**DEPARTMENT OF METALLURGICAL ENGINEERING**

**M.TECH. (INDUSTRIAL METALLURGY)**
**(with effect from 2015-2016 academic year)**

**I – SEMESTER**

| Code No | Course Title | Scheme of Instruction | | | Scheme of Examination | | | . Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | Lec. | Tut. | Total | Exam. Duration | Theory/Lab./Viva | Sess. | | |
| IMT 11 | Core subject 1<br>Advances in iron and steel making | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 12 | Core subject 2<br>Metal Casting | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 13 | Core subject 3<br>Metal Forming | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 14 | Core subject 4<br>Metal Joining | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 15 | Elective subject 1<br>a. Composite Materials<br>b. Polymer Technology<br>c. Ceramic Technology | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 16 | Elective subject 2<br>a. Corrosion Engineering<br>b. Alloy Steels<br>c. Surface Engineering | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 17P | Casting Lab | -- | 3 | 3 | Viva-voce | 50 | 50 | 100 | 2 |
| IMT 18P | Seminar | -- | 3 | 3 | Viva-voce | - | `100 | 100 | 2 |
| **TOTAL** | | ***24*** | ***6*** | ***30*** | ***24*** | ***470*** | ***330*** | ***800*** | ***28*** |

***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. Duration | Theory/Lab. /Viva | Sess. | | |
| IMT 21 | Core subject 1 Failure Analysis | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 22 | Core subject 2 Strengthening Mechanisms | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 23 | Core subject 3 1ndustrial Heat Treatment | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 24 | Core subject 4 Powder Metallurgy | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 25 | Elective subject 1<br>a. Nano Materials<br>b. Non Destructive Testing<br>c. Fracture Mechanics | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 26 | Elective subject 2<br>a. XRD and EM<br>b. Solidification Processing<br>c. Phase Transformations | 4 | - | 4 | 3 | 70 | 30 | 100 | 4 |
| IMT 27P | Forming and Welding Lab | -- | 3 | 3 | Viva-voce | 50 | 50 | 100 | 2 |
| IMT 28P | Seminar | -- | 3 | 3 | Viva-voce | - | 100 | 100 | 2 |
| **TOTAL** | | ***24*** | ***6*** | ***30*** | ***24*** | ***470*** | ***330*** | ***800*** | ***28*** |

***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 | Subject | Scheme of Examination | Total Marks | Credits |
|---|---|---|---|---|
| IMT 31 | Dissertation (Preliminary) | Viva-voce | 100 | 10 |

***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 Examination | Total Marks | Credits |
|---|---|---|---|---|
| IMT 41 | Dissertation (Final) | 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.

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## I SEMESTER

## IMT 11- ADVANCES IN IRON & STEEL MAKING

Periods / week: 4 Credits: 4 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: 4 Sessionals: 30 xam: 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 FORMING

Periods / week: 4 Credits: 4 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

## IMT 14 - METAL JOINING

Periods / week: 4 Credits: 4 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.

Corrosion of welds

**Reference:**

ASM Metal hand book

## IMT 15– (Elective - 1)
## (a). COMPOSITE MATERIALS

Periods/week: 4 Credits: 4 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). CERAMIC TECHNOLOGY

Periods/week: **4** Credits: **4** 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- $Al_2O_3$-$SiO_2$, BaO-$TiO_2$; Three component systems- MgO- $Al_2O_3$-$SiO_2$.

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*

## (c). POLYMER TECHNOLOGY

Periods/week: 4 Credits: 4 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*

## IMT 16- (Elective 2)

## (a). CORROSION ENGINEERING

Periods / week: 4 Credits: 4 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: 4 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: 4 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 17P-CASTING LAB

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

A laboratory project on any one of these topics.
1. $CO_2$ Molding, 2. Shell Molding, 3. Vacuum Molding, 4. NDT of castings
5. Design of Gating systems, 6. Sand Testing

## IMT 18P-SEMINAR

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## II SEMESTER

## IMT 21-FAILURE ANALYSIS

**Periods / week: 4 Credits: 4 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: 4 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: 4 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- POWDER METALLURGY

Periods/week: 4 Credits: 4 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.


**IMT 25- (Elective - 3)**

**(a). NANO MATERIALS**

Periods/week: 4 Credits: 4 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.

***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). NON-DESTRUCTIVE TESTING

Periods / week: 4 Credits: 4 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

## (c). FRACTURE MECHANICS

Periods / week: 4 Credits: 4 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- (Elective 4)

## (a). X-Ray Diffraction and Electron Microscopy

Periods / week: 4 Credits: 4 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.

**Text Books:**

1. X-ray diffraction – B.D.Cullity
2. Transmission Electro Microsopy-G.Thomas.

## (b). Solidification Processing

Periods / week: 4 Credits: 4 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: 4 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 27P- FORMING & WELDING 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 and microstructural changes in copper, brass and SS
4. Mechanical properties, microstructural changes in cold worked and annealed brass and stainless steel.
5. Ericsen ductility test
7. Study on microstructure of different zones of aluminium and steel welds.

## IMT 28P- SEMINAR

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## III SEMESTER

## DISSERTATION (Preliminary)

Periods /week: Semester Credits: 10 Exam: 100

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

## IV SEMESTER

## DISSERTATION (Final)

Periods /week: Semester Credits: 14 Exam: 100

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

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