Appendix " S" Item No. 37

**DEPARTMENT OF METALLURGICAL ENGINEERING**

SCHEME OF INSTRUCTION & SYLLABUS FOR

**BTECH (METALLURGICAL ENGINEERING)**

(Effective from 2019 -20 admitted Batch - As per AICTE Scheme)

I / II semester

 Code Subject Periods Exam Sessio- Exam Total Credits

 No L T P Hours nals Marks Marks

ENG 1206 Elements of Materials Science 3 1 — 3 30 70 100 4

 II / IV First semester

MET 211 Metallurgical Thermodynamics I 3 1 — 3 30 70 100 3

MET 212 Mineral Beneficiation 3 1 — 3 30 70 100 3

MET 213 Principles of Extractive Metallurgy 3 1 — 3 30 70 100 3

MET 214 Fuels, Refractories & Furnaces 3 1 — 3 30 70 100 3

MET 215 Non Metallic Materials 3 1 — 3 30 70 100 3

MET 216 Engg. Science Course( **ESC):**
 Introduction to Instrumentation 3 1 — 3 30 70 100 3

MET 217 **Mandatory Course (MC):**
 Environmental Sciences - - - - - - - 0

MET 218 P Mineral Beneficiation Lab — — 3 3 50 50 100 1.5

MET 219 P Fuels Lab — — 3 3 50 50 100 1.5

 TOTAL 30 24 280 520 800 21

 II / IV Second semester

MET 221 Metallurgical Thermodynamics II 3 1 — 3 30 70 100 3

MET 222 Physical Metallurgy 3 1 — 3 30 70 100 3

MET 223 Iron Making 3 1 — 3 30 70 100 3

MET 224 **Humanities (OEC - I):**
 Managerial Economics 3 1 — 3 30 70 100 3

MET 225 Mechanical properties of Materials 3 1 — 3 30 70 100 3

MET 226 Non Destructive Testing 3 1 — 3 30 70 100 3

MET 227 P Metallography Lab — — 3 3 50 50 100 1.5

MET 228 P Mechanical Metallurgy Lab — — 3 3 50 50 100 1.5

 TOTAL 30 24 280 520 800 21

III / IV First semester

MET 311 Materials Characterization 3 1 — 3 30 70 100 3

MET 312 Advances in Iron making 3 1 — 3 30 70 100 3

MET 313 Non-Ferrous Extractive
 Metallurgy - I 3 1 — 3 30 70 100 3

MET 314 Steel Making 3 1 — 3 30 70 100 3

MET 315 Metal Joining Processes 3 1 — 3 30 70 100 3

MET 316 **PEC-I:**Foundry Technology 3 1 — 3 30 70 100 3

MET 317 P Metal Casting Lab — — 3 3 50 50 100 1.5

MET 318 Soft Skills — — 3 3 50 50 100 1.5

 TOTAL 30 24 280 520 800 21

III / IV Second semester

MET 321 Heat Treatment 3 1 — 3 30 70 100 3

MET 322 Foundry Practices 3 1 — 3 30 70 100 3

MET 323 Metal Forming 3 1 — 3 30 70 100 3

MET 324 Advances in Steel Making
 & Production of Ferro Alloys 3 1 — 3 30 70 100 3

MET 325 Non-Ferrous Extractive
 Metallurgy - II 3 1 — 3 30 70 100 3

MET 326 **PEC-II:**Composite Materials 3 1 — 3 30 70 100 3

MET 327 Mandatory Course (MC):
 Indian Constitution/
 Essence of Indian
 Traditional Knowledge - - - - - - - 0

MET 328 P Heat Treatment Lab — — 3 3 50 50 100 1.5

MET 329 P Materials Processing Lab — — 3 3 50 50 100 1.5

 TOTAL 30 24 280 520 800 21

IV / IV First semester

MET 411 Strengthening mechanisms 3 1 — 3 30 70 100 3

MET 412 Environmental degradation of
 Materials 3 1 — 3 30 70 100 3

MET 413 Engineering Materials 3 1 — 3 30 70 100 3

MET 414 **Humanities (OEC-II):**
 Industrial Management and
 Entrepreneurship 3 1 — 3 30 70 100 3

MET 415 **PEC-III:**Nano materials 3 1 — 3 30 70 100 3

MET 416 P Electro-Metallurgy lab — — 3 3 50 50 100 1.5

MET 417 Project Project-I — — 6 — 50 50 100 5

 TOTAL 33 21 280 520 800 21.5

IV / IV Second semester

MET 421 **PEC-IV:** Powder Metallurgy 3 1 — 3 30 70 100 3

MET 422 **PEC-V:** Failure Analysis 3 1 — 3 30 70 100 3

MET 423 Project Project II — — 20 — 50 50 100 10

 TOTAL 32 9 230 260 400 16

Total Credits: 160

 Year I Semester II Semester Total

 First 19 19.5 38.5

 Second 21 21 42

 Third 21 21 42

 Fourth 21.5 16 37.5

 Total Credits 160

**DEPARTMENT OF METALLURGICAL ENGINEERING**

**SCHEME OF INSTRUCTION & SYLLABUS FOR**

**BTECH (METALLURGICAL ENGINEERING)**

**(Effective from 2019 -20 admitted Batch - As per AICTE Scheme)**

**SYLLABUS - I / II semester**

**MET 1206 – ELEMENTS OF MATERIALS SCIENCE**

 Periods/week: **3L -1T** Credits: **4** Sessionals: **30** Exam: **70**

Introduction, classification of materials**,** Space lattice and unit cells, crystal systems, Indices for planes and directions. Structures of common metallic materials.

Crystal defects: Point, Line and surface defects. Dislocations, types, Burgers’ Vector. Dislocation movement by slip, climb and cross slip. Dislocation sources. Slip systems for BCC, FCC and HCP metals, Critical resolved shear stress (CRSS) for slip, Twinning, Stacking faults, Jogs, Kinks.

Electrical and Electronic properties of materials, Electronic conductivity, free electron theory and band theory of solids. Intrinsic semi-conductors. Super conductivity. Magnetic properties, Dia, para, ferro, ferri magnetism. Soft and hard magnetic materials and applications. Optical properties of materials. Refractive index, absorption emission of light, optical fibers. Opto-electronic materials.

*Text books:*

1. Material Science and Engineering by V.Raghavan

2. Physical Metallurgy by S. H. Avner.

*Reference books:*

1. Material Science and Engineering by L.H.Van Vleck, 5th edition, Addision Wealey(1985)

2. Structure and properties of Materials by R.M.Rose, L.A.Shepard and J.Wulff, Vol.1,4 John Willey (1966) .

3. Essentials of Material Science by A.G.Guy, McGraw Hill(1976).

4. The Science and Engineering Materials by D.R.Askeland. 2nd Edition, Chapman and Hall (1990).

5. Physical Metallurgy, Vijendra Singh

**SYLLABUS - II / IV First semester**

**MET 211 - METALLURGICAL THERMODYNAMICS – I**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

 Introduction - Basic concepts in thermodynamics. Objectives and limitations of classical thermodynamics. Zeroth law of thermodynamics. First Law of Thermodynamics - Forms of Energy, Heat and Work, Joules Experiments, Conservation of Energy, Concept of Maximum Work, Isothermal Expansion, Reversible, Adiabatic Expansion, Constant Pressure Processes, Constant Volume Processes, Enthalpy.

Second Law of Thermodynamics -Efficiency of cyclic process. Carnot cycle. Entropy. Thermodynamic equation of state. Statistical Entropy, Physical Meaning of Entropy, Boltzman Equation, Mixing Entropy, Stirling’s Approximation, Auxiliary Functions. Fundamental Equations of State, Maxwell Relationships. Other Thermodynamic Relations, Chemical Potential, Gibbs - Helmholtz Equation, Criteria of Equilibria.

Third law of Thermodynamics, Heat Capacity and Entropy Changes. Sensible Heats, Transformation Heats, Reaction Heats, ÄCp, ÄH=f(T), ÄS=f(T), Adiabatic Flame Temperatures, Heat Balances.

Phase Equilibria in One Component Systems , Clausius - Claperyon Equation, Heats of Vaporization from Vapor Pressure Data, Shift in Transformation Temperature with Pressure. Fugacity, activity and equilibrium constant. Vant Hoff’s isotherm. Ellingham diagrams and application.

*Text books:*

1. Introduction to Metallurgical Thermodynamics, David R. Gaskell.

2. Problems in Thermodynamics & Kinetics, G.S.Upadhyaya and R.N.Dubey.

*Reference:*

1**.**  Chemical Metallurgy, J.J.Moore

2. Physical Chemistry of Metals, L.S.Darken and G.Gurry, Tata Mc-Graw hill.

3. Metallurgical Thermodynamics, ML Kapoor Part I & II

4. Metallurgical Thermodynamics, Tupkary

**MET 212 - MINERAL BENEFICIATION**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Objectives and scope. Classification of minerals. An elementary concept of liberation. Comminution: Study of primary and secondary crushing and grinding units like Jaw, Gyratory, and reduction Gyratory and roll crushers. Theory of Ball Mill operation, Rittinger’s , Kick’s and Bond’s laws of crushing and grinding.

Laboratory sizing units. Screening. Ellutriation. Sedimentation. Representation of size analysis data. Sizing equipment used in industry. Elementary concepts of movement of solids in fluids. Stokes and Newtons laws. Reynold’s number. Free and hindered settling. Classification and its application in mineral dressing.

Heavy media separation and coal washing. Tabling. Jigging. Magnetic and Electro static separation. Elementary treatment of principles of flotation. Surface tension, surface energy, and contact angle. Floatability, frothers, collectors and modifying agents. Differential flotation. Flotation circuits.

Study of basic de-watering techniques like-sedimentation – filtration – drying., Simple flow sheets for Beneficiation of Fe, Mn, Cr, Cu, Pb, Zn and beach sands.

*Text books:*

1. Principles of Mineral Dressing, Gaudin, A.M.

*References;*

1. Mineral Processing Technology, S.K.Jain

2. Unit operation in Chemical Engineering.

**MET 213 - PRINCIPLES OF EXTRACTIVE METALLURGY**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

General Methods of Extraction. Pyro-metallurgy: Roasting, Types of roasting, Roasting equipment and methods, Predominance area diagrams, Smelting, Smelting furnaces. Hydro Metallurgy: Advantages and disadvantages, Principles of leaching, Leaching kinetics and factors affecting. Electro Metallurgy- classification. Principles of refining. Use of vacuum, Zone refining, Vacuum arc re-melting, Electron beam melting, Electro slag refining. Cementation. Electro refining, Electro deposition.

Raw materials: Occurrence and distribution of iron ores in India. Evaluation of iron ore, coke and limestone. Preparation of iron ores: Methods of Beneficiation, Agglomeration of Iron ores. Sintering: Raw materials, Mechanism of sintering, Sintering machine and its efficiency. Types of sinter. Recent trends in sintering practice. Pelletizing: Raw materials, Theory of Bonding, Bonding mechanism. Disc and Drum pelletiser, Firing units. Indian sintering and pelletisation plants.

*Text books:*

1. Introduction to modern iron making, R.H. Tupkary

2. Introduction to modern iron making, A.K. Biswas

3. Physical Chemistry of Iron & Steel Making, C.Bodsworth

4. Extraction of Non-Ferrous Metals, H.S.Ray, R.Sridhar and K.P.Abraham

*References:*

1. MSTS-United Steel Corporation, Pittsburgh

2. Blast furnace theory & practice- Vol.I & II ,Julius JH.Strysbugen

3. Metallurgy of Non-Ferrous Metals, Dennis, W.H.

4. Non-Ferrous Metallurgy, Sebryukov, N.Min, Pub. Moscow

**MET 214 - FUELS, REFRACTORIES AND FURNACES**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Solid fuels: Classification. Proximate analysis & ultimate analysis of coal. Carbonization of coal. Coke making and by products recovery. Testing and properties of coke. Liquid fuels: Classification. Petroleum refining. Distillation. Gaseous fuels: Classification. Production of PG, WG, CWG, LD gas, Coke oven gas and BF gas.

Refractories: Properties, classification and general description. Manufacture, properties and applications of Alumino-silicate, Silica, Dolomite, Magnesite, Chromite and Carbon refractories. Importance and study of SiC, ZrO2 and cermets. Testing of refractories.

Elements of heat transmission. Steady state conduction, convection and radiation. Furnaces. Classification of furnaces and their use in metallurgical industries. Heat sources, Heat utilization in furnaces, Heat losses in furnaces and furnace efficiency. Heat balance and Sankey diagrams. Principles of waste heat recovery. Recuperators and regenerators. Protective atmospheres.

*Text books:*

1. Fuels, furnaces and refractories by O.P.Gupta

2. Experimental methods for Engineers, J.P.Holman, McGraw Hill Publication.

*Reference:*

1. Fuels, Technology by Hinues

2. Fuels by Gilchrist

3. Refractories by Chesty

**MET 215 - NON METALLIC MATERIALS**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Polymers: Classification, properties and applications, Molecular structure of polymers, Polymerization, Mechanical properties of polymers

Ceramics: Classification properties and applications, Mechanical properties of Ceramics, Glass and Glass ceramics, Processing of Ceramics Classification, properties and applications of Textiles, Adhesives, polymer and ceramic Foams

*Text books*

1. Textbook of Polymer Science; Fred W. Billmeyer, Wiley 2007

2. Introduction to Ceramics; Kingery, Bowen, Uhlman. Wiley India Pvt Limited, 2012

3. Composite Materials: Science and Engineering; Krishan K. Chawla, Springer, 2012

**MET 216- ENGG. SCIENCE COURSE (ESC):
INTRODUCTION TO INSTRUMENTATION**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Basic concepts. Introduction. Definition of terms. Calibration standards. Generalized measurement system. Causes and types of experimental errors. Analysis.

Transducer and electric sensing devices. Differential transformer. Capacitive and piezo electric.

Pressure measurement. Mechanical pressure measurement devices. Low pressure measurement. McLeod gauge- Pirani Thermal conductive gauge- Ionization gauge.

Flow measurement methods.

Temperature measurement. by mechanical and electrical effects-Measurement by radiation. Strain measurement. Strain gauges.

*Text books:*

1. Experimental methods for Engineers, J.P.Holman, McGraw Hill Publication.

2. Mechanical measurements, Sirohi, Radhakrishnam.

3. Electron Beam Analysis of materials, Lorento

**MET217 - Mandatory Course (MC): ENVIRONMENTAL STUDIES**

 Periods/week: **0** Credits: **0** Sessionals: **0** Exam: **0**

Introduction to Environmental Studies – Importance – Types of Ecosystems – Lake-River-Marine-Forest-Desert-Bio-Deversity.

Resources Natural – Water- Mineral-Food- Forest – Energy-Land-Use and Exploitation-Environmental Degradation- Remedial measures.

Environmental Pollution causes, Effects, standards and control (A) Air pollution; (b) Water Pollution; (c) Soil pollution; (d) Marine pollution; (e) Noise pollution

Legal aspects of pollution, Air (Prevention and control of pollution) Act, Water (Prevention and control of pollution) Act, Environmental Protection 1980 Act., Forest Conservation Act.

Role of People to protect environment-Rolle of NGOS, (a) Global issues (b) Green House Effect (c) Global Warming (d) Nuclear accidents

Local issues causes and action, Air pollution due to industries, Automobiles, Public interest Litigation case studies-Success stores, Leather industries, Taaj \* Mathura Refinery, Silent Valley

*Text Books*

1. Introduction to Envrionmental sciences – Turk & Turk and Witties

2. Environmental Sciences – P.D.Sarma

**MET 218 P - MINERAL BENEFICIATION LAB**

 Periods/week: **3P** Credits: **1.5** Sessionals: **50** Exam: **50**

List of experiments:

1. Sampling by coning and quartering and riffle sampler.

2. Determination of average particle size by sieve analysis.

3. Determination of optimum time of sieving.

4. Studies on size reduction using laboratory Jaw Crusher.

5. Studies on size reduction using laboratory Roll Crusher.

6. Studies on size reduction using laboratory Ball Mill.

7. Heavy media separations (sink and float experiment)

8. Laboratory experimentation Froth Flotation.

9. Determination of Grindability of Coal.

**MET 219 P: FUELS LAB**

 Periods/week: **3P** Credits: **1.5** Sessionals: **50** Exam: **50**

List of experiments:

1. Determination of Flash and fire points of oils. (Open cup)

2. Determination of Flash and fire points of oils (Closed cup)

3. Determination of Calorific value of fuels (solids, liquids) by Bomb calorimeter

4. 4. Determination of Calorific value of fuels (gaseous) by gas calorimeter.

5. To determine the kinematic and absolute viscosity of the given sample oil using Redwood Viscometer I.

6. To determine the kinematic and absolute viscosity of the given sample oil using Redwood Viscometer II.

7. Determination of carbon residue.

**SYLLABUS - II / IV Second semester**

**MET 221 - METALLURGICAL THERMODYNAMICS – II**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

The Behavior of Gases. Compressibility Factor, Law of Corresponding States, Equations of State, Fugacity. Reactions Equilibria - The effect of temperature and pressure on equilibrium constant.

Equilibria in Gaseous Systems, The Equilibrium Constant and ÄG°, Reaction Extent Problems, Equilibria in Systems Containing Condensed Phases, Ellingham Diagram, Activities.

Solution Thermodynamics - Thermodynamic solutions. Raoult’s law. Henry’s law. Sievert’s law. Absolute and Partial and Integral Molar Quantities, Relative and Partial Integral Molar Quantities, Ideal Solutions, Excess Quantities, Gibb’s Duhem Equation, Tangent Intercept Method, a=f(T), Change in Reference State, 1 wt % Reference State Interaction Parameters. Actual solutions. Regular solutions.

Application of the laws of thermodynamics to metallurgical processes, electrochemistry, interfacial phenomena, extraction and refining of materials.

Kinetics of Metallurgical reactions. Collision theory. Theory of absolute reaction rates.

*Text books:*

1. Introduction to Metallurgical Thermodynamics, David R. Gaskell.

2. Problems in Thermodynamics & Kinetics, G.S.Upadhyaya and R.N.Dubey.

*Reference:*

1**.**  Chemical Metallurgy, J.J.Moore

2. Physical Chemistry of Metals, L.S.Darken and G.Gurry, Tata Mc-Graw hill.

3. Metallurgical Thermodynamics, ML Kapoor Part I & II

*4. Metallurgical Thermodynamics, Tupkary.*

**MET 222 - PHYSICAL METALLURGY**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Solidification. Solidification of pure metals, alloys and eutectic. Nucleation and growth, Homogenous and Heterogeneous, constitutional super cooling, coring and segregation.

Phase rule, principles of construction and interpretation of binary phase diagrams. Invariant reactions, Free energy composition diagrams, uses and limitations of phase diagrams.

Equilibrium and non-equlibrium phase diagrams-Fe-C, Cu-Zn, Cu-Sn, Al-Si, Al-Cu, Pb-Sn. Sb-Sn, Ternary diagrams and interpretation of Structures on cooling.

Diffusion of metals-Fick’s law, mechanisms of diffusion, solutions to diffusion Equations, diffusion in alloys, Kirkendal efect, Factors affecting, diffusion, grain Boundary diffusion, applications.

*Text books:*

1. Physical Metallurgy - S.H.Avner

2. Physical Metallurgy - V.Raghavan

3. Physical Metallurgy - Vijendra Singh

4. Mechanical Metallurgy - G.E. Dieter

*Reference book:*

1. Physical Metallurgy - R.E.Reed Hill

**MET 223 - IRON MAKING**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

 Properties and testing of raw materials: Room temperature and high temperature physical properties, Reducibility tests, factors affecting reducibility. Blast furnace and accessories: Description of modern blast furnace. Design of blast furnace stoves, Blast furnace refractories, Blast furnace cooling system, Gas cleaning system. Charging system, Distribution of burden in blast furnace, Blast furnace instruments.

Physical chemistry: Blast furnace physical structure, blast furnace reactions, Distribution of elements in molten metal and slag. Internal and External desulphurization, Blast furnace slag properties and uses. Acid and Basic burdening practices, Blast furnace operation, irregularities and remedies. Modern developments in blast furnace practice

Alternate routes of pig iron production: Electric arc furnace process, Low shaft furnace, Mini Blast Furnace process, Char coal furnace process. Production of wrought iron.

*Text books:*

1. Introduction to modern iron making, R.H. Tupkary

2. Introduction to modern iron making, A.K. Biswas

3. Physical Chemistry of Iron & Steel Making, C.Bodsworth

*References:*

1. MSTS-United Steel Corporation, Pittsburgh

2. Blast furnace theory & practice- Vol.I & II ,Julius JH.Strysbugen

**MET 224- HUMANITIES (OEC - I): MANAGERIAL ECONOMICS**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Unit –I : Significance of Economics and Managerial Economics:

**Economics:** Definitions of Economics- Wealth, Welfare and Scarcity definition Classification of Economics- Micro and Micro Economics.

**(Two periods)**

**Managerial Economics:** Definition, Nature and Scope of Managerial Economics, Differences between Economics and Managerial Economics, Main areas of Managerial Economics, Managerial Economics with other disciplines.

**(Four periods)**

**Demand Analysis:Demand -** Definition, Meaning, Nature and types of demand, Demand function, Law of demand-Assumptions and limitations. Exceptional demand curve. **(Two periods)**

**Elasticity of demand** - Definition, Measurement of elasticity, Types of Elasticity (Price, Income, Cross and Advertisement), Practical importance of Price elasticity of demand, Role of income elasticity in business decisions, Factors governing Price Elasticity of demand. **(Four periods)**

**Demand Forecasting -** Need for Demand forecasting, Factors governing demand forecasting, Methods of demand forecasting: Survey methods- Experts’ opinion survey method and consumers Survey methods.

**(Four periods)**

**Utility Analysis:** Utility- Meaning, Types of Economic Utilities, Cardinal and Ordinal Utility, Total Utility, Marginal Utility, The law of Diminishing Marginal Utility and its Limitations**. (Two periods)**

Unit –II : Theory of Production and Cost analysis:

**Production -** Meaning, Production function and its assumptions, use of production function in decision making; Law of Variable Proportions: three stages of the law.   **(Four periods)**

**Cost analysis -** Nature of cost, Classification of costs - Fixed vs. Variable costs, Marginal cost, Controllable vs. Non - Controllable costs, Opportunity cost, Incremental vs. Sunk costs, Explicit vs. Implicit costs, Replacement costs, Historical costs, Urgent vs. Postponable costs, Escapable vs. unavoidable costs, Economies and Diseconomies of scale.

**(Four periods)**

Unit –III : **Market Structures** : Definition of Market, Classification of markets; Salient features or conditions of different markets - Perfect Competition, Monopoly, Duopoly , Oligopoly, Importance of kinked demand curve; Monopolistic Competition. **(Four periods)**

Unit –IV : **Pricing Analysis** : Pricing - Significance: Different Pricing methods- Cost plus pricing, Target pricing, Marginal cost pricing, Going -rate pricing, Average cost pricing, Peak load pricing, Pricing of joint Products, Pricing over the life cycle of a Product, Skimming pricing Penetration pricing, Mark- up and Mark- down pricing of retailers. **(Four periods)**

Unit –V : Business cycles, Inflation and Deflation: **Business cycles** - Definition, Characteristics, Phases, Causes and Consequences; Measures to solve problems arising from Business cycles. **(Four periods)**

**Inflation -**Meaning, Types, Demand- pull and Cost push inflation, Effects of Inflation, Anti- inflationary measures. **(Four periods)**

**Deflation-** Meaning, Effects of Deflation, Control of Deflation, Choice between Inflation and Deflation. **(Two periods)**

*Text Books:*

1. Sankaran,S., **Managerial Economics,** Marghan Publications, 2015, Chennai.

2. Aryasri, A.R., **Managerial Economics and Financial Analysis,** MC Graw Hill Education, New Delhi,2015.

*Reference Books:*

1. Dwivedi, D.N., **Managerial Economics,** Vikhas Publishing House Pvt. Ltd. 6th Edition, New Delhi, 2004.

2. Dewett, K.K., **Modern Economic Theory**, S.Chand & Company Ltd., New Delhi, 2005.

**MET 225 – MECHANICAL PROPERTIES OF MATERIALS**

 Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Introduction, Impact of testing.

Tension test: Engineering stress strain curve. True stress and true strain diagram. Ductility measurements. Typical stress strain diagrams. Yield point phenomenon, strain ageing.

Compression Test: Fundamentals of testing, applications.

Hardness test: Introduction, Brinell, Vickers and Rockwell hardness, Micro hardness.

Fracture: Introduction, types of fracture in metals. Brittle fracture and impact testing: The problems of brittle fracture. Notched bar impact tests, significance of transition temperature, metallurgical factors affecting transition temperature

Creep and stress rupture: The creep curve. Stress rupture test. Structural changes during creep, mechanisms of creep deformation, High temperature alloys, presentation of engineering creep data, prediction of long time properties

Fatigue: Introduction, Stress cycles, S-N diagram, mechanisms of fatigue, Factors influencing fatigue properties, corrosion fatigue, thermal fatigue.

*Text books:*

1. Mechanical Metallurgy, George E Dieter, McGraw Hill.

2. Testing of Materials, A.V.K.Suryanarayana, Prentice Hall of India.

*Reference Books:*

1. Testing of Engineering Materials, Donald et.al., McGraw Hills.

2. Metals hand book

**MET 226 – NON-DESTRUCTIVE TESTING**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Visual Examination. Leakage Testing: Penetrant methods: Principles, equipment, applications and limitations. Magnetic methods: Principles of magnetism and magnetization. Principles of magnetic particle inspection. The magnaflux machine. The process. The magnetic bath. Methods for the application of magnetic bath. Demagnetization. Application of the method. Salient features of the process.

Ultrasonic testing: Types of ultrasonic waves. Flow detection and ultrasonic energy. Interpretation of results and limitations.

X-ray radiography: Production of X-rays. X-ray tube. The Radiograph. Optical factors which effect the radiograph. X-ray films. Filters and screens. Sensitivity of a radiograph. Gamma ray radiography: Production of gamma-rays, interpretation of the radiograph. Safety precautions.

Electrical methods: Thermoelectric methods. Eddy Current methods. Detection of the eddy currents. Eddy current instruments. Continuous inspection and testing.

*Reference Books:*

 1. Metals Hand Book Vol.11 (Non-Destructive Testing)

 2. Non-Destructive Testing-W.J.Mc GONNANGLE

**MET 227 P: METALLOGRAPHY LAB**

 Periods/week: **3P** Credits: **1.5** Sessionals: **50** Exam: **50**

About 12 experiments on the Metallography of common ferrous and Non-Ferrous metals and alloys, experiments on thermal analysis.

**MET 228 P – MECHANICAL METALLURGY LAB**

 Periods/week: **3P** Credits: **1.5** Sessionals: **50** Exam: **50**

List of Experiments:

1. Hardness testing (Brinell, Vickers, Rockwell)

2. Ericsen Cupping Test

3. Tensile & Bend Testing

4. Shore seleroscope hardness test

5. Poldi Testing

6. Cold working & annealing

7. Impact testing

8. Visual Inspection

9. Die penetration testing

10. Magnetic particle testing

11. Ultrasonic testing

12. Radiography testing

**SYLLABUS - III / IV First semester**

**MET 311 – MATERIALS CHARACTERIZATION**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Metallography- Macro and Micro examination of examination of metals and alloys, principles of construction of optical and electron microscopes. Resolution and magnification. Optical aberrations and correction for image quality. Specimen preparation, technique for transmission electron microscopy.

Production and properties of X-rays, Electromagnetic radiation, continuous and characteristics spectrum, absorption. Fillers. Diffraction. Bragg’s law, scattering by atom, electron, unit cell, structure factor calculation.

Diffraction Methods: Laue’s method, rotating crystal, Debye scherrer – Specimen preparation, film loading, powder method, Determination of crystal structure, determination of precision lattice parameter, sources of error in measurements.

Applications – Effect of plastic deformation. Determination of particle size, grain size, residual stresses, determination of phase diagrams, order-disorder transformation.

Chemical Analysis by X-ray techniques, X-ray fluorescence. X-ray specto meters, qualitative and quantitative analysis, micro analysis of metals and alloys, EDX, WDX.

*Text books:*

1. X-ray diffraction – B.D.Cullity

2. Transmission Electro Microsopy- G. Thomas.

**MET 312 - ADVANCES IN IRON MAKING**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

**Sponge Iron making:** Principles and classification of sponge iron processes, Coal based processes: Rotary kiln process; Rotary hearth furnace process (Fastmet process, ITmk3 process); Gas based processes –Finmet process, Midrex process, HYL processes (HYL -III & HYL –IVM processes).

**Smelting Reduction (SR):** Fundamental of SR, Classification and important SR processes: Mini Blast Furnace process, COREX process, Finex process, Fastmelt process, Hismelt process, Romelt process.

*Text books:*

1. Iron making & Steel Making- Theory and Practice- Ahindra Ghosh, Amit Chattterjee

2. Sponge Iron Production by Direct reduction of Iron Oxide – Amit Chatterjee

3. Hot metal production by Smelting Reduction of Iron Oxide - Amit Chatterjee

**MET 313 - NON FERROUS EXTRACTIVE METALLURGY –I**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Extraction of Metals. Aluminum. Uses. Ores. Bayer’s process of Alumina production. Hall-Heroult process. Cryolite and carbon electrode manufacture. Hoopes process of refining. Indian plant practice. New processes. Alcoa process.

Magnesium. Uses. Ores. Pidegon’s process. Extraction by Dows process.

Tin: Uses. Ores. Concentration, smelting and refining.

Copper. Uses. Pyro-metallugical processes. New processes. Flash smelting. WORCA and Noranda processes. Hydro-metallurgy of copper. Copper production in India.

Nickel: Brief description of Ni extraction from sulphide ores.

Lead. Uses. Ores. Treatment of ore and production of metal.

Zinc. Uses. Pyro-metallurgical and hydro-metallurgical extraction methods. Imperial smelting process.

*Text books:*

1. Extraction of Non-Ferrous Metals, HS Ray, R Sridhar and KP Abraham

*References:*

1. Metallurgy of Non-Ferrous Metals, Dennis, WH

*2. Non-Ferrous Metallurgy, Sebryukov, N Min, Pub. Moscow*

**MET 314 - STEEL MAKING**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

History of Steel Making: Cementation and crucible processes.

Principles Steel Making: Chemistry of Steel Making processes, Theories of slag. Oxidation of Si, Mn and C. Desulphurization, Dephosphorization and deoxidation. Mixers, Raw materials for steel making

Pneumatic Steel Making Process: Acid and basic Bessemer process, Side blown converter.

Open Hearth Process: Operation and chemistry of the process. Developments in OHP: AJAX, TANDEM, Tilting and twin hearth process.

BOF Process: LD, LD-AC, LAM process, OG process, Kaldo, Rotor and OBM.

Electric Furnace Process: Various electric processes, their advantages and limitations. EAF construction, lining and operation. Discussion on manufacture of stainless steel.

Casting: Pit side process and teeming methods. Ingot moulds. Solidification of steel. Ingot defects and remedies. Continuous casting of steel.

*Text books:*

1. Steel Making, R.H.Tupkary

2. Steel Making, Kudrin

3. Steel Making, Biswas

*References:*

1. The making, shaping and treating of steel-USS.

**MET 315 - METAL JOINING PROCESSES**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Introduction. Importance and classification. Basic concepts in arc welding and gas welding. General theory of arc welding. Principle, operation and application of shielded metal arc welding. Tungsten inert gas , plasma arc, studs, submerged arc, metal inert gas and CO2 welding processes. Electro-slag welding.

Resistance welding processes. Spot , seam, flash butt, upset butt, Thermit welding, Electron beam and laser beam welding. Solid state welding processes. Diffusion bonding, ultrasonic. Explosive inertia/friction welding. Soldering and brazing.

*Text books:*

1. Welding and Welding Technology, R.L.Little

2. Welding Technology, N.K.Srinivasan

**MET 316 - FOUNDRY TECHNOLOGY**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Introduction. Status of foundry industry and comparison with other manufacturing processes. Types of foundries. Basic operations.

Patterns. Pattern making. Materials for pattern making. Types of patterns. Pattern allowance. Core boxes.

Moulding materials. Properties. Preparation and testing.

Moulding processes. Sand mounding. Moulding techniques. Hand and machine compaction. Machine moulding. Cores and core making. Sodium silicate processes. Shell, Investment and Die-casting. Centrifugal casting.

Solidification – Crystallization and development of cast structure. Directional solidification and single crystal growth. Foundry characteristics.

Principles of gating and risering. Casting design considerations.

*Text books:*

1. Principles of Metal Casting, Heine, Loper and Rosenthal, Tata Mc Grawhill

2. Foundry Technology, PC Jain, Tata Mc Grawhill

3. Foundry Technology, PR Beeely, London-Buterworths.

**MET 317 P- METAL CASTING LAB**

Periods/week: **3p** Credits: **1.5** Sessionals: **50** Exam: **50**

List of Experiments

Various sand tests will be carried out like:

1. Permeability test

2. Green Compression

3. Green Shear

4. Dry Compression

5. Dry shear

6. Toughness

7. Hardness

8.Shatter Index

9. Clay content

10. AFS grain size measurement

**MET 318 – SOFT SKILLS**

Periods/week: **3P** Credits: **1.5** Sessionals: **100**

1. Basic skills, Listening, Speaking, Reading, Writing

2. Non-Verbal, Grooming (Personnel Appearance), Using Space, Body Language, Paralanguage

3. Basic Etiquette, Introducing, Conversion-Small talks, Table Manners, Telephone / Cell phone manners

4. Goal Setting, Immediate, short term, long term, Smart Goals, Strategies to achieve goals

5. Time-Management, Types of time, Identifying time wasters, Time Management Skills

6. Using Telephone, Making and receiving calls, Handling wrong numbers and unnecessary calls, Intonation, Enuciation

7. Leadership and Team Management, Qualities of good leader, Leadership styles, Decision Making, Problem solving, Negotitation skills

8. Assertiveness, Assertiveness and aggressiveness, Disagreement, Openness and Expressiveness, Self Concept, Positive thinking

9. Group Discussion, Purpose (intellectual ability, Creativity, Approach to a problem, solving, Tolerance, Qualities of a leader), Group behaviour, Analysing Performance

10. Job Interview, Identifying Job Openings, Preparing a Resume (Basic, Functional, specific), Covering letter (solicited / unsolicited), Interview (Opening, Body-Answer Q, Close-Ask Q), Types of questions, Handling difficult questions

*Reference Books*

1. ‘*Technical Communication’ Principles & practice* by Meenaskshi Raman and Sangeetha Sharma, Oxford University Press.

2. ‘*Development Communication Skills’* by Krishna Mohan & Meera Banerji, Macmillian Publishers.

3. ‘*Technical Writing’ Process and Product* by Sharon J.Gerson & Steven M.Gerson, Pearson Education Publishers

4. ‘*Technical Communication skills’* by Rizvi , Tata McGraw Hill Publications

5. ‘*The Oxford Guide to Writing and Speaking’* by John Seely,Oxford University Press

**SYLLABUS - III / IV Second semester**

**MET 321 - HEAT TREATMENT**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Phase transformation in Fe-C system, Critical temperatures. Austenite grain size designation. Inherently fine-grained and inherently coarse grained steel. Importance of grain size and its determination. Heat Treatment Furnaces and atmospheres.

T-T-T Curves. Effect of cooling on transformation of austinite, pearlite, bainite and martensite. Annealing, normalizing, hardening and tempering of steels. Austempering . Martempering . Patenting and spheroidizing.

Effect of alloying elements. Hardenability of steels. Factors affecting and its determination. Thermo-mechanical treatments. Ausforming. Strain tempering.

Surface hardening. Carburising, nitriding , cyaniding, carbonitriding. Induction and flame hardening.

*Text books:*

1. Heat treatment, Rajan

2. Heat treatment of metals, Zakharov

*References:*

1. Physical Metallurgy, V.Raghavan

2. Introduction to Physical Metallurgy, S.H.Avner

3. Physical Metallurgy Principles, R.E. Reed- Hill.

4. Physical Metallurgy for Engineers, Clark and Varney

**MET 322 - FOUNDRY PRACTICES**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

· General principles of melting Cupola and its operation. Modern developments in cupola. Melting practice of Al, Cu and Mg alloys.

· Defects in castings.

· Fettling.

· Inspection and quality control.

· Metallurgy of cast irons. Foundry practices of white, gray, SG and malleable irons. Alloy cast irons.

· Steel foundry practice.

· Modernization and mechanization of foundries

*Text books:*

1. Principles of Metal Casting, Heine, Loper and Rosenthal, Tata Mc Grawhill

2. Foundry Technology, PC Jain, Tata Mc Grawhill

3. Foundry Technology, PR Beeely, London-Buterworths.

**MET 323 - METAL FORMING**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Fundamentals of metal working. Classification of forming processes. Flow-stress determination. Temperature in metal working . Strain-rate effects. Metallurgical Structure . Friction and Lubrication.

Forging classification. Forging equipment. Open die and closed die forging. Calculation of forging loads in closed die forging. Forging defects. Rolling classification. Rolling mills and accessories. Hot and cold rolling. Elements of roll pass design. Rolling of bars and shapes. Forces and geometric relationships in rolling. Rolling variables . Problems and defects in rolled products. Torque and Horse power.

Extrusion .Classification. Extrusion equipment . Hot extrusion. Deformation, lubrication and defects in extrusion. Hydrostatic extrusion. Extrusion of tubing. Miscellaneous working operations . Drawing of rods wires and tubes.. Sheet metal forming.

*Text Books*

1. Mechanical Metallurgy by G.E. Dieter McGraw Hill Book Co.,

2. Introduction to Physical Metallurgy by S.H.Anver, McGraw Hill

**MET 324 - ADVANCES IN STEEL MAKING &
PRODUCTION OF FERRO ALLOYS**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Hybrid Steel making processes, SIP and EOF process.

 Continuous steel making processes: WOCRA, IRSID, Spray steel making, Recent trends in steel making processes.

Secondary steel making processes: Stirring Treatments, Synthetic slag refining, Injection metallurgy, Plunging Techniques, Post solidification treatments, vacuum treatments, decarburization techniques, secondary refining furnaces (LF furnace).

Gases in steel, vacuum treatment of liquid steel

Production of Ferro alloys: Fe-Si, Fe-Mn, Fe-Cr, Fe-V, Silico-Manganese.

*Text books:*

1. Steel Making, R.H.Tupkary

2. Steel Making, Kudrin

3. Steel Making, Biswas

*References:*

1. The making, shaping and treating of steel-USS.

**MET 325 - NON FERROUS EXTRACTIVE METALLURGY –II**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Production flow sheets of extraction of Gold and Silver.

Uranium. Extraction of Uranium. Production flow sheet of Jaduguda ore.

Production flow sheets of extraction of Thorium.

Brief outlines of extraction of Plutonium.

Titanium. Production of Titanium chloride from Ilmenite. Production of Ti sponge.

Zirconium production in India.

Nuclear Reactor Technology. Fuel for nuclear reactors. Basic components of a reactor characteristics and requirements. Types of reactors.

Text books:

1. Extraction of Non-Ferrous Metals, HS Ray, R Sridhar and KP Abraham

*References:*

1. Metallurgy of Non-Ferrous Metals, Dennis, WH

*2. Non-Ferrous Metallurgy, Sebryukov, N Min, Pub. Moscow*

**MET 326 - COMPOSITE MATERIALS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Introduction: Definition, classification, properties, applications, advantages and limitations of composites, Types of matrix and reinforcements, and their properties. Mechanics of Composites, Iso strain and Iso stress conditions, Role of fibers, Critical fiber length.

Fabrication of Polymer Matrix Composites (PMCs): Properties, Applications and Limitations of PMCs; Various fabrications methods- Hand Layup technique, Spray Up Technique, Filament welding, Pultrusion, Autoclave based methods, Injection moulding, Extrusion.

Fabrication of Metal Matrix Composites (MMCs): Properties, Applications of MMCs; Fabrications methods: Liquid methods- Duralcan process, Spray forming, Squeeze casting, Stir casting; Solid state process- Diffusion bonding.

Fabrication of Ceramic Matrix Composites (CMCs): Properties, Applications and limitations of CMCs; Various fabrications methods: Cold pressing and sintering, Hot pressing, Liquid infiltration, Lanxide process.

Fabrication of Carbon-Carbon Composites (CCCs): Properties, Applications and limitations of CCCs; Processing of CCC- Solid, Liquid and Gas phase pyrolysis processes.

*Text books:*

1. Materials Science and Engineering: An Introduction - William D Callister Jr

2. Composite Materials-Krishma K Chawla

*Reference books:*

1. ASM Handbook Volume 21: Composites

**MET 327:MANDATORY COURSE (MC):**

**INDIAN CONSTITUTION / ESSENCE OF
INDIAN TRADITIONAL KNOWLEDGE**

Periods/week:Credits:Sessionals:Exam:

Course content

1. Meaning of the constitution law and constitutionalism

2. Historical perspective of the Constitution of India

3. Salient features and characteristics of the Constitution of India

4. Scheme of the fundamental rights

5. The scheme of the Fundamental Duties and its legal status

6. The Directive Principles of State Policy – Its importance and implementation

7. Federal structure and distribution of legislative and financial powers

between the Union and the States

8. Parliamentary Form of Government in India – The constitution powers and status of the President of India

9. Amendment of the Constitutional Powers and Procedure

10. The historical perspectives of the constitutional amendments in India

11. Emergency Provisions : National Emergency, President Rule, Financial Emergency

12. Local Self Government – Constitutional Scheme in India

13. Scheme of the Fundamental Right to Equality

14. Scheme of the Fundamental Right to certain Freedom under Article 19

15. Scope of the Right to Life and Personal Liberty under Article 21

**MET 328 P - HEAT TREATMENT LAB**

Periods/week: **3P** Credits: **1.5** Sessionals: **50** Exam: **50**

List of Experiments:

1. Annealing, Normalizing, hardening and tempering of steels.

2. Recovery and recrystallization of cold worked metal.

3. Effect of quenching media on hardening

4. Study of welded structures.

5. Jomney End Quench Test.

6. Pack carburizing of low carbon steels.

7. Age hardening of aluminum alloys

8. Effect of time and temperature on tempering

**MET 329 P - MATERIALS PROCESSING LABORATORY**

Periods/week: **3P** Credits: **1.5** Sessionals: **50** Exam: **50**

Use of basic tools and operations of the following trades

 S.No. Trade Number of jobs

 1 Foundry 4

 2 Welding 4

 3 Machining Step and taper turning-2

**SYLLABUS - IV / IV First semester**

**MET 411 - STRENGTHENING MECHANISMS**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Strengthening from grain boundaries, Hall-Petch relation, ASTM grain size measurement, yield-point phenomenon, strain aging.

Solid solution strengthening: Elastic interaction, modulus interaction, stacking fault interaction, electrical interaction, short range order interaction, long range order interaction.

Cold working: Strain hardening of single crystals, annealing of cold worked metal, recovery, recrystallization and grain growth.

Strengthening from fine particles: Principle, mechanisms and examples of Precipitation hardening (age hardening), Dispersion hardening. Fiber strengthening, strength and moduli of composites (Iso-strain and Iso-stress condition), influence of fiber length, orientation and concentration

Strengthening by phase transformations: Annealing, Normalizing and Hardening. Martensite strengthening.

*Text Books:*

1. Mechanical Metallurgy - George E Dieter

2. Mechanical Behaviour of Materials - Thomas H Courtany

3. Materials Science and Engineering an Introduction - William D Callister Jr

4. Materials Science and Engineering – V Raghavan

**MET 412 - ENVIRONMENTAL DEGRADATION OF MATERIALS**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Corrosion – Electrochemical aspects of Corrosion. Corrosion cells/Electro chemical cells, Concentration cells, Temperature cells. Determination of Electrode potential. Thermodynamic aspects - Nerrnest equation, Helmholtz equation. Galvanic series. Polarization resistance , Linear polarization technique for evaluation of Icorr.

Corrosion – Practical aspects .Importance. Direct and indirect losses. Types and Forms of Corrosion. Uniform Corrosion, Pitting Corrosion, Galvanic Corrosion, and Integranular Corrosion, Stress Corrosion cracking. Cavitation Erosion, Erosion Corrosion. Corrosion Fatigue. Differential aeration corrosion. Corrosion rate expressions. Testing methods. Effect of velocity, flow-rate, concentration, temperature and inhibitors on corrosion rates. Corrosion rate calculations.

Electroplating, Principles – Throwing power and its evaluation. Commercial plating of Cu, Ni, Cr, Zn. Commercial anodizing process. Cathodic and Anodic protection.

*Text books:*

1. An introduction to Electrometallurgy, Sharan and Narain, Standard Publishers

2. Corrosion Engineering, MG Fountana, Mc-Graw Hill book company

3. Electro Beam Analysis of Materials, Loretto.

**MET 413 - ENGINEERING MATERIALS**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Classification, properties and applications of:

· Carbon Steels: Low, medium and high carbon steels, HSLA, Dual Phase steels

· Alloy Steels: High strength structural steels, Tool steels, Stainless steels, High Temperature alloys

· Cast irons: White cast iron, Malleable Cast iron, Grey Cast iron, Ductile Cast iron

· Light alloys: Al, Mg, Ti, Be and its alloys

· Copper and its alloys

*Text Books*

1. Introduction to Physical Metallurgy - SH Avner

2. Physical Metallurgy Principles and Practice –Raghavan.V

**MET 414 - HUMANITIES (OEC-II):
INDUSTRIAL MANAGEMENT AND ENTREPRENEURSHIP**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Unit-I Basic Concepts of Management: **Management: -** Definition, Nature and Importance ; Functions of the Management; Levels of Management; F.W Taylor’s Scientific Management; Henry Fayol’s Principles of Management;

**(Eight Periods)**

Unit-II : **Forms of Business Organizations:** Introduction, **Types of Business organizations: Private Sector**- Individual Ownership , Partnership, Joint stock companies and Co-Operative organizations**; Public sector**- Departmental Organizations, Public Corporations and Government Companies; The Joint sector Management.  **(Eight periods)**

Unit-III : **Production and operations Management:** Plant location- Factors to be considered in the selection of Plant location; Break - even analysis- Significance and managerial applications; Importance of Production Planning and Control and its Functions; Human Resource Management and Functions of Human Resource Manager (in brief); Functions of Marketing; Methods of Raising Finance.  **(Ten periods)**

Unit-IV : **Entrepreneurship:** Definition, Characteristics and Skills, Types of Entrepreneurs, Entrepreneur vs. Professional Managers, , Growth of Entrepreneurs, Nature and Importance of Entrepreneurs, Women Entrepreneurs, Problems of Entrepreneurship.  **(Six periods)**

Unit-V : **Entrepreneurial Development and Project Management:** Institutions in aid of Entrepreneurship Development, Idea generation: Sources and Techniques;, Stages in Project formulation ; Steps for starting a small enterprise - Incentives for Small Scale Industries by Government.

 **(Eight periods)**

*Text Books:*

(1) Sharma,S.C, and Banga, T.R., Industrial Organization & Engineering Economics, Khanna Publishers, Delhi, 2000.

(2) Vasant Desai, The Dynamics of Entrepreneurial Development and Management (Planning for future Sustainable growth), HImalayan Publishing House, 2018.

*Reference Books:*

 (1) Aryasri, A.R., Management Science, McGraw HIll Education (India Private Limited, New Delhi 2014.

 (2) Sheela, P. and Jagadeswara Rao, K., Entrepreneurship, Shree Publishing House, Guntur, Andhra Pradesh, 2017.

**MET 415 –NANO MATERIALS**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

Importance of Nano–Technology, Emergence of Nano–Technology, Bottom-Up and Top–down approaches, challenges in Nano–Technology.

Zero-dimensional Nano particles through homogeneous nucleation: Growth of nucleii, synthesis of metallic nano particles, Nano particles through heterogeneous nucleation:

One-dimensional Nano wires and rods, Spontaneous growth: Evaporation and Condensation growth, vapor- liquid - solid growth, Template based synthesis

Two Dimensional Nano-structures, Physical Vapour Deposition (PVD, Chemical Vapour Deposition (CVD),Atomic Layer Deposition (ALD). Applications of Nano materials.

*Text Books:*

1. Nanostructures and Nanomaterials: Synthesis, properties and
applications

2. Guozhong Cao – Imperial College Press.

**MET 416 P - ELECTRO METALLURGY LAB**

Periods/week: **3P** Credits: **1.5** Sessionals: **50** Exam: **50**

LIST OF EXPERIMENTS:

1. Experimental verification of Faraday’s laws.

2. Determination of throwing power of electrolytes.

3. Electro plating of copper.

4. Electro plating of Nickel.

5. Anodizing of Aluminium.

**MET 417: PROJECT - I**

Periods/week: **3P** Credits: **5** Sessionals: **50** Exam: **50**

**SYLLABUS - IV / IV Second semester**

**MET 421 - POWDER METALLURGY**

Periods/week: **3L -1T** Credits: **3** Sessionals: **30** Exam: **70**

**Introduction:** Advantages and limitations of powder metallurgy.

Powder production methods: Mechanical, Chemical, Electrolytic and atomization Methods. Commercial production of metallic powders.

Powder characteristics: Composition and structure, particle size, shape, specific surface, surface topography, flow rate, apparent and tap density, pressing properties.

Compaction of metal powders: Pressure and Pressureless compaction techniques: Die compaction, Cold Isostatic pressing, Powder rolling, Powder forging, Explosive forming; High Temperature Compaction methods: Hot Pressing, Hot Extrusion, Spark Plasma Sintering, H I P.

Principles and practice of sintering: Sintering mechanisms, stages of sintering, Driving forces for sintering, sintering atmospheres, Liquid phase sintering, Post sintering operations.

**Applications of powder metallurgy:** Cermets, bearing materials, dispersion strengthened materials and other miscellaneous applications.

*Text Books*

1. Powder Metallurgy Science, Technology and Applications – P.C. Angelo & R. Subramanian

2. Powder Metallurgy – J.S. Hirschhorn

3. Treatise on Powder Metallurgy – C. Goetzel, vol. 1&2.

4. Powder Metallurgy Practice and Applications – R.L. Sands & C.R. Shakespeare.

5. Handbook of Powder Metallurgy – H. H. Hausner & M.Mal- 2nd Ed.

**MET 422 -FAILURE ANALYSIS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Sources of Failures, Steps in Failure Analysis, Characteristics of ductile and brittle fracture, ductile to brittle transition. High temperature failures,
Fatigue failures, Corrosion failures and their identification, Failures of industrial components like casting and welding.

Some case studies in failure analysis.

*Text Books/Reference:*

Analysis of Metallurgical failures-VJ Collangelo and PA Heiser

**MET-423: PROJECT - II**

Periods/week: **3P** Credits: **10** Sessionals: **50** Exam: **50**

 **DEPARTMENT OF METALLURGICAL ENGINEERING**

**M.TECH. (INDUSTRIAL METALLURGY)**

(with effect from 2019-2020 academic year)

**I – SEMESTER**

Code No Course Title Scheme of Instruction Scheme of Examination Total Credits

 Lec. Tut. Total Exam. Theory/ Sess.
 Duration Lab./Viva

IMT 11 Core subject 1Advances in
 iron and steel making 4 - 4 3 70 30 100 3

IMT 12 Core subject 2Metal Casting 4 - 4 3 70 30 100 3

IMT 13 Core subject 3Metal Joining 4 - 4 3 70 30 100 3

IMT 14 Programme Elective
 1a. Composite Materials
 b. Polymer Technology
 c. Ceramic Technology 4 - 4 3 70 30 100 3

IMT 15 Programme Elective
 2a. Corrosion Engineering
 b. Alloy Steels
 c. Surface Engineering 4 - 4 3 70 30 100 3

IMT 16 Research Methodology
 and IPR 3 - 3 - 70 30 100 2

IMT 17 Audit Course-1 3 - 3 - 70 30 100 0

IMT 18 Casting Lab — 3 3 Viva-voce 50 50 100 2

IMT 19 Welding Lab — 3 3 Viva-voce 50 50 100 2

 TOTAL 26 6 32 15 590 310 900 21

***Note:*** The viva-voce for the labs/seminars shall be held with the course instructor/faculty member and an external examiner nominated by the university from any academic institution/industry/R&D organization.

**II - SEMESTER**

Code No Course Title Scheme of Instruction Scheme of Examination Total Credits

 Lec. Tut. Total Exam. Theory/ Sess.
 Duration Lab./Viva

IMT 21 Core subject 3Failure Analysis 4 - 4 3 70 30 100 3

IMT 22 Core subject 4Strengthening
 Mechanisms 4 - 4 3 70 30 100 3

IMT 23 Core subject 51ndustrial
 Heat Treatment 4 - 4 3 70 30 100 3

IMT 24 Programme Elective
 3a. Powder Metallurgy
 b. Energy materials
 c. Electronic Materials 4 - 4 3 70 30 100 3

IMT 25 Programme Elective
 4a. Non Destructive Testing
 b. Metal forming
 c. Fracture Mechanics 4 - 4 3 70 30 100 3

IMT 26 Audit Course-2 3 - 3 - - - - 0

IMT 27 Physical Metallurgy Lab — 3 3 Viva-voce 50 50 100 2

IMT 28 Testing of materials Lab — 3 3 Viva-voce 50 50 100 2

IMT 29 Mini project with Seminar **—** 3 3 Viva-voce - 100 100 2

 TOTAL 23 9 32 15 450 350 800 21

***Note:*** The viva-voce for the labs/seminars shall be held with the course instructor/faculty member and an external examiner nominated by the university from any academic institution/industry/R&D organization.

**III – SEMESTER**

Code No Course Title Scheme of Instruction Scheme of Examination Total Credits

 Lec. Tut. Total Exam. Theory/ Sess.
 Duration Lab./Viva

IMT 31 Programme Elective
 5a. Nano Composites
 b. Functional materials
 c. Bio materials 4 - 4 3 70 30 100 3

IMT 32 Open Elective
 a. Materials Characterization
 b. Solidification Processing
 c. Phase Transformations 4 - 4 3 70 30 100 3

IMT 33 Dissertation-I **—** - - - - 100 100 6

 TOTAL 8 - 8 6 140 160 300 12

***Note:*** The Dissertation shall be evaluated through Viva-voce examination by a committee with HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 30,30 and 40 percent by the members respectively.

**IV - SEMESTER**

 Code No Subject Scheme of Total Marks Credits
 Examination

 IMT 41 Dissertation – II Viva-voce 100 14

***Note:*** The Dissertation shall be evaluated through Defence and Viva-voce examination by a committee with an External Examiner nominated by University, HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 20, 20, 20 and 40 percent by the members respectively.

Audit course 1 & 2

1. English for Research Paper Writing

2. Disaster Management

3. Sanskrit for Technical Knowledge

4. Value Education

5. Constitution of India

6. Pedagogy Studies

7. Stress Management by Yoga

8. Personality Development through Life Enlightenment Skills.

Total Credits: 68

 Year I Semester II Semester Total

 First 21 21 42

 Second 12 14 26

 Total Credits 68

**IMT 11- ADVANCES IN IRON & STEEL MAKING**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Sponge Iron making: Coal based processes: Rotary kiln process, Rotary hearth furnace process (Fastmet process, ITmk3 process). Gas based processes –Finmet process, Midrex process, HYL processes (HYL -III & HYL –IVM processes).

Smelting Reduction (SR): Fundamental of SR, Classification and important SR processes: COREX process, Finex process, Hismelt process, Romelt process.

Hybrid Steel making processes, Continuous steel making processes: WOCRA, IRSID, Spray steel making. Secondary steel making processes, Inert Gas Purging, decarburization techniques, vacuum treatments, Ladle Furnace (LF).

*Text books:*

1. Iron making & Steel Making- Theory and Practice- Ahindra Ghosh, Amit Chattterjee

2. Sponge Iron Production by Direct reduction of Iron Oxide – Amit Chatterjee

3. Hot metal production by Smelting Reduction of Iron Oxide - Amit Chatterjee

4. Modern Steel Making- R.H. Tupkary, V.R. Tupkary

**IMT 12-METAL CASTING**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

New and emerging casting techniques: Counter gravity low pressure casting, squeeze casting, semi solid metal casting and forging, plaster molding, ceramic molding, replicast process.

Design consideration: Risers, gating, casting, dimensional tolerances and allowances.

*References:*

1. Principles of Metal Casting – Richard Heine, Carl Loper, Philip Rosenthal

2. Foundry Technology-Bailey

3. Casting Technology – Vol 4 ASM Metals Hand book

**IMT 13 - METAL JOINING**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Flux assisted GTAW process, lead free soldering, friction welding processes, friction stir welding and friction surfacing, micro joining, microwave Joining and hybrid welding

Heat flow and temperature distribution in and around weld metal., calculation of heat input and heat affected zone width.

Problems during welding of carbon steels, welding of stainless steels. Schaffler diagram.

Welding of aluminum alloys, welding of titanium alloys and welding of dissimilar metals.

*Reference:*

1. ASM Metal hand book

**IMT 14– (Elective - 1)**

**(a). COMPOSITE MATERIALS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Introduction: Definition, classification, properties, applications, advantages and limitations of composites, Types of matrix and reinforcements, and their properties. Mechanics of Composites, Iso strain and Iso stress conditions, Role of fibers, Critical fiber length.

Fabrication of Polymer Matrix Composites (PMCs): Properties, Applications and Limitations of PMCs; Various fabrications methods- Hand Layup technique, Spray Up Technique, Filament welding, Pultrusion, Autoclave based methods, Injection moulding, Extrusion.

Fabrication of Metal Matrix Composites (MMCs): Properties, Applications of MMCs; Fabrications methods: Liquid methods- Duralcan process, Spray forming, Squeeze casting, Stir casting; Solid state process- Diffusion bonding.

Fabrication of Ceramic Matrix Composites (CMCs): Properties, Applications and limitations of CMCs; Various fabrications methods: Cold pressing and sintering, Hot pressing, Liquid infiltration, Lanxide process.

Fabrication of Carbon-Carbon Composites (CCCs): Properties, Applications and limitations of CCCs; Processing of CCC- Solid, Liquid and Gas phase pyrolysis processes.

*Text books:*

1. Materials Science and Engineering: An Introduction - William D Callister Jr

2. Composite Materials-Krishma K Chawla

*Reference books:*

1. ASM Handbook Volume 21: Composites

**(b). POLYMER TECHNOLOGY**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Polymer Structures: Polymer molecules chemistry, shape, weight, structure, and configurations. Classification, properties and applications, Thermoset and Thermo plastic polymers, Polymerization, Copolymers, Polymer crystallinity, Polymer crystals, Defects in polymers, Diffusion in Polymeric materials.

Characteristics and Processing of Polymers: Mechanical Behaviour of Polymers, Deformation Mechanisms and strengthening of Polymers, Glass transition phenomenon in polymers, Polymer synthesis and Processing.

*Text books:*

1. Materials Science and Engineering: An Introduction - William D Callister Jr

**(c). CERAMIC TECHNOLOGY**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Introduction: Definition- Classification of Ceramics- Traditional Ceramics – Structural Ceramics, Fine Ceramics, Bio Ceramics. Structure of Ceramic Crystals: Oxide structures, Silicate structures, Glass formation, Types of Glasses

Ceramic Phase diagrams: Two component systems- Al2O3-SiO2, BaO-TiO2; Three component systems- MgO- Al2O3-SiO2.

Powder preparation techniques: Sol-gel technology, Precipitation, Coprecipitation, Hydrothermal precipitation

Ceramic processing techniques: Die compaction, Hot pressing, Cold Isostatic Pressing (CIP), Hot Isostatic Pressing (HIP), Sintering: Principles and processes. Slip casting, Tape Casting.

*Text Books:*

1. Introduction to Ceramics: W.D. Kingery et al- John Wiley

2. Materials Science and Engineering: An Introduction - William D Callister Jr

**IMT 15- (Elective 2)**

**(a). CORROSION ENGINEERING**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Introduction, Polarization and passivity, Pourbaix diagrams.

Forms of corrosion, Characterization and remedial measures of uniform corrosion, Galvanic corrosion, pitting corrosion, crevice corrosion, intergranular corrosion, erosion corrosion and stress corrosion cracking.

Corrosion prevention methods: Alteration of Environment (Inhibitors), Design, Coatings, Cathodic and anodic protection, Material selection, Metallurgical aspects, Corrosion fatigue, Hydrogen damage (hydrogen blistering, hydrogen embrittlement, prevention).

Corrosion of welds.

*Text books:*

An introduction to Electrometallurgy, Sharan and Narain, Standard Publishers

Corrosion Engineering, MG Fontana, Mc-Graw Hill Book Company

Electro Beam Analysis of Materials, Loretto.

**(b). ALLOY STEELS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Low-carbon steels: Introduction, Conventional low carbon steels, cold forming characteristics, Dual phase steels, Mild steel, HSLA steels, Formability of HSLA steels, Strengthening Mechanisms, Structure property relationships.

Medium and High carbon ferrite- pearlite steels – structure property relationships, Ferrite – Pearlite steels, Bainitic steels, requirements and developments. Rail structurals, Spring steels and High strength structural steels – heat treatment, structure, properties and applications.

Ultra – high strength steels: Thermomechanical treatments (TMT), Maraging steels, Ausforming steels, Strengthening mechanisms, structure-property relationships. Mechanical properties and applications.

Heat and corrosion resistant steels – Basic Principals, Low chromium heat resistant steels, Stainless steels: Classification, Composition, Heat Treatment, Microstructure properties and applications.

Tool steels Classification and property requirements, Composition – Heat Treatment Microstructure – properties and applications of various groups of alloy tool and die steels.

*Text Books:*

Physical Metallurgy and the design of steels: F.B. Pickering

Physical Metallurgy of Steels: W.C. Leslie.

**(c) SURFACE ENGINEERING**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Introduction to surface modification, need for surface modification, surface properties, surface property modification, history of surface modification.

Plating and coating process: Concept of coating, types of coatings and classification of coatings based on application and manufacturing methods, properties of coating, hardfacing, anodizing, PVD, CVD, Electrodeposition, electroless deposition, hot dipping.

Thermomechanical process: Plasma nitriding, boronising, nitriding, carbonitriding, carburizing, nitrocarburizing, thermal spraying, plasma spraying.

Thermal processes: Hardening, tempering, annealing, laser hardening, laser surface alloying, laser cladding, electron beam hardening.

General design principles related to surface engineering, design guidelines for surface preparation, surface engineering solutions to specific problems.

*Text Books:*

Advanced Thermally Assisted surface engineering processes, Ramanarayan Chattopadhyay, Kluwer Academy Publishers.

Surface Engineering of metals: Principles, Equipment and Techniques, Tadeusz Burakowski, Tadeusz Wierzchon, CRC Press.

Laser Material Processing, W. Steen, Springer.

**IMT 16-RESEARCH METHODOLOGY AND IPR**

Periods/week: **3** Credits: **2** Sessionals: **30** Exam: **70**

**IMT 17-AUDIT COURSE-1**

Periods/week: **3** Credits: **0** Sessionals: **30** Exam: **70**

**IMT 18-CASTING LAB**

Periods/week: **3** Credits: **2** Sessionals: **50** Exam: **50**

A laboratory project on any one of these topics.

1. Sand Testing

2. CO2 Molding,

3. Shell Molding,

4. Design of Gating systems,

5. Vacuum Molding,

6. NDT of castings

**IMT 19- WELDING LAB**

Periods/week: **3** Credits: **2** Sessionals: **50** Exam: **50**

1. Study on microstructure of different zones of aluminium and steel welds.

II SEMESTER

**IMT 21-FAILURE ANALYSIS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Sources of Failures, Steps in Failure Analysis,

Characteristics of ductile and brittle fracture, ductile to brittle transition. High temperature failures,

Fatigue failures,

Corrosion failures and their identification,

Failures of industrial components like casting and welding.

Some case studies in failure analysis.

Text Books/Reference:

Analysis of Metallurgical failures-VJ Collangelo and PA Heiser

**IMT 22- STRENGTHENING MECHANISMS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Strengthening from grain boundaries, Hall-Petch relation, ASTM grain size measurement, yield-point phenomenon, strain aging.

Solid solution strengthening: Elastic interaction, modulus interaction, stacking fault interaction, electrical interaction, short range order interaction, long range order interaction.

Cold working: Strain hardening of single crystals, annealing of cold worked metal, recovery, recrystallization and grain growth.

Strengthening from fine particles: Principle, mechanisms and examples of Precipitation hardening (age hardening), Dispersion hardening. Fiber strengthening, strength and moduli of composites (Iso-strain and Iso-stress condition), influence of fiber length, orientation and concentration Strengthening by phase transformations, Martensite strengthening.

*Text Books:*

1. Mechanical Metallurgy - George E Dieter

2. Mechanical Behaviour of Materials - Thomas H Courtany

3. Materials Science and Engineering an Introduction - William D Callister Jr

4. Materials Science and Engineering – V Raghavan

**IMT 23-INDUSTRIAL HEAT TREATMENT**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Furnaces, salt bath equipment, fluidized bed equipment, vacuum furnaces. Heat treatment of Cast iron, tool steels, stainless steel and heat resistant alloys, non-ferrous alloys: Al, Cu, Mg, Ti. Thermo mechanical processing of steels.

*Text books:*

1. Heat treatment, Rajan

2. Heat treatment of metals, Zakharov

*References:*

1. Physical Metallurgy, V Raghavan

2. Introduction to Physical Metallurgy, SH Avner

3. Physical Metallurgy Principles, RE Reed-Hill.

4. Physical Metallurgy for Engineers, Clark and Varney

IMT 24- (Elective - 3)

**(a) POWDER METALLURGY**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Introduction: Advantages and limitations of powder metallurgy. Applications of powder metallurgy.

Powder production methods: Mechanical, Chemical, Electrolytic and atomization Methods. Commercial production of metallic powders.

Powder characteristics: Composition and structure, particle size, shape, specific surface, surface topography, flow rate, apparent and tap density, pressing properties.

Compaction of metal powders: Pressure and Pressure-less compaction techniques: Die compaction, Cold Iso-static pressing, Powder rolling, Powder forging, Explosive forming; High Temperature Compaction methods: Hot Pressing, Hot Extrusion, Spark Plasma Sintering, H I P.

Principles and practice of sintering: Sintering mechanisms, stages of sintering, Driving forces for sintering, sintering atmospheres, Liquid phase sintering, Post sintering operations.

*Text Books*

1. Powder Metallurgy Science, Technology and Applications – P.C. Angelo & R. Subramanian

2. Powder Metallurgy – J.S. Hirschhorn

3. Treatise on Powder Metallurgy – C. Goetzel, vol. 1&2.

4. Powder Metallurgy Practice and Applications – R.L. Sands & C.R. Shakespeare.

5. Handbook of Powder Metallurgy – H. H. Hausner & M.Mal- 2nd Ed.

 **(b) ENERGY MATERIALS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

· Energy requirements in a global scale and in the Indian context.

· Evaluation of energy sources from the perspective of clean energy. Carbon equivalent

· Introduction to different types of energy storage and conversion devices and technologies. Synthesis and characterization of materials used for these technologies, Properties desired in the materials, Techniques to evaluate the properties and performance, failure modes and analysis, environmental impact of the following technologies:

o Fuel cells

o Batteries

o Supercapacitors

o Solar energy conversion devices

o Wind

o Mechanical Energy storage

*Text books*

1. Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, 2004

**(c) ELECTRONIC MATERIALS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

· Intrinsic semiconductors. Electron and hole (carrier) concentrations.

· Fermi energy level, effect of temperature on Fermi energy

· Carrier mobility

· Direct vs. indirect band gap materials

· Elemental vs. compound semiconductors. Extrinsic semiconductors. Doping – p and n type semiconductors

· Carrier concentration and Fermi level as a function of temperature. Drift mobility. Light and heavy doping

· Semiconductor diodes – p-n junctions at equilibrium. Forward and reverse bias. IV characteristics. Band diagram. Diode breakdown mechanisms

· LEDs and solar cell materials. Transistors – MOSFETs. Band diagram and channel formation. Threshold voltage. I-V characteristics

· Introduction to semiconductor manufacturing – history, process flow, manufacturing goals. Bulk Si crystal growth

· Overview of manufacturing technology – oxidation, photolithography, etching, doping, deposition, planarization. Clean room classifications

· CMOS manufacturing steps. Process monitoring – blank and patterned thin film measurement. Defect inspection. Electrical testing. Yield monitoring & statistical process control. Definitions of yield, process control, defect density. Process integration. Assembly and packaging

*Text books*

1. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley 2017

*Reference books*

1. Principles of Electronic Materials and Devices, S. O. Kasap, McGraw Hill Education, 2017

IMT 25- (Elective - 4)

**(a). NON-DESTRUCTIVE TESTING**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Visual examination. Leakage Testing.

Penetrant methods: Principles, equipment, applications and limitations.

Magnetic methods: Principles of magnetism and magnetization. Principles of magnetic particle inspection. The magna flux machine. The process. The magnetic bath. Methods for the application of magnetic bath. Demagnetization. Application of the method. Salient features of the process.

Ultrasonic testing: Types of ultrasonic waves. Flow detection and ultrasonic energy. Interpretation of results and limitations.

X-ray radiography: Production of X-rays. X-ray tube. The Radiograph. Optical factors which effect the radiograph. X-ray films. Filters and screens. Sensitivity of a radiograph.

Gamma ray radiography : Production of gamms-rays, interpretation of the radiograph. Safety precautions.

Electrical methods: Thermoelectric methods. Eddy current methods. Detection of the eddy currents. Eddy current instruments. Continuous inspection and testing.

*Text Books:*

1. Metals Hand book Vol.11 (Non-Destructive Testing)

2. Non-Destructive Testing-WJ Mc Gonnangle

**(b) METAL FORMING**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Fundamentals of metal working, mechanics of metal forming, temperature of metal working, hot working, cold working.

Forging, classification of forging processes, forging of plate, forging of circular disc, open-die and close-die forging, forging defects

Rolling, rolling processes, forces and geometrical relationship in rolling, simplified analysis of rolling load, rolling variables, problems and defects in rolled variables.

Extrusion, classification of extrusion processes, hot extrusion, analysis of extrusion processes, defects in extrusion

 Sheet metal forming, deep drawing, forming limit criteria, defects in formed parts.

*Text Books:*

1. Mechanical Metallurgy- GE Dieter

2. Principles of Metal Working- Surendar Kumar

3. Principles of Metal working-GW Rowe

*Reference:*

1. ASM Metals Handbook

**(c). FRACTURE MECHANICS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Introduction, Fracture Criteria, Theoretical strength, stress concentration factor, Griffith crack theory, strain-energy release rate.

Mechanism of fracture: Introduction, cleavage fracture, ductile fracture, fatigue cracking, environment assisted cracking, evaluation of fracture toughness. Introduction to LEFM: Concept, Analysis of simple crack problems, nucleation and propagation of cracks, correlation between microstructure and fracture behaviour in different materials.

Crack behaviour in elastic-plastic materials, effect of strain rate, environment, temperature and irradiation on fracture behaviour of materials, Application of fracture mechanicsis to material selections, alloy design and design of structures.

Conventional approach to fatigue crack growth in reactive environment, static and cyclic loading.

*Text Books:*

Fracture Mechanics: Fundamentals and Applications, T.L. Anderson,crc press Inc., 1995.

ASM Handbook: Fatigue and Fracture, S.R. Lampman, (Rechnical Ed), ASM Internationsl, 1996.

**IMT 26-AUDIT COURSE-2**

Periods/week: **3** Credits: **0** Sessionals: **30** Exam: **70**

**IMT 27- PHYSICAL METALLURGY LAB**

Periods/week: **3** Credits: **2** Sessionals: **50** Exam: **50**

Metallographic studies of:

\* Plain Carbon steels,

\* Cast Irons,

\* Stainless steels,

\* copper, brass

\* Aluminium and bearing materials

**IMT 28- TESTING OF MATERIALS LAB**

Periods/week: **3** Credits: **2** Sessionals: **50** Exam: **50**

1. Rolling of Copper, brass, stainless steel and plain carbon steel using laboratory mills.

2. Determination of tensile properties, n & K

3. Mechanical properties studies in cold worked Aluminium, copper, and steels etc.

4. Ericsen ductility test

**IMT 29- MINI PROJECT WITH SEMINAR**

Periods/week: **3** Credits: **2** Sessionals: **50** Exam: **50**

III SEMESTER

IMT 31- (Elective - 5)

**(a). NANO COMPOSITES**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Synthesis of Nano Materials: Bottom-Up and Top–down approaches, Mechanical grinding method, Sol-Gel process, Gas Phase synthesis, Gas Condensation Processing (GPC) and Chemical Vapour Condensation (CVC).

Classification of Nano composites: Metal Matrix Nano composites (MMNC), Polymer Matrix Nano composites (PMNC) and Ceramic Matrix Nano composites (CMNC), Matrix and reinforcements, Properties and Applications.

Processing of Metal matrix nano composites (MMNCs): Liquid processes- Stir Casting route, Ultrasonic method, Solid process- Mechanical Alloying method. Compaction techniques- Hot Pressing, Spark Plasma Sintering and Microwave sintering.

 Processing of polymer matrix nano composites: nano tubes, nano layered (clay) and nano particles reinforced polymer matrix nano composites (PMNCs); processing of ceramic matrix nano composites (CMNCs).

*Text books:*

1. Challenges and Advantages in Nano composite processing techniques, V. Viswanathan, T. Laha, K. Balani, A. Agarwal and S. Seal., 2006

2. Nano composites: Synthesis, Structure, Properties and New Application Opportunities, Pedro Henrique Cury Camargo, Kestur Gundappa Satyanarayana, Fernando Wypych., 2009

3. Introduction to Nano composite Materials, Properties, Processing, Characterization, Thomas E. Twardowski, DesTech Publications, April 2007

4. Nano composite Science and Technology, Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, 2006, Wiley-VCH.

**(b). FUNCTIONAL MATERIALS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

\* Characteristics and types of functional materials. Crystal structure and Properties. – Effect of size on properties, effect of interfaces on properties

\* Band structure, Semiconductor devices – Theory, examples and applications of Optically active materials

\* Dielectrics, piezo- and ferroelectric materials

\* Magnetic materials and storage applications.

\* Smart materials

\* Applications in electronic, communication, aerospace, automotive, energy industries

*Text books*

1. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic applications; Deborah D L Chung, World Scientific Publishing, 2010

**(c). BIO MATERIALS**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

\* Types of biomaterials

\* Biological environment

\* Mechanical and physico-chemical properties of biomaterials

\* Resorbability, bio degradation, Biological responses, compatibility, cytotoxicity, cell biomaterial interactions, associated characterization

\* Metals, Polymers, Ceramics, Natural biomaterials

\* Blends, composites, biopolymers, Hydrogels

\* Drug delivery systems

*Text books*

1. Introduction to Biomaterials: Basic Theory with Engineering Applications; C.L Agrawal, J.L. Ong, Mark R Appleford, Gopinath Mani, Canbridge University Press, 2013

**IMT 32- Open Elective**

**(a). MATERIALS CHARACTERIZATION**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Production and properties of X-rays, Electromagnetic radiation, continuous and characteristics spectrum, absorption. Fillers. Diffraction. Bragg’s law, scattering by atom, electron, unit cell, structure factor calculation.

Diffraction Methods: Laue’s method, rotating crystal, Debye scherrer – Specimen preparation, film loading, powder method, Determination of crystal structure, determination of precision lattice parameter, sources of error in measurements.

Applications – Effect of plastic deformation. Determination of particle size, grain size, residual stresses, determination of phase diagrams, order-disorder transformation.

Principles of construction of electron microscopes.SEM and TEM. Specimen preparation and technique for transmission electron microscopy.

Principles of Thermo gravometry - TGA and DTA

*Text Books:*

1. X-ray diffraction – B.D.Cullity

2. Transmission Electro Microsopy-G.Thomas.

3. Materials Charecterization - P.R.Khangaonkar

**(b). Solidification Processing**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Properties of metals and alloys before and during solidification. Surface phenomena. Basic terms, surface energy, surface tension, wetting angle. Wetting speed. Classification and influence of wetting.

Homogeneous and heterogeneous nucleation, with plane front, cellular and dendritic pattern, columnar and equiaxed grain growth. Phenomena affecting the quality of castings such as micro-segregation, constituent under-cooling, macro-segregation and porosity formation.

*Text Books:*

Solidification processing M. Flemings, McGraw-Hill, 1974

Fundamentals of Solidification, Trans. Tech. Publications, Switzerland, 1992

**(c). Phase Transformations**

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Theory of Nucleation, Homogeneous and Heterogeneous Nucleation, Nucleation Kinetics, Growth Kinetics, Different types of Diffusion Growth. Nucleation and Grain size, Super Cooling, Directional Solidifications, and Segregations.

Study of Fe-Fe3C Phase Diagram, Phase Transformation in Steel on heating and cooling, Austenitic Grain Growth on heating, Determination of Grain Size, Isothermal Transformation Diagrams, Perlite, Bainite and Martensitic Transformations, Transformation of Austenite on Continuous Cooling. Annealing, Normalizing, Hardening and Tempering of steel, Hardenability, Mechanism of Heat removal during Quenching, Quenching media, Residual stresses and Quench Cracks, Martempering and Austempering,

Purpose of alloying, Effect of alloying on Fe-Fe3C Phase Diagram, Temperature Time Transformation (TTT) and Continuous Cooling Transformation (CCT) Plots, Secondary Hardening, Temper embrittlement. Classification of alloys steel, high strength low alloys steel, corrosion resistant steel, tool steel, Hadfield Mn steel, Different types of cast irons, White cast iron, grey cast iron, malleable cast iron, S.G iron and alloy cast iron.

Flame and Induction Hardening, Laser beam Hardening (LBM), Carburizing (solid, liquid and gas), Nitriding, Cyaniding, Boronizing. Solution Treatment, Ageing treatment, Nucleation of Precipitates, Theory of Precipitation Hardening, Effect of variables on Precipitation Hardening.

*Text Books:*

Phase Transformation in Metals and Alloys, VNR International, 1992 – D. A. Porter and K. E. Easterling.

Engineering Physical Metallurgy, Mir Publishers, 1997 – Y. Lakhtin.

Phase Transformation, Prentice Hall of India, 1992 – V. Raghavan.

**IMT 33- DISSERTATION -I**

Periods/week: **4** Credits: **6** Exam: **100**

The student has to give a review presentation of comprehensive Design/Experimental project on a selected topic.

IV SEMESTER

**IMT 41- DISSERTATION -II**

Periods/week: **Semester** Credits: **14** Exam: **100**

The student has to submit a comprehensive Design/Experimental project thesis and give a final viva presentation.