# METALLURGY AND MATERIALS SCIENCE

**CURRICULUM STRUCTURE OF II B.TECH.**
**(COMMON FOR REGULAR AND SANDWICH)**

**Effective from 2008-2009**

## III-Semester

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Course code</th>
<th>Subject Title</th>
<th>Contact hours</th>
<th>Credits</th>
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<tr>
<td>01</td>
<td>MT201</td>
<td>Structure &amp; Properties of Materials</td>
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<tr>
<td>02</td>
<td>MT202</td>
<td>Principles of Physical Metallurgy</td>
<td>3 - - 3</td>
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<td>03</td>
<td>ILE201</td>
<td>Institutional Elective-I Device Materials (MT225)</td>
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<td>04</td>
<td>ME213</td>
<td>Mechanical Technology</td>
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<td>EE216</td>
<td>Electrical Technology</td>
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<td>Engineering Mathematics-III</td>
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## IV Semester

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<td>01</td>
<td>MT206</td>
<td>Metallurgical Thermodynamics</td>
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<td>02</td>
<td>MT207</td>
<td>Principles of Metal working</td>
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<tr>
<td>03</td>
<td>MT208</td>
<td>Material Analysis</td>
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<td>04</td>
<td>MT209</td>
<td>Geology and Ore Dressing</td>
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<td>Introduction to Psychology</td>
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26 Hrs
S.Y.B.Tech. Third Semester

MT201 STRUCTURE AND PROPERTIES OF MATERIALS

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

OBJECTIVES:

- Introduce students to the field of materials testing and materials science.
- To build the foundation for the subjects to be studied further in the branch.

Unit 1
Classification of materials based on applications and structure, Structure of Materials: Types of bonds, Crystallography: System of crystal lattices, space lattice, unit cell, primitive cell, crystallographic directions and planes, Miller indices of directions and planes, non crystalline materials.

Unit 2

Unit 3
Imperfections in crystals: Point and line imperfections- vacancies, impurity atoms, Frenkel and Schottky imperfections, Dislocations- screw, edge and mixed, Slip system-slip plane and slip direction, Burgers vector. Slip in plastic deformation, Twin in crystals. Grain boundaries, twin boundaries, stacking faults, Large angle and small angle boundary.

Unit 4

Unit 5

Unit 6
Fatigue and Impact tests, Charpy and Izod methods, DBTT, fracture toughness, creep tests. Non-destructive testing methods: visual and leak testing, dye-penetrant tests, magnetic crack detection, eddy current, x-ray radiography, ultrasonic and acoustic emission methods.
TEXT BOOKS:
- Askland & Phule, Material science & Engineering of materials

REFERENCE BOOKS:
MT202 PRINCIPLES OF PHYSICAL METALLURGY

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Quiz/Assignment –20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

OBJECTIVES:
- To introduce the basic concepts of physical metallurgy of ferrous and non-ferrous alloys.

Unit 1 (05)
Metallography: Specimen preparation for microscopic examination for different metals and alloys, electrolytic polishing, etching and mounting techniques, metallurgical microscope, grain size significance and measurement, macroscopic examination methods, types of non metallic inclusions.

Unit 2 (06)
Solid Solutions and Phase diagrams: Solid solution and intermediate phases, Gibb’s phase rule, phase equilibria, alloy phases and compounds, Binary equilibrium diagrams and related microstructures, Lever rule application, Non equilibrium cooling of alloys, Ternary diagrams-simple systems.

Unit 3 (08)

Unit 4 (08)
Hardenability: Mass effect, Grossman method, Critical and ideal critical diameter, Jominy End Quench method, Use / Significance of Hardenability data, Effect of grain size and composition, Residual stresses, Quench cracking

Unit 5 (05)
Cast Irons: Fe-Graphite diagram, Factors controlling microstructure, Types of cast irons :gray ,White ,malleable cast, Nodular, Chilled and Mottled cast iron, Step bar test, Alloy cast irons: Ni hard, Ni resist, Silal, Austempered ductile iron

Unit 6 (06)
Department of Metallurgy and Materials Science,
College of Engineering, Pune
Revised on 29 Jan 2009
Copper and Copper base Alloys: Microstructure, Properties and applications.
Aluminium and Aluminium alloys: Classification and temper designations of Aluminium alloys, precipitation hardening, Titanium alloys and their applications

TEXT BOOKS:
- Askland & Phule, Material science & Engineering of materials
- George Vanwert, Metallographic Techniques, ASM Publ.
- Vijendra Sharma,

REFERENCE BOOKS:
- Reed Hill, Physical Metallurgy
- Raghvan, Physical Metallurgy
- W.F.Smith, Foundation of Material Science & Engineering, McGraw Hill
ILE201 INSTITUTIONAL ELECTIVE-I

Department of Metallurgy and Materials Science is floating ‘MT 225 Device Materials’ as Institutional Elective-I. The details are given in a separate file.

**Teaching Scheme**
Lectures: 3 hrs/week

**Examination Scheme**
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

**OBJECTIVES:**

- Unit 1 (06)
- Unit 2 (06)
- Unit 3 (06)
**ME213 MECHANICAL TECHNOLOGY**

**Teaching Scheme**
Lectures: 3 hrs/week

**Examination Scheme**
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

**OBJECTIVES:**
- To apply fundamentals of Thermodynamics to various power producing and power absorbing devices.
- To understand basic principle of fluid mechanics & application to pumps.
- To understand basic modes of heat transfer & to evaluate performance of heat exchangers.

**Unit 1**  
**IC Engines:**  
(07)
Air standard Otto, Diesel cycles, systems classifications of I.C. engines such as fuel supply system for SI & CI engines, ignition system, cooling system, lubrication system, Performance of IC Engine – Indicated power, Brake power, Thermal efficiency, Specific fuel consumption.

**Unit 2**  
**Fuels: Boilers & steam Turbines:**  
(07)
Boilers: Classification, Essential of a good boiler, Mounting and accessories, Efficiency calculations.
Steam turbines: Types, construction, Working, Compounding, Velocity diagram, Calculation of diagram efficiency

**Unit 3**  
**Compressor & Gas turbine:**  
(07)
Gas Turbine: Classification, Brayton cycle, thermal efficiency

**Unit 4**  
**Fluid Mechanics:**  
(07)
Definition, Properties, Types of fluid flow Continuity equation, Euler’s equation, Bernoulli’s equation and its application, Flow Measurement – venturi, orifice etc.

**Unit 5**  
**Pumps & Water turbine:**  
(06)
Pumps: Rotary & reciprocating pumps,-construction & operation, pumps performance, their selection.
Water Turbine: Types, constructional details

**Unit 6**  
**Heat Transfer:**  
(06)
Modes & laws of heat transfer, Fourier’s law, Newton’s law, Stefan Boltzmann law, elementary problems on conduction, convection & radiation, insulating materials, use of shields, heat exchangers-overall Heat Transfer coefficient, LMTD for parallel & counter flow heat exchanger
TEXT BOOKS:
- Modi, Seth, Hydraulics And Hydraulics Machinery.
- S.P. Sukhatme, Heat Transfer, Orient Longman

REFERENCE BOOKS:
- Govindrao N.S., "Fluid flow Mechanics, Tata McGraw Hill
EE 216  ELECTRICAL TECHNOLOGY

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

OBJECTIVES:
- To teach the students basic concepts of Electrical Engg & their applications to metallurgical processes

Unit 1
DC Machines: (08)
a) DC Generator: Construction, generating action, emf equations, types of generators, and characteristics of generators
b) D.C motor: Motoring action, significance of back emf, types of dc motors, voltage & current relationships of different motors, torque equation, torque-speed characteristics, Different methods of starting (need of starter) different method of speed control, braking & applications.

Unit 2
Induction Motor: (08)
Types, principle of operation, types, slip, power flow diagram, torque equation, condition of max. torque, torque slip characteristics, various methods of speed control, braking & applications.

Single Phase Motors:
a) Single phase induction motors
b) Special purpose motors- A.C. series motors, universal motors
Factor affecting choice of above motors for industrial applications like rolling mills, cranes, shear press, Mechanical press

Unit 3
ALTERNATORS: Construction features, synchronous speed, frequency of induced emf, emf equation, regulation by synchronous impedance method.

Unit 4
Electrical Heating: (10)
Resistance Heating: Direct and Indirect methods, Stefan’s law of radiation of heat, Material used and designing of heating element, efficiency and control equipment. Induction Heating: Construction, Working principle of induction furnace, High/ Low frequency generation, Core type furnace, Coreless type furnace, High frequency eddy current heating.


Unit 5
Electrical Welding: Types, control equipment, source, Applications of resistance and Arc welding, welding transformer (construction working principle & application)

Unit 6
(04)
Electrolytic Processes: Principle, Equipment used and applications of electrolytic processes like extraction and refining of metals.

TEXT BOOKS:
- Stephen J., Fundamental of Electrical Machinery.
- Nagrath & Kothari 2/e, Electrical Machines.

REFERENCE BOOKS:
- Dr. P. S. Bhimra, Electrical Machines
- Little Richard, Welding Technology
- Rajan & Sharma, Heat Treatment & Furnaces
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<thead>
<tr>
<th><strong>MA201</strong></th>
<th><strong>ENGINEERING MATHEMATICS III</strong></th>
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<td><strong>Teaching Scheme</strong></td>
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<tr>
<td>Lectures: 3 hrs/week</td>
<td>Quiz/Assignment – 20 marks</td>
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<td>Mid-Sem test – 30 marks</td>
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<td>End Sem exam – 50 marks</td>
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Details are available with Department of Mathematics
MT204   STRUCTURE AND PROPERTIES OF MATERIALS LABORATORY

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Term work: 50 Marks
Practical: 50 Marks

TERMWORK:
List of Experiments: (Completing any 08 sets from the below mentioned sets of experiment)

1. TENSILE TESTING (2 sets):
   Study of universal testing machine, principle and construction, 1) Tension test:
   To conduct tensile test on standard samples of M.S./ Aluminium/ C.I., Plotting of stress-strain curves and comparison of test results. 2) Study the effect of Gauge length on percent elongation.

2. HARDNESS TESTING (5 Sets):
   Study of hardness testing machines such as:
   1) Brinell
   2) Vickers and
   3) Poldi
   4) Study of Rockwell/ Rockwell superficial hardness testing machines and testing various materials with these machines using different loads and indenters (i.e. Scales).
   5) Study of Microhardness/ Schleroscope and testing various materials.

3. COMPRESSION TESTING (1 set):
   Compression test on C.I./Aluminium (or Brass); study of the effect of L/D ratio on the test results.

4. FATIGUE TESTING (1 set): Study of fatigue testing machine

5. IMPACT TESTING (1 set):
   Study of Pendulum impact testing machine and conducting impact test on samples of various materials/with different notches and interpretations of result.

6. TORSION TEST (1 set): On wire samples of mild steel / spring steel.

7. BEND TEST (1 set): On plate/torr steel rod samples.

8. NON-DESTRUCTIVE TESTING (5 sets): STUDY OF
   1) Dye penetrant
   2) Magnetic particle
   3) Eddy current
   4) Radiography
   5) Ultrasonic methods.

9. Other test (2 sets):
   Determination of porosity, density and cold crushing strength of ceramic materials, Hardness testing of polymers and elastomers by Durometer.

10. Study of various crystal lattice models, crystalline defects etc. (1 set)
MT205

PHYSICAL METALLURGY LABORATORY

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Term work: 50 Marks
Practical: 50 Marks

TERMWORK:
List of Experiments (ANY 08):

1. Preparation of specimens for microscopic examination.
2. (a) Preparation of specimens by hot mounting and cold mounting.
   (b) Study of metallurgical microscope
3. Preparation of etching reagents for steels and cast iron & study its mechanism.
4. Observation of microstructures using image analyzer, Quantitative Metallography software, grain size, shape, phases, distribution, porosity.
5. Grain size measurement by Mcquid & oxidation method.
9. Observation & drawing of microstructures of (a) Plain carbon steels, (b) Cast irons
10. Macroscopic examination for: (a) Sulphur distribution, (b) Flow lines
11. Assessment of nonmetallic inclusions in steels.
12. Observation of defects/flow lines etc. by St. Zoom Microscope
ME214  MECHANICAL TECHNOLOGY LABORATORY

Teaching Scheme  Examination Scheme
Laboratory: 2 hrs/week  Term work: 50 Marks

TERMWORK:
List of Experiments:

1. Study of Solex carburettor & Bosch type fuel injector pump.
2. Test on Diesel/Petrol engine to determine BP, bsfc, Brake thermal efficiency
3. Study of boiler mountings & accessories
4. Trial on reciprocating air compressor
5. Determination of coefficient of discharge of flow through venturimeter
6. Trial on centrifugal pump
7. Determination of thermal conductivity of insulating metal.
8. Test on parallel & counter flow heat exchanger.

EE219  ELECTRICAL TECHNOLOGY LABORATORY

Teaching Scheme  Examination Scheme
Laboratory: 2 hrs/week  Term work: 50 Marks
Practical: 50 Marks

TERMWORK:
List of Experiments:

1. External & internal characteristics of a D.C. shunt generator.
2. A) Speed control of D.C. shunt machine by
   (i) Armature voltage control
   (ii) Field current control method
   B) Study of motor starters
   (i) 3 point starter
   (ii) 4 point starter
   (iii) 2 point starter
3. Load test on D.C Shunt motor
4. Load test on 3ph. Induction motor to determine its performances
5. Study of induction motor starters
6. Load test on 1ph induction motor
7. O.C. & S.C. test on Alternator
8. Direct loading on Alternator.
S.Y.B.Tech. Fourth Semester

MT206 METALLURGICAL THERMODYNAMICS

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

Examination Scheme
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

OBJECTIVES:
To teach the students the importance of thermodynamic concepts with reference to metallurgical systems.

Unit 1: [07]

Unit 2: [08]
Second law of thermodynamics, Entropy, Effect of temperature on entropy, Statistical nature of entropy, Combined statements of first and second law of thermodynamics, Gibb’s free energy, Helmholtz’s free energy, Maxwell’s equations, Gibbs-Helmholtz equation, Clausius-Claeyson’s equation and its application to phase changes, Free energy as criterion for equilibrium and its applications to metallurgical reactions, Third law of thermodynamics.

Unit 3: [07]
Activity, Equilibrium constant, Le-Chatelier’s principle, Chemical potential, Law of mass action, Effect of temperature and pressure on equilibrium constant, Vant Hoff’s isotherm, Free energy-temperature diagrams, oxygen potential and oxygen dissociation pressure, Gibb’s phase rule and its applications, Free energy composition diagram.

Unit 4 [07 hrs]
Solutions, Partial molar quantities, Ideal solutions, Raoult’s law, Non ideal solutions, Gibbs-Duhem equation, Free energy of formation of solution, Regular solutions, application to phase equilibria, excess thermodynamic quantities.

Unit 5 [07 hrs]
Electrochemical cell, Determination of thermodynamic quantities using reversible electrochemical cell, EMF cell, electrode potential, Electrode potential-pH diagrams and their applications

TEXT BOOKS:

REFERENCE BOOKS:
MT207

PRINCIPLES OF METALWORKING

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

OBJECTIVES:
To make the students aware of strength of materials and their processing by mechanical
working. To introduce the students about the improvement in metallurgical quality obtained
by mechanical working.

Unit 1:[06]
Types of loading in materials used in engineering. Basic ideas about stress, direct stress,
and shear stress. Hooke’s law for three dimensions. Stresses and strains in bodies under
variety of loads and with varying dimensions. Thin cylinders under pressure. Hoop stress
and longitudinal stress. Concept and determination of two dimensional principal planes and
principal stresses, maximum shear stress.

Unit 2:[06]
Mohr’s circle of stress - two dimensions, numerical problems based on analytical and Mohr’s
circle method. System of a body under three dimensional stresses. Matrix representation of
the state of stress under three dimensions, determination of principal stresses, principal
planes and maximum shear stress for three dimensional state of stress, hydrostatic and
deviator component of stress relationship, strain energy, stress concentration.

Unit 3:[06]
Plastic deformation, flow curve, yielding criteria - Von Mises’ & Tresca, plastic stress-strain
relations, plastic deformation of single crystal, CRSS, strain hardening, cold, hot and warm
working processes, strain rate effect, metallurgical structure, friction and lubrication,
hydropstatic pressure and workability.

Unit 4:[06]
Classification of forming processes. Forces and geometrical relations in rolling. Projected
length of contact. Neutral point. Forward slip and backward slip. Rolling force and rolling
load. Angle of contact and angle of friction. Material spread in rolling. Torque and
horsepower in rolling. Problems and defects in rolled products.

Unit 5:[06]
Open and closed die forging. Calculations of forging loads in closed die forging. Residual
forces in forging. Forging defects. Drawing of rods wires and tubes. Analysis of tube
drawing, Temperature increase in wire drawing. Die wear. Water-cooling of dies. Residual
stresses in drawn products.

Unit 6:[6]
Extrusion. Classification of extrusion processes. Extrusion equipment. Hot and Cold
extrusion. Deformation and lubrication in extrusion. Analysis of extrusion process.
Hydrostatic extrusion. Extrusion of tubing. Extrusion defects.
Sheet metal forming and forming methods. Rubber forming. Shearing and blanking,
Bending, Stretch forming, Deep drawing. Forming limit criteria. Defects in formed parts.
Concept of machinability.
TEXT BOOKS:


REFERENCE BOOKS:

- Metals Handbook Vol. IV (Forming), ASM
MT208

MATERIAL ANALYSIS

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

OBJECTIVES:
1. To study the details of qualitative and quantitative analysis of different materials.
2. To become familiar with different international standards for material specification.

Unit 1:
Importance of chemical analysis in research and industries. Gravimetric analysis, conditions for practically complete precipitation, effect of pH, common ion effect, salt effect, organic precipitants, application to determination of silicon, nickel, magnesium, zinc, sulphur etc.

Unit 2:
Sparingly soluble salts, solubility product, acid bases and buffers, definitions of Bronsted and Lewis acids, buffer capacity, pH calculation of acid-base reactions.

Unit 3:
Volumetric analysis: Oxidation-reduction methods, reactions of permanganate, dichromate, iodometric and iodimetric titrations, precipitation, complexometric titrations, EDTA methods, applications to determination of manganese, copper, phosphorous, sulphur, chromium, tin etc, volumetric methods for carbon by combustion and gas analysis, gas chromatography.

Unit 4
Electrical potentials and emf of reactions, Nernst equation, cell notation and standard electrodes, concentration cells, pH measurements, ion-sensitive electrodes, potentiometric titrations, applications to quantitative analysis. Electrogravimetry- principle, advantages, limitations and applications.

Unit 5
Absorption of radiation by solutions, Beers-Lambert Law, absorption equation, UV-visible spectro photometry applications, limitations of the method, fluorescence methods, calibration methods. General principles of IR spectro-photometry, Raman spectra and Fourier Transform (FT) methods.

Unit 6

TEXT BOOKS:

REFERENCE BOOKS:
- Vogel, Quantitative Inorganic Analysis.
- Alexeyev, Quantitative Inorganic Analysis.
MT209 GEOLOGY AND ORE DRESSING

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Quiz/Assignment – 20 marks
Mid-Sem test – 30 marks
End Sem exam – 50 marks

OBJECTIVES: To understand the principles of Geology and ore dressing as applied for metal winning. To know various deposits of minerals/ores on the earth

Unit 1: [06]

Unit 2: [06]

Unit 3: [06]

Unit 4 [06]

Unit 5 [06]
Classification of classifiers, study of settling cones, rake classifier, spiral classifier and cyclones. Heavy media separation: Principles, flow chart, different media used. Washability curves for easy, normal and difficult coal.
Jigging: Theory of jigging. jigging machines, Tabling:-study of stratification on a table. shaking tables, wilflley table.

Unit 6 [6]
TEXT BOOKS:
- A.M. Gaudin Principle of Mineral Dressing
- Handbook of Mineral Dressing – Ores and Industrial Minerals A. E. Taggart

REFERENCE BOOKS:
- S.J. Trusscott, Text book of Ore dressing
- S.K. Jain, Ore dressing
- Berry A Willis Mineral Dressing Technology
- J.S.S. Brame and J.C. King Edward Fuels – Solid, Liquid and Gaseous
- G.W. Himus Elements of Fuel Technology
MA225 ENGINEERING MATHEMATICS IV

Teaching Scheme
Lectures: 3 hrs/week
Practical: 2 Hr/Week

Examination Scheme
Mid-Sem – 30, Assignments- 20
End Sem exam – 50 marks.

OBJECTIVES:
- To apply computer programming to solve problems in Materials & Metallurgy
- To analyze experimental data
- To introduce the basic principles of Computer aided drawing & design

Unit 1
Computer Programming, Algorithm, Flow chart, Types of Data Variables, Flow Control Operations, Functions, Pointers, and Storage Classes

Unit 2

Unit 3

Unit 4
Finite difference and Finite volume method, line by line method, tridiagonal matrix solver, Grid generation: uniform & non-uniform grid, non-orthogonal grid, unstructured grid, Multigrid system, grid independence test, stability analysis.

Unit 5

Unit 6

TEXT BOOKS:
- Computer Oriented Numerical Methods, 3rd edition, V. Rajaraman, Prentice Hall India, N. Delhi
AS204 INTRODUCTION TO PSYCHOLOGY

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme

Details are available with Department of Applied Science

OBJECTIVES:

TEXT BOOKS:
MT210  PRINCIPLES OF METALWORKING LABORATORY

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Term work: 50 Marks
Practical: 50 Marks

TERMWORK:
List of Experiments:
1. Study of rolling mill and effects of rolling on microstructure and hardness of mild steel and brass samples.
2. Study of open- and closed die forging processes. To perform open die forging of mild steel or low carbon steel samples.
4. To perform wire drawing and annealing operations on a copper wire and study the effects on its hardness and microstructures.
5. To study and perform sheet metal working operations like deep drawing, stretch forming, shearing and blanking and sheet bending.
7. Study of defects in various metal working operations by Stereo zoom microscope.
8. Use of quantitative metallography and image analysis technique to study any one of the above mentioned metal working operation.
9. Demonstration of hot forging/working operation and analyzing changes in microstructure with image analyze.

MT211  MATERIAL ANALYSIS LABORATORY

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Term work: 50 Marks
Practical: 50 Marks

TERMWORK:
List of Experiments (Any Twelve)
1. Estimation of carbon in steels by colorimeter.
2. Estimation of Si in steels & cast iron
3. Estimation of Mn in steels & cast iron
4. Estimation of P in steels & cast iron
5. Estimation of Ni in steels & stainless steels
6. Estimation of Cr in steels & stainless steels
7. Estimation of Mo in steels & stainless steels
8. Estimation of Sn in Cu-base alloys
9. Estimation of Pb in Pb-base alloys
10. Estimation of Cu & Pb by electro-gravimeter
11. Study of C-S analyzer based on NDIR method
12. Study of Strohlien’s apparatus
13. Study of Atomic absorption spectroscope
14. Study of Vacuum emission spectroscope
### MT212 Geology and Ore Dressing Laboratory

**Teaching Scheme**
Laboratory: 2 hrs/week

**Examination Scheme**
Term work: 50 Marks  
Practical: 50 Marks

**TERMWORK:**
**List of Experiments:**

2. Construction, Working Principle of Ball mill and grinding of ores by wet and dry grinding in a ball mil
3. Study of laboratory sizing techniques and reporting of sizing data
4. Study of settling cones, rake classifier, spiral classifier and cyclones
5. Conduct separation of minerals by  
   (a) Froth floatation,  
   (b) Magnetic separation  
   (c) Electrostatic separation