**

Basic statistical inference and hypothesis testing: Estimation, basic tests such as t-test, z-test, F-test, χ^2 -test. Nonparametric tests: Sign test, Wilcoxen signed rank test.

Unit V: **[4 hrs]**

Regression methods: Simple linear regression and multiple regression.

Unit VI: **[4 hrs]**

Engineering applications of statistics (Branch specific (any 2)): Discussion on reliability and quality control. Introduction to random processes, stochastic processes, Markov chains, Machine learning and data science.

Text Books:

- Ronald E, Walpole, Sharon L. Myers, Keying Ye, Probability and Statistics for Engineers and Scientists (8th Edition), Pearson Prentice Hall, 2007.
- Tilman M. Davies, The book of R: A first course in Programming and Statistics (1st Edition), No Starch Press, USA, 2016.

Reference Books :

- Ross S.M., Introduction to probability and statistics for Engineers and Scientists (8th Edition), Elsevier Academic press, 2014
- S. P. Gupta, Statistical Methods, S. Chand & Sons, 37th revised edition, 2008.
- Kishor S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications (2nd Edition), Wiley Student edition, 2008.
- Stephens L.J., Schaum's outline of statistics for Engineers, Latest edition, 2019.
- The practice of Business Statistics by Manish Sharma and Amit Gupta, Khanna Publishing Company Private Limited, New Delhi, 2014.

References for R Software :

- Norman Matloff, The Art of R Programming - A Tour of Statistical Software Design, (1st Edition), No Starch Press, USA, 2011.
- Sudha Purohit, Sharad Gore, Shailaja Deshmukh, Statistics using R (2nd Edition), Narosa Publications, 2019.
- Randall Pruim, Foundations and Applications of Statistics - An introduction using R (2nd Edition), American Mathematical Society, 2018.
- Hadley Wickham and Garrett Grolemund, R for Data Science: Import, Tidy, transform, Visualize and Model Data, (1st Edition), O'Reilly Publications, 2017.

[ML-21001] Constitution of India

Teaching Scheme:
Lectures: 1hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem exam - 60 Marks

Course Outcomes

At the end of course Student will be able to

1. Interpret the Preamble and know the basics of governance of our nation.
2. Identify the different aspects covered under the different important Articles.
3. Apprehend the basic law, its interpretation and the important amendments.
4. Understand our Union and State Executive better.
5. Recognize the basic that along with enjoying the rights one needs to fulfill one's duties.
6. Summarize and Gain confidence on our Constitution by knowing it better.

Unit 1 : **[5 hrs]**

Understanding the concept 'Rule of Law '
Meaning and history of Constitution.
Introduction to The Constitution of India, understanding its objects.
Preamble to the constitution of India

Unit 2: **[4 hrs]**

Understanding the concept of Human Rights and Fundamental Rights.
Fundamental rights under Part – III, exercise of the Rights, limitations and important cases.
Prerogative Writs.
Fundamental duties & their significance.

Unit 3: **[4 hrs]**

Relevance of Directive principles of State Policy.
Legislative, Executive & Judiciary (Union and State)
Constitutional Provisions for Scheduled Castes, Scheduled Tribes, & Backward classes.
Constitutional Provisions for Women & Children

Unit 4: **[2 hrs]**

Emergency Provisions.
Electoral procedure in India
Amendment procedure and few important Constitutional Amendments

Text Books:

1. Introduction to the Constitution of India by Durga Das Basu (Students Edn.) Prentice – Hall EEE, 19th/20th Edn..
2. Engineering Ethics by Charles E.Haries, Michael. S.Pritchard and Michael J.Robins Thompson Asia,.

Reference Books:

1. An Introduction to Constitution of India by M.V. Pylee, Vikas Publishing.

Humanities and Social Sciences Open Course

[AS(HS)-21001] English Language Proficiency

Teaching Scheme:
Lectures : 2 hrs/week

Examination Scheme:
T1 and T2: 60 Marks
End-Sem Exam: 40 Marks

Course Outcomes:

At the end of the course, student will be able to

1. Understand concepts of English language and apply them practically.
2. Reproduce meaningful and well-structured sentences for conversation or speech in English.
3. Analyze, comprehend and write well and effectively produce enhanced formal communication in English.
4. Display their Presentation skills and participate and produce healthy discussions both formally and informally among peers using English.
5. Create impact by acquiring professional skills, confidently face interviews and be better employable and industry ready.

Unit 1: English for communication [8 hrs]

Basic understanding of language and its need for effective business communication for Engineers, Formal and informal expressions, Vocabulary Building, Business Idioms

Unit 2: Presentation Skill Development [6 hrs]

Oral Presentations, Basic Mannerisms and Grooming required for professionals, Cross cultural communication, Business Etiquette

Unit 3: Business Writing [8 hrs]

Writing Mechanics, Note making, Summarizing, Letter & Email Writing, Business Reports, Statement of Purpose

Unit 4: Employability Enhancement [6 hrs]

Job Readiness, Interview Skills and Mock Interviews

Reference books:

1. Business Communication by Shalini Verma (2nd Edition) (Vikas Publishing House)
2. Communication for Business: A Practical Approach by Shirley Tailor (Longman)
3. Communication Skills for Engineers by S. Mishra & C. Murali krishna (Pearson)
4. Communication Skills for Technical Students by T.M. Farhathullah (Orient Longman)
5. Enhancing Employability at Soft Skills by Shalini Varma (Pearson)
6. Written Communication in English by Saran Freeman (Orient Longman)
7. Corporate Communication by Jaishri Jethwaney (Oxford University Press)

8. Business Correspondence and Report Writing, R. C. Sharma & Krishna Mohan (Tata McGraw Hill)
9. Essential English Grammar (Intermediate & Advanced) Raymond Murphy (CUP)

[AS (HS)-21002] German Language

Teaching Scheme:
Lectures : 2 hrs/week

Examination Scheme:
Assignments: 40 Marks
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of the course

1. Acquire knowledge of facts about Germany and German culture (cultural sensitization).
2. Adapt pronunciation of German letters and greetings.
3. Identify and calculate numerical till 1000.
4. Describe themselves and third person.
5. Construct simple questions or sentences and interact with the teacher and classmates.
6. Comprehend time and time related phrases, illustration of the same in conversations.
7. Handle day to day situations like placing an order in the restaurant or interact with shopkeeper in the supermarket.

Unit 1:Guten Tag! (Good day) [6 hrs]

Greetings, self introduction and partner introduction, numbers till 100, how to mention telephone number and email address, about countries, nationalities and languages.

Unit 2:Freunde, Kollegen und ich (Friends, colleagues and myself) [6 hrs]

Hobbys, days of the week, months, seasons and professions, classroom objects and classroom communication

Unit 3: Dining out. [6 hrs]

Understanding German cusine, meal courses, names of the ingredients, conversation with the waiter and in the supermarket.

Unit 4:Uhrzeit (Timing) [6 hrs]

Mention time, daily routine, making appointments

Unit 5:Grammatik (grammar) [6 Hrs]

Vocab, Verb conjugations, WH-question, verbs, pronounciation, personal pronouns, articles, Singular and Plural, negation.

Reference Books:

1. Dengler.S., Rusch. P., Schmitz.S., & Sieber.T. Netzwerk, Deutsch als Fremdsprache. 2015. Goyal Publishers & Distributors Pvt. Ltd. Delhi, India
2. You tube video series “learn German”, “easy German” etc.
3. Funk.H., Kuhn.C., & Demme.S. Studio d A1. Deutsch als Fremdsprache. 2011. Goyal Publishers & Distributors Pvt. Ltd. Delhi, India.

[AS (HS)-21003] Japanese Language

Teaching Scheme:

Lectures : 2 hrs/week

Examination Scheme:

Assignments: 40 Marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Acquire knowledge of facts about Japan and Japanese culture,
2. Familiarize with pronunciation of Japanese letters and daily greetings, Accent, Intonation and Japanese Writing System Hiragana, Katakana and Kanji
3. Identify numbers, Colors, Years, Months and Days, Time expressions, Directions to read the city map
4. Describe themselves and third person and family members
5. Construct simple questions or sentences and interact with the teacher and classmates.
6. Apply Engineering Terminology and Japanese work culture such as Monozukuri, 5S, Kaizen, 3M, 5W1H etc.

Unit 1 **[6 hrs]**

Introduction to Japanese Language (Nihongo)

Recognize Japanese Characters Hiragana. Can read /write Hiragana script
Use basic classroom expressions
Exchange greetings Can thank someone or apologize someone
Recognize Japanese Characters Katakana Can read /write Katakana script
Can ask someone to say something again if you don't really understand

About Me & Food

Give simple self-introduction Can ask and answer where you live and your age.
Can write your name, nationality, date of birth and occupation in Japanese.
Recognize the parts of a business card
Talk someone briefly about your family using a family photo and answer simple questions such as who is that? Number of family members.
Talk about your favorite foods you like and dislike. Talk about your breakfast.
Can respond when offered a drink. For example saying what you want to drink.
Can look at menu in a fast food restaurant and understand what is available.

Can look at different restaurants' signboards and understand what each place is.

Unit 2 **[6 hrs]**

Home & Daily life

Say what kind of house you live in. Say what you have in your home.
Write an e mail inviting someone to your home. Visit/ Welcome a friend.
Ask /say where to put things in the room. Can read the buttons on an electric appliance
Can listen to a simple explanation when being shown around a room and understand the layout.
Recognize the name and address on signs. Talk about your daily routine. Say the time you do something. Talk about your schedule at work for the week.
Can listen to short and simple instructions at work and understand what to do.
Can read a simple, handwritten note at work and understand the instructions.
Can ask someone to lend you something at work.
Can look at a list of equipment and confirm if you have all the items

Unit 3 **[7 Hrs]**

Holidays and Days off 1 and Towns

Can give a simple answer when asked about your hobbies and favorite things to do.
Talk about what you do on your days off.
Can read an event poster and find the important information such as the date, time and place.
Can ask and answer questions about whether you are going to an event etc.
Can say when you are available, when you are inviting someone to something or being invited
Recognize station and Taxi signs.
How to get to particular destination using a map
Can say how you go to work and how long it takes.
Describe places in town and location
Can look at common signs in a station and understand what they mean.

Unit 4 **[6 Hrs]**

Shopping & **Holidays and Days off 2**

Talk about what you want to buy.
Can ask staff in a shopping center etc. Where to go for a certain item and understand the answer.
Can look at discount signs and read the prices.
Make a brief comment on things in a shop.
Can read a short blog / simple e mail
Can talk in simple terms about impressions of the holiday / trip.
Can write a simple post for social media etc. About what you did in holiday.

References Books

- Marugoto A1 Katsudo Starter Coursebook for Communicative Language Activities.

- Marugoto A1 Rikai Starter Coursebook for Communicative Language Competences
- The Japan Foundation
- Minna no Nihongo Main Textbook Elementary Lesson 1-12
- Minna no Nihongo Translation & grammatical Notes in English Elementary Lesson 1-12,3A Corporation Goyal Publishers

[AS (HS)-21004] Spanish Language

Teaching scheme
Lectures: 2 hrs / Week

Evaluation scheme
Assignments: 40 Marks
End Semester: 60 Marks

Course Outcomes:
At the end of the course, student will demonstrate the ability to:

1. Acquire knowledge of facts about Spain and Latin Americaand Spanish culture, pronunciation of Spanish letters and greetings.
2. Identify and calculate numerical till 1000.
3. Describe themselves and third person.
4. Construct simple questions or sentences and interact with the teacher and classmates.
5. Comprehend time and time related phrases, illustration of the same in conversations, handle day to day situations like placing an order in the restaurant or interact with shopkeeper in the supermarket.

Unit 1 **[6 hrs]**

¡Hola! (Hello)

Greetings, self introduction and partner introduction, numbers till 100, how to mention telephone number and email address, about countries, nationalities and languages. Hobbys, days of the week, months, seasons and professions, classroom objects and classroom communication.

Unit 2 **[6hrs]**

La comida (Food)

Understanding Spanish cusine, meal courses, names of the ingredients, converstaion with the waiter and in the supermarket.

Unit 3 **[6 hrs]**

La ropa (clothing)

Clothing, accessory (as per weather), season + weather, vocabulary, Demonstrative pronouns, how to ask about price, numbers till 1000.

Unit 4 **[6 hrs]**

La hora (Timing)

Mention time, daily routine, making appointments

Unit 5 **[6 hrs]**

La gramática (grammar)

Vocab, Verb conjugations, WH-question, verbs, pronounciation, personal pronouns, articles, Singular und Plural, negation.

Reference Books

- Aula internacional Jaime Corpas, Eva García, Agustín Garmendia, Neus Sans Baulenas (contributor), published by Goyal Publishers and Distributors Pvt. Ltd.

[HS-21001] Entrepreneurship Principles and Process

Teaching scheme

Lectures: 1 hr / week

Evaluation scheme

Field Work/Assignments 40 Marks
End Semester 60 Marks

Course Outcomes:

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

1. Discover, develop, and assess different types of Entrepreneurial ventures and opportunities.
2. Learn about opportunity and risk analysis
3. Use the strategies for valuing your own company, and how venture capitalist and angel investors use valuations in negotiating milestones, influence and control
4. Pick correct marketing mix and how to position the company in the market by using analytical tools
5. Learn how to sale themselves and the product/service and to handle objections
6. Know how organizations operates, their process matrices, start new ventures, write winning business plans

Unit 1 **[3 hrs]**

Market Research

Introduction to Entrepreneurship, Profile of the Entrepreneur, Market Gap /Opportunity Analysis, Market Research Methods, Defining the Focal Market: Market Segmentation, Industry analyzing– Research /Competitive Analysis. Company/ Organization Types, Legal Aspects, Taxation, Government Liaison, Building the Team, Mergers and Acquisitions

Unit 2 **[4 hrs]**

Business Finance, Marketing & Digital Marketing

Shares and Stakes, Valuation, Finance Creation (Investors/Financers), Revenue Plans and Projections, Financial Ratios, Business Lifecycle, Break Even. Marketing Basics, Marketing Strategy and Brand Positioning, Plans and Execution Techniques, Marketing Analytics, Online Marketing

Unit 3 **[3 hrs]**

Sales & Operations Management

Understanding Sales, Pitching Techniques, Sales strategies, Inside Sales v/s Outside Sales, RFP Operational Basics, Process Analysis, Productivity, Quality

Unit 4 **[2 hrs]**

Start-ups Start-up Basics, Terms, Start-up Financing, Start-up Incubation, Start-up Incubation, Getting Listed

Text Books

- The Startup Playbook: Secrets of the Fastest- Growing Startups From Their Founding Entrepreneurs by David Kidder
- True North by Bill George and Peter Sims
- Cardullo,M.W.P.E.(1999).Technological entrepreneurism: Enterprise formation, financing, and growyh. England: Research Studies Press Ltd.

Reference Books

- Kanungo, R.N.(1998).Entrepreneurship and innovation: Models for development(Ed., Vol.2). New Delhi: Sage.
- Van Nostrand. Verma , J.C.,& Singh ,G.(2002).Small business and industry: A hand book for entrepreneurs. New Delhi: Response-Sage.
- Richard A Brealy & Steward C Myres. Principles of Corporate Finance, McGraw Hills, 7thEdn,2004
- Prasanna Chandra, Financial Management: Theory and Practice, Tata McGraw Hills, 6thEdn, 2004IMPandey,FinancialManagement,Vikas Publishing

[MT-21010] Mini Project

Teaching Scheme:
Laboratory: 4 hrs/week

Examination Scheme:
Term work - 50 Marks
End-Sem exam - 50 Marks

Course Outcomes:

At the end of course students will be able to

1. Identify the problem definition of project by analysing the literature review.
2. Design the experiments and its setup to obtain the specific objective of project
3. Work in laboratory effectively and safely on multidisciplinary projects.
4. Communicate the technical information effectively in both verbal and written forms.

Project Work:

The students shall be assigned a small project, which will test their creativity in the area of design and development, setting of new experiments. It should form a part of literature

and feasibility survey. The outcome of mini-project should preferably lead to a major project. Collection of samples for metallography laboratory, cold models concerned with metallurgical processes. Mini-project can be the stage-I of the major project where literature survey and experimental-planning for the major project will be the main goals. At the end of semester student shall submit a detail write-up on the project work undertaken by them including literature survey from reputed journals, proceedings, conferences, problem definition, objective of project, experimental planning/methodology. Evaluation will be on the basis of the attendance, set up created and seminars delivered/oral examination given by the students.

Department Elective:

[MT(DE)-21001] Wire Drawing & Sheet Metal Forming

Teaching Scheme:
Lectures : 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem exam : 60 marks

Course Outcomes (CO):

At the end of course students will be able to

1. Understand the manufacturing, microstructure, properties and applications of wire drawing and sheet metal forming.
2. Apply the knowledge of mechanical working processes and the mechanical metallurgy to appreciate the working principle of wire and sheet metal manufacturing processes.
3. Analyze the manufacturing, microstructure, properties and application relationship to interpret the manufacturing process outcome.
4. Compare the various inspection techniques based on application, fabrication and service conditions to carry out the defects and failure analysis.
5. Design the manufacturing process flowchart and process parameters for wire drawing and sheet metal forming suitable for a particular application.

Unit I: Introduction to Mechanical working [6 hrs]

Basics of metal forming, hot, cold and warm working of metals, strain rates in metal forming, an overview of elementary stress analysis and yield criteria, description and analysis of various bulk forming processes (forging, extrusion, wire drawing and rolling), concept of Workability. Understanding the influence of alloying elements, temperature and cooling rates post deformation processing (recovery, recrystallization and grain growth) on the evolution of microstructure and properties.

Unit II: Drawing of rods, wires and tubes [6 hrs]

Theory and practice of wire drawing, Wire drawing equipment, drawing die and die design, calculations of optimum die parameters, the Stelmor cooling process, Fundamentals of wire processing – acid pickling and descaling, coatings, lubricants, heat treatment on wire - annealing and tempering, patenting drawing strains, strain rate.

Unit III: Testing and applications of wire [6 hrs]

Mechanical testing–Hardness, tensile testing (yield strength, Ultimate Tensile Strength, ductility measurement - reduction of area), torsion, fatigue. NDT Techniques – Eddy Current Testing, Defects and failure analysis – inclusions, centerburst, crow feet, die chatter, galling, applications of wires and their basic principles e.g. tire cords, ball bearings, etc.

Unit IV: Introduction to Sheet metal working [6 hrs]

Introduction to sheet metal working,selection of forming equipments –dies and presses,shearing operation, clearance, angular clearance, blanking die design, drawing-blank size calculations, forming limit criteria, number of draws, drawing force, Bending-Bend allowance, bending force calculations, springback and springback compensation,

Unit V :Sheet Metal Forming Processes [6hrs]

Sheet hydroforming, Incremental sheet metal forming, Explosive forming, Super plastic forming, Electrohydraulic and Magnetic Pulse forming Peen forming, Forming Limit Diagram, Sheet metal cutting, slotting, perforating and Notching of sheets

Unit VI: Testing &Applications of Sheet Metal Forming [6hrs]

Formability Testing, Cupping test on sheet metal, defects in sheet metal forming and their mitigation, applications of sheet metal, Economics of Sheet hetal Forming, application of software in sheet metal working.

Text Books:

•Steel Wire Handbook – Vol 1-4, edited by Allan B. Dove, The Wire Association

• Mechanical Metallurgy, 3rd Edition, George E Dieter, McGraw-Hill, London,1988.

•Serope Kalpakjian & Steven R. Schmid, “Manufacturing processes for engineering materials

Reference Books:

• International Branford, 1965,1968, 1969, 1972 Ferrous Wire – Volume 1 and 2, The Wire Association International

• Electrical Wire Handbook – Part 1 and 2, The Wire Association International

• Physical Metallurgy Principles, Reed-Hill, 2nd ed, East West Press, New Delhi, 1973

• Heat Treatment, ASM Handbook, Vol.4, ASM International, Ohio, 1991

•Research Articles from Technical Publications and Conferences.

Department Elective:

[MT(DE)- 21002] Tribology of Materials

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course outcomes:

At the end of course students will be able to

1. Define different types of wear and wear modes in tribology.
2. Classify different wear measurement techniques to interpret material wear behavior.
3. Select suitable material combination for improved tribological performance.
4. Analyze effect of material properties on wear rate of the materials.
5. Recommend suitable material system for desired operating window in tribology domain.
6. Modify tribological system for sustainable performance.

Unit I: Introduction to Tribology [7hrs]

Introduction to tribology, history of tribology, definitions and development of wear studies, factors influencing tribological phenomena, properties of materials relevant to friction and wear, scope and challenges; types of wear; relevant ASTM standards.

Unit II: Surfaces, Friction and Wear [7hrs]

Contact of engineering surfaces: Hertzian and non-hertzian contact, contact pressure and deformation in non-conformal contacts, causes of friction, stick-slip friction behaviour and friction instability, sliding and rolling friction, frictional heating and temperature rise, wear and wear types, mechanisms of wear; wear map.

Unit III: Lubrication [7hrs]

Lubricants and their physical properties, types of additives, extreme pressure lubricants, recycling of used oils and oil conservation, oil emulsion, selection of lubricants, hydrodynamic lubrication: Reynolds equation, infinite bearing, short bearing, elastohydrodynamic lubrication: principle and application, pressure - viscosity term in Reynolds equation, Hertz theory, Ertel-Grubin equation, Gas lubrication: Introduction, merits, demerits and applications, Lubrication in metal working: rolling, forging, drawing and extrusion.

Unit IV: Surface Engineering for wear and corrosion resistance [7 hrs]

Diffusion, coating, electro and electro-less plating, hot deep coating, metal spraying, cladded coating, crystallizing coating, selection of coating for wear and corrosion resistance, potential properties and parameters of coating.

Unit V: Wear monitoring, diagnosis and characterization techniques [7hrs]

Surface examination, vibration analysis, lubricant analysis, wear and friction measurement techniques, characterization of roughness and wear scar dimensions, microscopy techniques,

micromechanical properties techniques, thermal, chemical and x-ray methods

Unit VI: Tribology of materials **[7hrs]**

Tribology of brass, cast iron and aluminium-silicon alloys, tribology of metal matrix composites, tribology of ceramic matrix composites, tribology of polymeric solids and their composites, tribology of diamond and diamond-like carbon films; Biotribology, Ocular tribology, nanotribology.

Text Books:

- Tribology, Friction and Wear of Engineering Material, I. M.Hutchings, Philip Shipway, Second Edition, Elsevier Publication, 2017.
- Introduction to Tribology, Bharat Bhushan, Wiley Publication, 2013.

Reference Books:

- ASM Handbook; Friction, Lubrication and Wear Technology, Vol 18, ASM Publication, 2017.
- Principles and Application of Tribology, B. Bhushan, Second Edition, Wiley Publication, 2013.
- Introduction to Tribology in bearings, B. C. Majumdar, Wheeler Publishing, 1986
- Engineering Tribology, G. W. Stachowiak and A. W. Batchelor, Wiley publication, 2005.

Department Elective:

[MT(DE)-21003] Non Destructive Testing

Teaching Scheme:
Lectures : 3 Hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem Exam : 60 marks

Course outcomes:

At the end of course students will be able to

1. Define and demonstrate basic knowledge and comparison of the NDT methods.
2. Select and apply suitable method for testing and evaluation
3. Identify application areas of the various methods and their limitations and recommendations
4. Analyze and evaluate results of various testing methods
5. Design and develop NDT methods, simulation methods and their use

Unit I: **[6 hrs]**

Introduction of NDTs: Introduction: Testing and its types, Brief description about NDE/NDT (Scope, advantages, limitations, and applications), Role of NDT in quality control, NDT codes and standards, Basic principle, types, and characteristics methods. evaluation, advantages, limitations and applications of visual optical methods, dye penetrate testing,

Remote Visual Inspection (RVI), NDT related competences: Non-destructive testing Qualification and certification of NDT personnel (ISO 9712:2012)

Unit II: **[6 hrs]**

Electromagnetic testing (ET): Basic theory of magnetism, Magnetization & demagnetization methods, Types of ET, Magnetic-particle inspection (MT or MPI): testing procedures and equipment's, (ISO 9934, ASTM E- 709), Applicable standards & acceptance criteria, Factor affecting MPI, Advantages, limitations, and applications, Advanced ET like Alternating current field measurement (ACFM), Alternating current potential drop measurement (ACPD), Direct current potential drop measurement (DCPD), Magnetic flux leakage testing (MFL), Remote field testing (RFT), Eddy Current Testing (ECT)

Unit III: **[6 hrs]**

Eddy current testing: Basic principles and applicable laws, Conductivity of a material, Self and mutual inductance, Impedance plane, Skin effect, Techniques used for ECT, Coli arrangements, Types of circuit, Inspection probes, Eddy current testing procedures and equipment's, Applicable standards & acceptance criteria, Factor affecting ECT, Advantages, limitations, and applications, Advanced ECT like Pulsed Eddy Current (PEC), Remote Field Eddy Current (RFEC)

Unit IV: **[6 hrs]**

Radiographic testing (RT): Basic principles of radiography, Radiation sources, Effect of radiation in film, radiographic, imaging, image formation, image quality, image interpretation, radiation shielding,, digital radiography, Inspection procedures and equipment's, Type of display and display system, Applicable standards & acceptance criteria, Factor affecting RT, Advantages, limitations, and applications, Protection against radiation, Advanced ECT like Real Time Radiography (RTR) / Digital Radiography, computed radiographic testing, Neutron imaging, SCAR (small, controlled area radiography) X-ray computed tomography (CT)

Unit V: **[6 hrs]**

Ultrasonic Testing (UT): Basic principles of UT, basics of ultrasonic waves, pulse and beam shapes, ultrasonic transducers Generation of ultrasound, Characteristics of an ultrasonic beam; Probe construction Inspection procedures and equipment's, Types of display and display system, Applicable standards & acceptance criteria, Factor affecting UT, Advantages, limitations, and applications, Advanced ECT like Internal Rotating Inspection System (IRIS), Phased Array Ultrasonic Technique (PAUT),Long Range Ultrasonic Testing (LRUT),Automated Ultrasonic Testing, Time of flight diffraction (ToFD) Guided wave ultrasonic testing

Unit VI: **[6 hrs]**

Acoustic Emission Testing (AET): Basic principles of AET, sources of acoustic emission, source parameters, Kaiser-Felicity theory, Inspection procedures and equipment's, Types of display and display system, Applicable standards & acceptance criteria, Factor affecting AET,

Advantages, limitations, and applications, Advanced ECT like Acoustic pulse reflectometry.

Textbooks:

- Baldev Raj, T. Jayakumar, M. Thavasimuthu, Practical Non-Destructive Testing, 3rd Ed., Narosa.
- J. Prasad, C.G.K. Nair, Non-Destructive Testing and Evaluation of Materials, Tata MacGraw Hill

Reference Books:

- B. Hull, Non-Destructive Testing, Springer.
- ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, Vol. 17, 9th Edition
- Louis Cartz, Nondestructive Testing, ASM International
- Paul E.Mix, Introduction to Nondestructive Testing: A Training Guide, 2nd Edition, Wiely Publication.

[MT- 21011] Foundry Technology

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme :
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Classify the casting processes and select appropriate patterns and moulds to make a desired casting.
2. Establish role of sand and sand additives in the production of sound castings.
3. Select appropriate molding and casting techniques to produce a desired casting.
4. Calculate charge required to operate various furnaces used in melting.
5. Establish the effect of solidification method on the microstructure and properties of a casting.
6. Find out the root cause of a casting defect and provide preventive and remedial solutions.

Unit I: [6 hrs]

Basic sand casting process, pattern, mould, core, gating, riser, casting yield, Classification of casting processes, Types of Foundries, General layout and sections in foundries, Patterns and Cores – Selection of parting line, allowances on pattern, pattern materials, color coding, core plates, core-boxes – metallostatic pressure, design of core print, chaplets

Unit II: [6 hrs]

Mold making - Green sand moulding, dry sand moulding, molding sands, Properties of foundry

sands and their testing, additives, Sand Control, core sands, mould compaction machines, Jolt, Jolt-squeeze, high pressure molding, sand slinger, refractory coatings, Venting, molding boxes, chills, roll of additives & technical terms in sand like total clay, active clay, latent clay, dead clay. Materials used for vacuum impregnation seals. Materials used for vacuum impregnation seals.

Unit III: [6 hrs]

Special molding and casting processes - CO_2-Silicate process, Core making- Introduction to modern core sand binders like, hot box, cold box, ester & Shell moulding, Evaporative Pattern (EPC) and Vacuum-sealed (V-) processes, Plaster mould, Ceramic mould, Investment casting, Die casting process – gravity die, pressure die, low pressure die and squeeze casting. Introduction to Mold & Core coatings, their significance in getting satisfactory casting quality, Testing of coatings.

Unit IV: [6 hrs]

Melting furnaces – Cupola and its types, Cupola charge calculations, chill testing of C.I., Rotary furnace, Induction furnace, Arc furnace, holding furnaces, inoculation, fluxes, degassing, use of vacuum, de-oxidation practices in steel and cast iron foundry, converters for SG iron making, effects of melt Fluidity and its testing, foundry refractory

Unit V: [6 hrs]

Solidification of metals and alloys, long freezing range and short freezing range alloys, Directional Solidification, Constitutional super-cooling, Segregation, Modes of solidification - planner, cellular, dendritic mode, Casting feeding – shrinkage, riser and chills, Cain's formula, NRL method, Inscribed circle method, modulus method, padding, Gating systems- fluid flow, Pressurized and non-pressurized gating systems, metal filtration, Software for casting process.

Unit VI: [6 hrs]

Shakeout, cleaning, fettling, finishing and heat treatment of casting, salvage of defective castings, Nature and causes of Casting defects, their remedial measures, Casting design, Quality control and assurance, Casting evaluation, statistical quality control, Inspection and testing of castings. Aluminium alloy, Magnesium alloy, copper alloy and special alloy foundry practice.

Text Books:

- P.L. Jain- Principles of Foundry Technology, 4thedition, Tata-McGraw-Hill, New Delhi, 2003.
- A.K. Chakrabarti, Casting Technology and cast alloys, Prentice-Hall of India, 2005.
- R.W. Hiene, C.R. Loper and P.C. Rosenthal, Principles of Metal Casting, Tata-McGraw-Hill, Reprint 1998.

Reference Books:

- Peter Beeley, Foundry Technology, 2nd edition, Butterworth-Heinemann, Oxford, 2001.
- ASM Handbook, Vol. 15, ASM International, OH, USA.

[MT-21012] Structural Metallurgy

Teaching Scheme:
Lectures: 3 hrs/week
Tutorial: 1 hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Understand fundamentals of dislocation theory, strengthening mechanisms, diffusion of solids nucleation and growth, solid state transformation, and creep resistant alloy
2. Apply knowledge of strengthening mechanism to improve strength of alloy
3. Analyzing effect of heterogeneous and homogeneous nucleation on overall transformation kinetics
4. Compare solid state phase transformations
5. Design HSLA using different strengthening mechanisms
6. Design creep resistant alloys

Unit I: [7 hrs]

Dislocation Theory: Methods of Observation of Dislocations, Elastic Properties of Dislocations, Strain Energy of Dislocations, Forces On and Between Dislocations, Dislocations in FCC and other crystal structure, Climb and cross slip of Dislocations, Multiplication of Dislocations, Dislocation Pile Ups, Strengthening by Dislocations, Work Hardening.

Unit II: [7 hrs]

Strengthening Mechanisms: Strengthening by Grain Boundaries, dislocation model of small angle grain boundary, Yield Point Phenomenon, Strain Ageing, Solid Solution Strengthening, strengthening from Fine Particles, Fiber Strengthening, Strengthening due to Point Defect, Texture Strengthening, Application of strengthening mechanism to design HSLA

Unit III: [7 hrs]

Diffusion in Solids: Types of diffusion, Fick's Laws of Diffusion, Solution of Fick's Laws and their Applications to various Metallurgical Processes-carburising, Atomic theory of diffusion, diffusion couples, semiconductors etc., Kirkendall Effect, Diffusion paths along grain boundaries and free surfaces, Diffusion in ionic crystals

Unit IV: [7 hrs]

Nucleation and Growth: The nucleation, Homogeneous and Heterogeneous Nucleation, Strain Energy Effect, Growth kinetics: Interface-controlled growth and diffusion controlled growth,

Overall transformation kinetics, , the glass transition, recovery, recrystallization and grain growth , Order-Disorder transformations-dislocations and stacking fault in ordered structure.

Unit V: **[8 hrs]**

Kinetics and Solid State phase transformation: Transformations in steels-Pearlitic and Bainitic transformation, Martensitic transformation-Bain distortion ,nature and multiplicity of habit planes, stabilization, Dimensional changes, Iron–Nickel martensitic transformation, Precipitation and Age Hardening - Study of Al-Cu system, Theories of Structural Changes during Aging, Massive transformation, Spinodal decomposition

Unit VI: **[6 hrs]**

Creep resistant alloys: Creep Mechanism, creep curve, Relation between dislocation density and stress, Super plasticity, Shape Memory alloys, development of creep-resistant, alumina-forming ferrous alloys for high-temperature structural applications

Text Books:

- V. Raghvan –Solid State phase Transformation, PHI, 2010.
- V. Raghvan - Material Science and Engineering,PHI,2004
- Porter, Easter ling Sherif -Phase transformation in Metals and Alloys-CRC Press, 2009
- Robert Reed - Hill - Physical Metallurgy Principles, Thomson/Brooks/Cole,2005
- Hayden, Moffat and Wolff - The structure and Properties of Materials, Vol-III (Mechanical Behavior), Wiley Eastern Pvt. Ltd,1991
- Dieter George E. - Mechanical Metallurgy, McGraw Hill. London, 1988.

Reference Books:

- Brophy, Rose and Wolff - Thermodynamics of Structure, Vol-II, Wiley Eastern Pvt. Ltd, New Delhi, 1964.
- Thomas H. Courtney-Mechanical Behavior of Materials-Waveland Press USA, 2005.
- Anthony Rollett, F J Humphreys, M. Hatherly, Gregory S. Rohrer, Recrystallization and Related Annealing Phenomena, 2004, Elsevier, UK.

[MT- 21013] Steel Making

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Find various processes involved in making of steels in mini steel plant and integrated steel plant.
2. Explain physicochemical reactions that are taking place during oxidation and reducing period in steelmaking.

3. Identify effect of input raw material including refractories on cleanliness of steel.
4. Distinguish impact of deoxidation, vacuum degassing and casting technology on production of sound casting suited for engineering applications.
5. Justify suitable process route for making sound and clean steel.
6. Design process to improve reaction kinetics and sustainability thereof.

Unit I: [7 hrs]

History of Steel Making from Bessemer steelmaking to present day equipment and practices, Integrate and Mini Steel Plants in India, Indian steel scenario as at present and Principles guiding Steel Plant location.

Unit II: [7 hrs]

Physical Chemistry of Steel Making: Thermodynamic and Kinetics of Refining Reactions, Carbon Reaction, Phosphorus Reaction, Sulphur Reaction, Silicon Reaction, Refining Slags and its properties, Importance and Mechanism of Decarburization Reaction, Reaction at Slag Metal interface.

Unit III: [7hrs]

Basic Oxygen Steel Making: BOF practice, Equipment, Operation and Process, slag Metal reactions in B.O.F., Raw material and flux practices, Modifications and further Development in Conventional BOF, Oxygen Lance: Design, Construction and Operation, Top and Bottom Blow processes, its advantages and disadvantage

Unit IV: [7hrs]

Electric Steel Making: Details of Electric Arc Furnaces, Its Variations, Sequence of EAF Operations, Various additions at Different Stages, Slag Control, UHP Arc Furnaces, Arc Furnace practices for Carbon and Low Alloy Steels

Unit V: [7hrs]

Secondary Steel Making Processes, Ladle Furnaces (L.F.), Vacuum Systems and Vacuum treatment of Steel, Gases in steel, LF-VD processes and AOD, VOD, VAD techniques, R-H degassers, Ladle Stirring and its Advantages, ESR-Principle and Technology, Deoxidation – Theory and practice, Floatation's of products, Modifications of Inclusions, Injection Metallurgy.

Unit VI: [7 hrs]

Continuous Casting (C.C.) and Ingot Casting, Ingot Casting: Types of Moulds, Advantages and Disadvantages, Ingot Defects and Remedies, Continuous casting: C.C. machines with its various units and types C.C. of Blooms, Slabs and Thin slabs EM S of Moulds, Reoxidation prevention methods during Steel Casting, Advantage of C.C. Environmental issues related to Steel Making.

Text Books:

- R. H. Tupkary, V. R. Tupkary, An introduction to modern Steelmaking, 7th Edition, Khanna Publications, Delhi, 2012.
- Ahindra Ghosh, Amit Chatterjee Iron and Steel making: Theory and practice, 2nd Edition, PHI learning Pvt. Ltd, New Delhi, 2011.

Reference Books:

- Darken and Gurry- Physical Chemistry of Metals, McGraw Hill, 1953.
- W.R. Irving, Continuous Casting, Maney Publishing, 1993.

[MT-21014] Foundry Technology Laboratory

Teaching Scheme:
Laboratory: 2 hrs/week

Examination Scheme:
Continuous evaluation - 50 Marks
End Sem Exam - 50 Marks

Course Outcomes:

At the end of course students will be able to

1. Prepare sand for various casting techniques and estimation of its characteristics
2. Design of pattern and core to produce a casting
3. Produce a casting and determine its mechanical and physical properties.

List of Experiments:

1) Performing Sand cleaning, conditioning and blending.
2) Determine AFS grain fineness number by using Sieve shaker.
3) Find Moisture content, Mould ability, Flow ability, Friability mold hardness.
4) Experiment on melting in Muffle or Induction furnace and produce a casting from the molten metal
5) Demonstrate Pattern and core making, preparation of core sand and it's testing e.g. Hardness, Flow ability, Mould ability, etc.
6) Performing Fluidity Test.
7) Performing Friability Test
8) Visit to at least one foundry around Pune.

MT- 21015] Non Ferrous Metallurgy Laboratory

Teaching Scheme:
Practical: 2hrs/Week

Examination Scheme:
Continuous Evaluation: 50 Marks
End Sem Exam: 50 Marks

Course Outcome:

At the end of course students will be able to

1. Understand phase diagrams of Copper, Aluminium, Nickel, Magnesium and Titanium base alloys and Classify different types of nonferrous alloys on the basis of microstructure.
2. Draw structure property relationship for various nonferrous alloys.
3. Interpret results of heat treatment given to nonferrous alloys.

List of Experiments:(Any eight)

1. Preparation of specimen of nonferrous alloys by electrolytic polishing and etching method.
2. To study phase diagrams of aluminium alloys and observe microstructure of cast and wrought aluminium alloys.
3. To study Cu-Zn phase diagram and observe the microstructure of brasses.
4. To study phase diagrams of Cu-Sn, Cu-Al, Cu-Ni,Cu-Si alloys and observe the microstructure ofvarious bonzes.
5. To study the microstructure of Bearing alloys (Babbitts) and correlate structure propertiesrelationship.
6. To study the precipitation hardening of aluminium alloys (2XXX,6XXX &7XXX)and Cu-Be bronze.
7. To study modification treatment of Al-Si alloys.
8. To study the heat treatment of titanium alloys.
9. To study heat treatment of magnesium alloys.
10. Colour Metallography of Nonferrous alloys.

Reference Books:

- Physical Metallurgy for Engineers – Donald S. Clark, & Wilbur R. Varney, CBS Publishers & Distributors, New Delhi
- Heat Treatment, Structure and Properties of Non-ferrous Alloys – Charlie R. Books, 1982, ASM.
- Introduction to Physical Metallurgy – Sidney H. Avner, McGraw-Hill Book Company, New Delhi
- Metals Handbook Ninth Edition – Vol.2, Properties and Selection: Non-ferrous alloys and PureMetals, American Society for Metals, Metals Park, Ohio.
- Light Alloys -I.J.Polmear, Butterworth Heinemann ,Third edition 1995

Course for B.Tech Minor (Metallurgical Engineering)

[MT(MI)-21002] Foundry Technology

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme :
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to

1. Classify the casting processes and select appropriate patterns and moulds to make a desired casting.
2. Establish role of sand and sand additives in the production of sound castings.
3. Select appropriate molding and casting techniques to produce a desired casting.
4. Calculate charge required to operate various furnaces used in melting.
5. Establish the effect of solidification method on the microstructure and properties of a casting.
6. Find out the root cause of a casting defect and provide preventive and remedial solutions.

Unit I: **[6 hrs]**

Basic sand casting process, pattern, mould, core, gating, riser, casting yield, Classification of casting processes, Types of Foundries, General layout and sections in foundries, Patterns and Cores – Selection of parting line, allowances on pattern, pattern materials, color coding, core plates, core-boxes – metallostatic pressure, design of core print, chaplets

Unit II: **[6 hrs]**

Mold making - Green sand moulding, dry sand moulding, molding sands, Properties of foundry sands and their testing, additives, Sand Control, core sands, mould compaction machines, Jolt, Jolt-squeeze, high pressure molding, sand slinger, refractory coatings, Venting, molding boxes, chills, roll of additives & technical terms in sand like total clay, active clay, latent clay, dead clay. Materials used for vacuum impregnation seals. Materials used for vacuum impregnation seals.

Unit III: **[6 hrs]**

Special molding and casting processes - CO2-Silicate process, Core making- Introduction to modern core sand binders like,hot box, cold box, ester & Shell moulding, Evaporative Pattern (EPC) and Vacuum-sealed (V-) processes, Plaster mould, Ceramic mould, Investment casting, Die casting process – gravity die, pressure die, low pressure die and squeeze casting. Introduction to Mold & Core coatings, their significance in getting satisfactory casting quality, Testing of coatings.

Unit IV: **[6 hrs]**

Melting furnaces – Cupola and its types, Cupola charge calculations, chill testing of C.I., Rotary furnace, Induction furnace, Arc furnace, holding furnaces, inoculation, fluxes, degassing, use of vacuum, de-oxidation practices in steel and cast iron foundry, converters for SG iron making, effects of melt Fluidity and its testing, foundry refractory

Unit V: **[6 hrs]**

Solidification of metals and alloys, long freezing range and short freezing range alloys, Directional Solidification, Constitutional super-cooling, Segregation, Modes of solidification - planner, cellular, dendritic mode, casting feeding – shrinkage, riser and chills, Cain's formula, NRL method, Inscribed circle method, modulus method, padding, Gating systems- fluid flow, Pressurized and non-pressurized gating systems, metal filtration, Software for casting process.

Unit VI: **[6 hrs]**

Shakeout, cleaning, fettling, finishing and heat treatment of casting, salvage of defective castings, Nature and causes of Casting defects, their remedial measures, Casting design, Quality control and assurance, Casting evaluation, statistical quality control, Inspection and testing of castings. Aluminium alloy, Magnesium alloy, copper alloy and special alloy foundry practice.

Text Books:

- P.L. Jain- Principles of Foundry Technology, 4thedition, Tata-McGraw-Hill, New Delhi, 2003.
- A.K. Chakrabarti, Casting Technology and cast alloys, Prentice-Hall of India, 2005.
- R.W. Hiene, C.R. Loper and P.C. Rosenthal, Principles of Metal Casting, Tata-McGraw-Hill, Reprint 1998.

Reference Books:

- Peter Beeley, Foundry Technology, 2nd edition, Butterworth-Heinemann, Oxford, 2001.
- ASM Handbook, Vol. 15, ASM International, OH, USA.

Course for B.Tech Honors
(Materials Engineering/Process Metallurgy)

[MT(HO)21003] Mechanical Behaviour of Materials

Teaching Scheme:
Lectures : 3 Hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem Exam : 60 marks

Course outcomes:

At the end of course students will be able to

1. Analyze mechanical deformation of the materials using analytical treatment.
2. Use mechanical metallurgical concepts in understanding mechanical deformation.
3. Identify failure modes and reasons of failures of engineering components.
4. Incorporate fracture mechanics concepts in the mechanical design.
5. Use micro structural principles for the design of fracture and creep resistant materials.

Unit I: **[6 hrs]**

Mechanical properties of materials, Theory of plasticity: The flow curve, yielding criteria for ductile metals, Plastic deformation of single crystal and polycrystalline materials, Deformation by slips, Deformation by twinning, strain hardening of single crystals.

Unit II: **[6 hrs]**

Dislocation theory: Dislocations in FCC, HCP and BCC lattice, forces on dislocations, forces between dislocations, dislocation climb, intersection of dislocations, Jogs, multiplication of dislocations, dislocation pile-ups.

Unit III: **[6 hrs]**

Strengthening mechanisms: Strengthening of grain boundaries, yield point phenomenon, strain aging, solid solution strengthening, strengthening from fine particles, fiber strengthening, martensitic strengthening.

Unit IV: **[6 hrs]**

Fracture mechanics and fracture toughness evaluation: Strain energy release rate, stress intensity factor, fracture toughness and design, KIC Plain-strain toughness testing, crack opening displacement, probabilistic aspects of fracture mechanics, toughness of materials.

Unit V: **[6 hrs]**

Fatigue of metals: Stress cycles, S-N curve, statistical nature of fatigue, low cycle fatigue,

structural features of fatigue, fatigue crack propagation, effect of stress concentration on fatigue, size effect, surface effects and fatigue, effect of metallurgical variables on fatigue, corrosion fatigue, effect of temperature on fatigue.

Unit VI: [6 hrs]

Creep and Stress rupture: High temperature materials problem, time dependent mechanical behavior, creep curve, stress rupture, structural changes during creep, mechanisms of creep deformation, deformation mechanism maps, fracture at elevated temperature, high temperature alloys and Fractography-important aspects.

Text Books:

- Mechanical Metallurgy – Geroge E. Dieter , SI Metric Edition ,1988, McGraw Hill Book Co Ltd ,U.K.
- Mechanical Behaviour of Materials, Marc Andre Meyers and Kishan Kumar Chawala, SecondEdition, 2009 , Cambridge University Press, U.K.

Reference Books:

- The Indian Academy of Sciences Proceedings : Engineering Science – Alloy Design , Vol 3 / Part 4, December 1980 and Vol 4 / Part 1, April 1981,Published by The Indian Academy of Sciences, Bangalore- 560080
- Dislocations and Mechanical Behaviour of Materials, M.N. Shetty, 2013 , PHI Learning Pvt Ltd,New Delhi -110092

Interdisciplinary Open Course

[MT(IOC) -21004] Materials and Processes for e-Mobility

Teaching Scheme:
Lectures :2 hrs /week

Examination Scheme:
T1 and T2: 20 Marks each
End Sem Exam : 60 marks

Course Outcomes:

At the End of Course students will be able to

1) Select appropriate battery technologies based on energy density, power density, life span, safety, cost, performance and environmental impact.
2) Establish structure - microstructure - electrical performance correlations for various components of a battery.
3) Recommend various hybrid vehicle configurations based on applications.
4) Adopt appropriate rare-earth and rare-earth free magnets for applications in various e-vehicles.
5) Design the processes for fabrication of various components required in e-vehicles.

Unit 1 **[4 hrs]**

Introduction to e-vehicles and their classification, Comparison with the IC Engine Technology, e-vehicles life cycle analysis and raw material availability, Economic considerations for batteries in e-vehicles, Value chain for electric car batteries, Concept of energy density and power density, Comparative study of energy and power density of various battery technologies

Unit 2 **[6 hrs]**

Structure of Li ion battery: electrolyte, cathode and anode active materials, binder and separator, Performance requirement of battery components, Electrolytes in Li-ion batteries: Synthesis, fabrication, microstructure investigation and determination of electrical properties, Chemistry of cathode and anode materials for Li-ion batteries, integration of cathode, anode and electrolyte, measurement of electrical properties of cells, Recycling of battery materials

Unit 3 **[6 hrs]**

Materials for sealing of batteries, Cell to battery pack manufacturing, electrical insulations in Battery packs, thermal management materials in battery packs, Tradeoffs between specific power, specific energy, performance, cost, life span and safety in principal Li-ion battery technologies, Looking beyond Li-ion batteries: Mg, Al and Fe ion batteries, pros and cons w.r.t. Li-ion batteries, Indian Scenario for Li and alternate battery materials

Unit 4 **[6 hrs]**

Superpercpacitors for electrical vehicles, principle and materials used, key electrical characterization techniques, Battery-supercapacitor hybrid arrangement for e-vehicles, Fuel cells

for electric vehicles, principle and materials used, key electrical characterization techniques, Battery-fuel cell hybrid arrangement for e-vehicles, Concept of battery-biofuel hybrid arrangement for e-vehicles

Unit 5 **[6 hrs]**

Critiitical Metals for electric motors: Nd, Eu, Y, Tb, Dy; manufacturing of rare earth and rare-earth free magnets for electric motors, Comparative Study on magnetic properties of rare earth and rare-earth free magnets, Recycling of magnetic materials from motors in e-vehicles, Structural materials for EVs: fibre reinforced composites, steels, Al etc., Materials required in charging stations

Text Books

- Richard Folkson, Alternative fuels and advanced vehicle technologies for improved environmental performance: Towards zero carbon transportation, Woodhead Publishing, 1st Edition, 2014
- M. Ehsani, Y. Gao, S. Longo, K. Ebrahimi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles, CRC Press, 3rd Edition, 2018
- R. Xiong, S. Weixiang, Advanced Battery Management Technologies for Electric Vehicles, Wiley, 1st Edition, 2019

Reference Books

- J. Jiang, C. Zhang, Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles, Wiley, 1st Edition, 2019
- D. Beeton, G. Meyer, Electric Vehicles Business Models: Global Perspectives, Springer, 1st Edition, 2015