COURSE STRUCTURE

&

SYLLABUS
(3rd – 8th SEMESTER)

FOR B.TECH PROGRAMME
IN
METALLURGICAL ENGINEERING

BIJU PATNAIK UNIVERSITY OF TECHNOLOGY ORISSA,
ROURKELA

2007 - 2008
## COURSE STRUCTURE
### SECOND YEAR B.TECH PROGRAMME
### METALLURGICAL ENGINEERING

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| Total | 8 | 28 | 28 |

### Notes
- **L-T-P** refers to Lecture, Tutorial, Practical hours respectively.
- **Practicals/Sessionals** include laboratory sessions for theoretical courses.
- **Contact Hrs. Credit** indicates the total contact hours and corresponding credit.
Module - I (9 Lectures)
Partial differential equations: The vibrating string. The wave equation & its solution.
The Heat equation and its solution

Module - II (10 Lectures)
Two-dimensional wave equation and its solution.
Laplace equation in polar, cylindrical and spherical coordinates. Potential.

Module - III (13 Lectures)
Complex analysis: Complex numbers and functions conformal mappings
Complex integration. Cauchy’s Theorem Cauchy's integral formulas.

Module - IV (8 Lectures)
Taylor’s and Laurent’s series, Residue theorem, evaluation of real integrals.
The Course covered by: Advance Mathematics by E. Kreyszig, John Wiley & Son’s (P) Ltd. (8th Edition)
Chapter 11 (except 11.6)
Chapter 12, 13, 14, 15

CPME 6203 FLUID MECHANICS & HYDRAULIC MACHINES (3-1-0)
1. Introduction: Scope of fluid mechanics and its development as a science
2. Physical property of Fluid
   Density, specific gravity, specific weight, specific volume, surface tension and capillarity, viscosity, compressibility and bulk modulus, Fluid classification.
3. Fluid static
   Pressure, Pascal’s Law, Pressure variation for incompressible fluid, atmospheric pressure, absolute pressure, gauge pressure and vacuum pressure, monometer.
4. Hydrostatic process on submerged surface, force on a horizontal submerged plane surface, force on a vertical submerged plane surface.
   Buoyancy and flotation, Archimedes’ principle, stability of immersed and floting bodies, determination of metacentric height.
Fluid dynamics: Introduction, Euler’s equation analog a streamline, energy equation, Bernoulli’s equation, Analysis of finite control volumes and its application to siphon, venture, office
Turbine: Classification, reaction, Impulse, outward flow, inward flow and mixed flow turbines, Francis & Kaplan turbines, Pelton wheel, Physical description and principle of operation, Governing of Turbine.
Centrifugal Pump: Principles of classification, Blade angles, Velocity triangle, efficiency, specific speed, characteristics curve.
Reciprocating Pump: Principles of working, slip, work done, effect of acceleration and frictional resistance, separation

Tex Books
1. Fluid Mechanics, A.K. Mohanty, PHI
3. Fluid Mechanics, Modi & Seth
BSCP 2201 PHYSICS - II (2-0-0)

This one semester Physics course is divided into four units. The unit - I deals with some aspects of nuclear physics, unit - II introduces certain features of condensed matter physics, unit - III deals with certain aspects of semiconductors and superconductors and unit - IV introduces Opto-electronic devices and fibre-optic communication system.

Unit - 1

This unit covers the basic principles and applications of different types of accelerators and their important applications.

Detailed constructional features of accelerators are not necessary.

1. Need for nuclear accelerators.
3. RF accelerators : Linear accelerator, cyclotron, electron accelerator, betatron.

Unit - 2

This Unit deals with diffraction in crystals and its role in determining crystal structure.

Study of crystal structure by diffraction methods, Bragg’s condition for crystal diffraction, Lau condition, Miller indices, Reciprocal lattice, Geometrical structure factor, Atomic form factor.

Unit - 3

This unit deals with certain features of semiconductors and superconductors.

2. Superconductivity : Superconductors and their properties, Meisner effect, Type - I and Type - II Superconductors, Thermodynamic properties of superconductors, London equation, Application of superconductors.

Unit - 4

This unit introduces some Opto - electronic devices and fibre - optic communication system.


LED : Principle construction of operation and application, Introduction to fibre optics, basic characteristics of optical fibres, optical fibre communication system.

Books Recommended

1. Nuclear Physics, P. R. Roy & B. P. Nigan
2. Particle Accelerators, M. S. Livingston & J. P. Blewett
3. Concepts of Modern Physics, A. Beiser
4. Introduction to Solid State Physics, C. Kittel
5. Introduction to Lasers, A. Avadhnulu
Module I (10 Lectures)
Water quality parameters and standards. Treatment of water for industrial and domestic purpose.

Module II (14 Lectures)
(To develop the basic concepts on corrosion and industrially important polymers.)

1. Corrosion:
   Dry and wet corrosion, Galvanic Corrosion, Stress Corrosion, Factors affecting corrosion, Corrosion Control: (Proper design and fabrication procedure, Cathodic protection, Passivation).

2. Polymers:
   Nomenclature and classification, Mechanism of polymerization (free radical and ionic) Thermoplastic and thermosetting resins, Some typical useful polymers: Polyethylene, PVC, polystyrene, PMMA, Nylon 6:6, Nylon 6, Bakelite, Terylene, Silicones, Natural and synthetic rubbers: Neoprene, Butyl and Polyurethane rubber, Vulcanization.

Module III (10 Lectures)
(To introduce the students about the basic concepts of fuels)

1. Fuels:
   Classification of fuels, calorific value, Analysis of Coal, Manufacturing process of metallurgical coke, Refining of Crude oil, Fractional distillation, Cracking, Knocking and antiknocking, Octane and Cetane number.
   Gaseous Fuel: Producer gas, Water gas, LPG & CNG.
   Combustion Calculation.

Module IV (6 Lectures)
1. Environment pollution:
   Green house effect, acid rain, depletion of ozone layer; Water pollution- bio chemical effect of lead, arsenic, mercury and fluorides, sewage-B.O.D. and C.O.D.

Books:

3. Environmental Pollution, A.K. Dey.
BSCC 2202 MATERIAL SCIENCES (2-0-0)

MODULE - I (10 Lectures)


MODULE - II (10 Lectures)

5. Dielectric Materials : Microscopic Displacement of atoms and molecules in an external dc electric field, Polarization and dielectric constant, Dielectric susceptibility. Temperature dependence, Dielectric Breakdown. Ferro electric material Piezoelectrics, Pyroelectrics, Dielectric Materials as electrical isulators.

MODULE - III (10 Lectures)

9. Ceramics : Types, Structure, Mechanical properties, applications

MODULE - IV (10 Lectures)


Text Books :

2. Vijaya M. S., Rangarajan G, Materials Science, TMH
3. Rajendra V., Marikani A., Materials Science, TMH
4. Van Vlack L. H., Elements of Material Science and Engineering, Addison Wesley
5. Material Science, Raghavan
6. Processes and Material of manufacture: Lindberg, PHI.

**BCSE 3201 OBJECT ORIENTED PROGRAMMING USING C++ (3-0-0)**

**Module I**

(10 Hours)
Introduction to object oriented programming, user defined types, polymorphism, and encapsulation. Getting started with C++ -syntax, data-type, variables, strings, functions, exceptions and statements, namespaces and exceptions, operators. Flow control, functions, recursion. Arrays and pointers, structures.

**Module II**

(10 Hours)
Abstraction mechanisms: Classes, private, public, constructors, member functions, static members, references etc. Class hierarchy, derived classes. Inheritance: simple inheritance, polymorphism, object slicing, base initialization, virtual functions.

**Module III**

(12 Hours)
Prototypes, linkages, operator overloading, ambiguity, friends, member operators, operator function, I/O operators etc. Memory management: new, delete, object copying, copy constructors, assignment operator, this input/output. Exception handing: Exceptions and derived classes, function exception declarations, Unexpected exceptions, Exceptions when handling exceptions, resource capture and release etc.

**Module IV**

(8 Hours)
Templates and Standard Template library: template classes, declaration, template functions, namespaces, string, iterators, hashes, iostreams and other type. Design using C++ design and development, design and programming, role of classes.

**Text Books:**
1. Bhave & Patekar- Object oriented Programming with C++, Pearson Education
3. Robert Lafore- Object oriented programming in Microsoft C++.
4. Balguru Swamy-C++, TMH publication

**HSSM 4201 ENGINEERING ECONOMICS AND COSTING(3-0-0)**

**Module I**

(10 Hours)
Present worth comparisons, Comparisons of assets with equal, unequal and infinite lives, comparison of deferred investments, Future worth comparison, pay back period comparison.

**Module II**

(10 Hours)
Benefit/ Cost analysis, quantification of project, cost and benefits, benefit/ cost applications, Cost – effectiveness analysis.

**Module III**

(10 Hours)

**Module IV**

(12 Hours)
1. Horn green, C.T., Cost Accounting, Prentice Hall of India
HSSM 4202 ORGANIZATIONAL BEHAVIOUR (3-0-0)

Module I (8 Hours)
Learning – Nature of Learning, How Learning occurs, Learning and OB.
Case Analysis

Module II (10 Hours)
Foundations of Individual Behaviour: Personality – Meaning and Definition, Determinants of Personality, Personality Traits, Personality and OB.
Case Analysis

Module III (12 Hours)
Case Analysis

Module IV (10 Hours)
Case Analysis

TEXTBOOKS:
Keith Davis, Organizational Behaviour, McGraw – Hill.

REFERENCE BOOKS:
Stephen P. Robbins, Organizational Behaviour, Prentice Hall of India.

CPMT 6201 INTRODUCTION TO PHYSICAL METALLURGY(3-1-0)

Module I (10 Hours)
1. Characteristic property of metals, bonding in solids, primary bonds like ionic, covalent and metallic bond, crystal system.
2. Solidification of pure metals, homogenous and heterogeneous nucleation processes, cooling curve, concept of supercooling, microstructures of pure metals, solidification of metal in ingot mould.

Module II  (10 Hours)

1. Concept of plastic deformation of metals, critical resolve share stress, dislocation theory, deformation by slip and twin, plastic deformation in polycrystalline metals, yield point phenomenon and related effects, concept of cold working, preferred orientation. Annealing: recovery; recrystalization and grain growth; hotworking.

2. Concept of alloy formation, types of alloys, solid solutions, factors governing solid solubility viz. size factor, valency factor, crystal structure factor and chemical affinity factor; order-disorder transformation.

Module III  (13 Hours)

1. Binary phase diagrams: (a) Isomorphous system, (b) Eutectic system, (c) Peritectic system, (d) Eutectoid system and (e) Peritectoid system. Allotropic transformation. Lever rule and its application, Interpretation of solidification behaviour and microstructure of different alloys belonging to those systems, Effect of non equilibrium cooling, coring and homogenization.

2. Iron-cementite and iron-graphite phase diagrams, microstructure and properties of different alloys (both steels and cast irons), types of cast iron, their microstructures and typical uses.

3. T-T-T diagram: Concept of heat treatment of steels i.e. annealing, normalizing, hardening and tempering; microstructural effects brought about by these processes and their influences on mechanical properties.

Module IV  (11 Hours)

1. Effect of common alloying elements on the equilibrium and T-T-T diagrams, concept of hardenability, factors affecting hardenability.

2. Common alloy steels, stainless steel, tool steel, high speed steel, high strength low alloy steel, microalloyed steel, specification of steels.

3. Physical metallurgy of common nonferrous alloys: Cu-Zn, Cu-Sn, Cu-Al systems, Microstructures and heat treatment of common alloys of these systems.

References:


2. Engineering Physical Metallurgy and Heat Treatment by Y. Lakhtin, Mir Publisher, Moscow.


7. An Introduction to Metallurgy, Sir Alan Cottrell, University Press

PRACTICALS

BENG 9202 BASIC ELECTRONICS LAB. (0-0-3)

(At least 8 experiments including 1 - 7 and any one from 8 - 10)
1. Familiarity with electronics components and Devices  
   Testing of a semiconductor Diode and a Transistor. IC pins connection (Digital Multimeter should be used should be used in testing components and devices).

2. Study and use of Oscilloscope to view waveforms and measure its amplitude and frequency.


4. Half wave and Full wave rectifiers without and with capacitor filter. Record of waveforms, Measurement of Average and rms values.

5. V - I Characteristics of anpn or pnp transistor. DC Biasing and measurement of dc voltages and currents.


7. Op amp in Inverting, non inverting, Integrating and Differentiating configuration, Record of wave forms.

8. Truth Tables of logic gates.

9. Study and experiment using MUX - DEMUX ICs / Shift Register IC.

10. Study on CMOS logic Inverter.

**BENG 9201 BASIC ELECTRICAL ENGINEERING LAB. (0-0-3)**

**List of Experiment (Any 8 of the following)**

1. Study and measurement the armature and field resistance of a DC machine.

2. Calibration of ammeter, voltmeter and wattmeter with the help of sub-standard instrument.

3. Verification of circuit theorems. Thevenin’s and Superposition theorems (with DC source only).

4. Voltage-current characteristics of incandescent lamps and fusing time-current characteristics of fuse wire.

5. Measurement of current, voltages and power in R-L-C series circuit excited by Single Phase AC supply.

6. Connection and starting of a three phase induction motor using direct online (DOL). or star-delta starter.

7. Connection and measurement of power consumption of a fluorescent lamp.

8. Determination of open circuit characteristics (OCC) of DC machine.


10. Connection and testing of a single phase energy meter (unity power factor load only)

11. Study of fan motor

**BCSE 9201 COMPUTER (OOP) WITH C++ LAB. (0-0-3)**  
(10 classes for 10 different programs)

1. Programs on concept of classes and objects.(1 class)

2. Programs using inheritance.(1 class)

3. Programs using polymorphism.(1 class)

4. Programs on use of operator overloading.(1 class)
5. Programs on use of memory management. (1 class)
6. Programs on exception handling and use of templates. (1 class)
7. Programs on File handling in C++. (1 class)

**BENG 9203 MECHANICAL ENGINEERING LAB. (0-0-3)**

**Group A (Mechanics / Material Testing Lab.)**
1. Determination of equilibrium of coplanar forces.
2. Determination of Moment of Intertia of Flywheel

**Group B**
4. Determination of Metacentric Height and application to stability of floating bodies.
5. Verification of Bernoulli’s Theorem and its application to Venturimeter.

**Group C**
7. Calibration of Bourden Type Pressure gage and measurement pressure using manometers.
8. Study of Cut-Sections of 2 stroke and 4 stroke Diesel Engine.

**CPME 9203 WORKSHOP - III (0-0-3)**
1. A job on lathe with taper turning, thread cutting, knurling and groove cutting
2. Gear cutting (with index head) on milling m/c
3. Working with shaper, planer and slotting m/c
4. Working with surface/ cylindrical grinding
5. TIG/ MIG welding, gas cutting

**CPMT 9201 PHYSICAL METALLURGY LAB. (0-0-3)**

**Suggested experiments:**
1. Preparation of metallurgical sample for microscopic observation.
2. Study of Metallurgical Microscope and familiarity with its components.
3. Determination of cooling curves of pure metals like Pb, Zn and Sn. Also acquaintance to differential cooling curves.
5. Microstructure of isomorphous alloys belonging to Cu-Zn, Cu-Sn and Cu-Ni systems.
6. Effect of cold working on hardness and microstructures of metals like Cu.
7. Recrystalization and grain growth in cold worked and annealed Cu.
8. Microstructure of plain carbon annealed steels with variation in carbon content
Module - I
Solution of equations by iteration, Newton’s method, Secant method, Interpolation
Numerical integration and differentiation

Module - II
Gauss Siedel iteration method for solving a system of linear equations, Runge Kutta Methods, Introductory Linear Programming, Introductory Programming

Module - III
Probability, Random variables, Probability distribution, mean & variance of distribution
Binomial, Poisson, hyper-geometric and normal distributions

Module - IV
Random sampling, estimation of parameters, confidence intervals, Testing of hypothesis, acceptance sampling, correlation and regression
Course covered by : Advance Mathematics by E. Kreyszig (8th Edition)
Chapter 17 (17.1 - 17.3, 17.5), Chapter 18 (18.4), Chapter 19 (19.1), Chapter 20, Chapter 21, Chapter 22

CPME 6202 MECHANICS OF MATERIALS - I (3-1-0)

MODULE - I (10 Hours)
1. Analysis of Axially Loaded Members :
   Composite bars in tension and compression - temperature stresses in composite rods - statically indeterminate problem.
2. Members in Biaxial State of Stress :
   Stresses in thin cylinders, thin spherical shells under internal pressure - wire winding of thin cylinders.

MODULE - II (12 Hours)
3. Strain Deformation :
   Two dimensional state of strain, Principal strains and principal axes of strain measurements, Calculation of principal stresses from principal strains.
4. Shear Force and Bending Moment Diagrams for Simple Beams :
   Support reactions for statically determinate beams, relationship between bending moment and shear force. Sheer force and Bending Moment diagrams.

MODULE - III (12 Hours)
5. Simple Bending of Beams :
   Theory of simple bending of initially straight beams, distribution of normal and shear stress, beams of two materials, Composite beams.
6. Deflection of Beams :
   Slope and deflection of beams by integration method and area - moment method.

MODULE - IV (6 Hours)
TEXT BOOKS:
1. Elements of Strength of Materials by Timoshenko & Young (Fifth Edition)
   Chapter: 1, 2, 3, 4, 5, 6, 7, 8 (Relevant articles only)

REFERENCE BOOKS:
2. Strength of Materials by G. H. Ryder

BSCC 2201 CHEMISTRY - II (2-0-0)
(Total No. of Lectures = 40)

Module I (10 Lectures)
Water quality parameters and standards. Treatment of water for industrial and domestic purpose.
Hardness of Water: Types of hardness, Units of hardness, Determination of hardness (EDTA method).
Disadvantages of hardwater in boiler, Water Softening Techniques (Lime soda, Ion exchange and zeolite).
Boiler feed water, Water for Domestic purposes (Municipal / Drinking Water)

Module II (14 Lectures)
(To develop the basic concepts on corrosion and industrially important polymers.
1. Corrosion:
   Dry and wet corrosion, Galvanic Corrosion, Stress Corrosion, Factors affecting corrosion,
   Corrosion Control: (Proper design and fabrication procedure, Cathodic protection, Passivation).
   (6 Lectures)

2. Polymers:
   Nomenclature and classification, Mechanism of polymerization (free radical and ionic)
   Thermoplastic and thermosetting resins, Some typical useful polymers: Polyethylene, PVC,
   polystyrene, PMMA, Nylon 6 : 6, Nylon 6, Bakelite, Terylene, Silicones, Natural and synthetic rubbers: Neoprene, Butyl and Polyurethane rubber, Vulcanization.
   (8 Lectures)

Module III (10 Lectures)
(To introduce the students about the basic concepts of fuels)
1. Fuels:
   Classification of fuels, calorific value, Analysis of Coal, Manufacturing process of metallurgical coke,
   Refining of Crude oil, Fractional distillation, Cracking, Knocking and antiknocking,
   Octane and Cetane number.
   Gaseous Fuel: Producer gas, Water gas, LPG & CNG.
   Combustion Calculation.

Module IV (6 Lectures)
1. Environment pollution:
   Green house effect, acid rain, depletion of ozone layer; Water pollution- bio chemical effect of lead, arsenic, mercury and fluorides, sewage-B.O.D. and C.O.D.

Books:
 MODULE - I (10 Lectures)


 MODULE - II (10 Lectures)

5. Dielectric Materials: Microscopic Displacement of atoms and molecules in an external dc electric field, Polarization and dielectric constant, Dielectric susceptibility. Temperature dependence, Dielectric Breakdown. Ferro electric material Piezoelectrics, Pyroelectrics, Dielectric Materials as electrical isolators.

 MODULE - III (10 Lectures)

   Plastics - Types: Thermosetting and thermoplastics. Transfer moulding, injection moulding, extension moulding, Blow moulding, Welding of plastics; Rubber types, application.
9. Ceramics: Types, Structure, Mechanical properties, applications

 MODULE - IV (10 Lectures)


 Text Books :

2. Vijaya M. S., Rangarajan G, Materials Science, TMH
3. Rajendra V., Marikani A., Materials Science, TMH
BSCP 2201 PHYSICS - II (2-0-0)

This one semester Physics course is divided into four units. The unit - I deals with some aspects of nuclear physics, unit - II introduces certain features of condensed matter physics, unit - III deals with certain aspects of semiconductors and superconductors and unit - IV introduces Opto-electronic devices and fibre-optic communication systems.

Unit - 1
This unit covers the basic principles and applications of different types of accelerators and their important applications.

Detailed constructional features of accelerators are not necessary.

1. Need for nuclear accelerators.
3. RF accelerators : Linear accelerator, cyclotron, electron accelerator, betatron.

Unit - 2
This Unit deals with diffraction in crystals and its role in determining crystal structure.
Study of crystal structure by diffraction methods, Bragg’s condition for crystal diffraction, Lau condition, Miller indices, Reciprocal lattice, Geometrical structure factor, Atomic form factor.

Unit - 3
This unit deals with certain features of semiconductors and superconductors.

2. Superconductivity : Superconductors and their properties, Meisner effect, Type - I and Type - II Superconductors, Thermodynamic properties of superconductors, London equation, Application of superconductors.

Unit - 4
This unit introduces some Opto - electronic devices and fibre - optic communication system.
LED : Principle construction of operation and application, Introduction to fibre optics, basic characteristics of optical fibres, optical fibre communication system.

Books Recommended
1. Nuclear Physics, P. R. Roy & B. P. Nigan
2. Particle Accelerators, M. S. Livingston & J. P. Blewett
3. Concepts of Modern Physics, A. Beiser
4. Introduction to Solid State Physics, C. Kittel
BCSE 3202 RELATIONAL DATABASE MANAGEMENT SYSTEMS (3-0-0)

Module I  (10 Hours)
Database System Architecture - Data Abstraction, Data Independence, Data Definitions and Data Manipulation Languages.
Data models - Entity Relationship(ER), Mapping ER Model to Relational Model, Network .Relational and Object Oriented Data Models, Integrity Constraints and Data Manipulation Operations.

Module II  (10 Hours)
Relation Query Languages, Relational Algebra, Tuple and Domain Relational Calculus, SQL and QBE.
Relational Database Design: Domain and Data dependency, Armstrong’s Axioms, Normal Forms, Dependency Preservation, Lossless design, Comparison of Oracle & DB2

Module III  (8 Hours)
Query Processing and Optimization: Evaluation of Relational Algebra Expressions, Query Equivalence, Join strategies, Query Optimization Algorithms.

Module IV  (12 Hours)
Advanced topics: Object-Oriented and Object Relational databases. Logical Databases, Web Databases, Distributed Databases, Data Warehouse and Data Mining.

Text Books:-
2. C.J.Date - An Introduction to Database Systems, Pearson Education

HSSM 4202 ORGANIZATIONAL BEHAVIOUR (3-0-0)

Module I  (8 Hours)
Learning – Nature of Learning, How Learning occurs, Learning and OB.
Case Analysis

Module II  (10 Hours)
Foundations of Individual Behaviour : Personality – Meaning and Definition, Determinants of Personality, Personality Traits, Personality and OB.
Case Analysis

Module III  (12 Hours)
Organizational Behaviour Process : Communication – Importance, Types, Gateways and Barriers to Communication, Communication as a tool for improving Interpersonal Effectiveness. Groups in

Case Analysis

Module IV


Case Analysis

TEXTBOOKS:
Keith Davis, Organizational Behaviour, McGraw – Hill.

REFERENCE BOOKS:
Stephen P. Robbins, Organizational Behaviour, Prentice Hall of India.

HSSM 4201 ENGINEERING ECONOMICS AND COSTING(3-0-0)

Module I

Present worth comparisons, Comparisons of assets with equal, unequal and infinite lives, comparison of deferred investments, Future worth comparison, pay back period comparison.

Module II

Benefit/ Cost analysis, quantification of project, cost and benefits, benefit/ cost applications, Cost – effectiveness analysis.

Module III

Depreciation, Computing depreciation charges, after tax economic comparison, Break-even analysis; linear and non-linear models. Sensitivity analysis: single and multiple parameter sensitivity.

Module IV


Text Book
1. Horn green, C.T., Cost Accounting, Prentice Hall of India

CPMT 6202 METALLURGICAL THERMODYNAMICS AND KINETICS (3-1-0)

Module I (10 Lectures)

Importance of Thermodynamics, definition of thermodynamic terms; concept of states, simple equilibrium. Equation of states, extensive and intensive properties, homogeneous and heterogeneous systems. Phase diagram of a single component system. Internal energy, heat capacity, enthalpy, isothermal, and adiabatic processes.
Second law of thermodynamics, entropy, degree of reversibility and irreversibility, criteria of equilibrium, auxiliary functions, combined statements, Maxwell’s relations, transformation formula, Gibbs-Helmoltz equation.

**Module II (9 Lectures)**
Concept of Third law of thermodynamics, temperature dependence of entropy, statistical interpretation of entropy, Debye and Einstein concept of heat capacity, relation between Cp and Cv, consequences of third law.
Fugacity, activity, equilibrium constant, use of S - functions, controlled atmospheres, homogeneous and heterogeneous equilibria.
Ellingham-Richardson diagrams, phase stability diagrams.

**Module III (13 Lectures)**

**Module IV (12 Lectures)**
Thermodynamics of electrochemical cells, solid electrolytes. Thermodynamics of point defects in solids.

**References**
3. Introduction to Metallurgical Thermodynamics by R. H. Tupkary; tu publishers, Nagpur.
8. Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.

**PRACTICALS**
**BENG 9201 BASIC ELECTRICAL ENGINEERING LAB. (0-0-3)**

**List of Experiment (Any 8 of the following)**
1. Study and measurement the armature and field resistance of a DC machine.
2. Calibration of ammeter, voltmeter and wattmeter with the help of sub-standard instrument.
3. Verification of circuit theorems. Thevenin’s and Superposition theorems (with DC source only).
4. Voltage-current characteristics of incandescent lamps and fusing time-current characteristics of fuse wire.
5. Measurement of current, voltages and power in R-L-C series circuit excited by Single Phase AC supply.
6. Connection and starting of a three phase induction motor using direct online (DOL). or star-delta starter.
7. Connection and measurement of power consumption of a fluorescent lamp.
8. Determination of open circuit characteristics (OCC) of DC machine.
10. Connection and testing of a single phase energy meter (unity power factor load only)
11. Study of fan motor

**BENG 9202 BASIC ELECTRONICS LAB. (0-0-3)**

(At least 8 experiments including 1 - 7 and any one from 8 - 10)

1. Familiarity with electronics components and Devices
   Testing of a semiconductor Diode and a Transistor. IC pins connection (Digital Multimeter should be used should be used in testing components and devices).
2. Study and use of Oscilloscope to view waveforms and measure its amplitude and frequency.
4. Half wave and Full wave rectifiers without and with capacitor filter. Record of waveforms, Measurement of Average and rms values.
5. V - I Characteristics of anpn or pnp transistor. DC Biasing and measurement of dc voltages and currents.
7. Op amp in Inverting, non inverting, Integrating and Differentiating configuration, Record of wave forms.
8. Truth Tables of logic gates.
9. Study and experiment using MUX - DEMUX ICs / Shift Register IC.
10. Study on CMOS logic Inverter.

**BCSE 9202 COMPUTER (RDBMS) LAB. (0-0-3)**

(10 Classes for 10 Different Programs)

1. Use of SQL syntax : Insertion, Deletion, Join), Updation using SQL. (1 class)
2. Program segments in embedded SQL using C as host language to find average grade point of a student, etc. (1 class)
3. Program for Log based data recovery technique. (1 class)
4. Program on data recovery using check point technique. (1 class)
5. Concurrency control problem using lock operations. (1 class)
6. Use of package (ORACLE) for programming approaches(2 classes)
7. Use of package (DB2) for programming approaches(2 classes)
8. Programs on JDBC/ODBC to print employee’s / student’s information of a particular department. (1 class)

**CPME 9203 WORKSHOP - III (0-0-3)**

1. A job on lathe with taper turning, thread cutting, knurling and groove cutting
2. Gear cutting (with index head) on milling m/c
3. Working with shaper, planer and slotting m/c
4. Working with surface/ cylindrical grinding
5. TIG/ MIG welding, gas cutting
BENG 9203 MECHANICAL ENGINEERING LAB. (0-0-3)

Group A (Mechanics / Material Testing Lab.
1. Determination of equilibrium of coplanar forces.
2. Determination of Moment of Intertia of Flywheel

Group B
4. Determination of Metacentric Height and application to stability of floating bodies.
5. Verification of Bernoulli’s Theorem and its application to Venturimeter.

Group C
7. Calibration of Bourden Type Pressure gauj and measurement pressure using manometers.
8. Study of Cut-Sections of 2 stroke and 4 stroke Diesel Engine.

CPMT 9202 MATERIAL PROCESSING LAB. (0-0-3)

Suggested experiments:
1. Examination of the various zones of the arc in arc welding process.
2. Effect of increasing amperage on the quality of weld bead.
4. Brazing of steel/cast iron and observation of the relevant joined microstructures.
5. Preparation of standard samples for common sand testing.
6. Measurement of green compression strength, permeability and moisture content in the moulding sand.
7. Determination of compressive strength in sodium silicate/CO2 mould as a function of gasing time and pressure.
8. Determination of the tensile strength of oil/resin bonded core sand.
### COURSE STRUCTURE
#### THIRD YEAR B.TECH PROGRAMME
#### METALLURGICAL & MATERIALS ENGINEERING

#### 5th Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>HSSM4301</td>
<td>Optimisation in Engineering</td>
<td>3-0-0</td>
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<tr>
<td>CPMT6301</td>
<td>Mineral Engineering and Fuel Technology</td>
<td>3-1-0</td>
<td>4</td>
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<tr>
<td>CPMT6302</td>
<td>Principles of Extractive Metallurgy</td>
<td>3-1-0</td>
<td>4</td>
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<tr>
<td>CPMT6303</td>
<td>Polymeric, Ceramic and Semiconducting Materials</td>
<td>3-0-0</td>
<td>3</td>
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<td>CPMT6304</td>
<td>Refractories and Furnaces</td>
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<td>Transport Phenomena</td>
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<tr>
<td>CPMT9302</td>
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#### 6th Semester

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<td>Production &amp; Operation Mgmt.</td>
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<tr>
<td>CPMT6306</td>
<td>Phase Transformation and Heat Treatment</td>
<td>3-1-0</td>
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<tr>
<td>CPMT6307</td>
<td>Deformation Behaviour of Materials</td>
<td>3-1-0</td>
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<tr>
<td>CPMT6308</td>
<td>Mechanical Working and Testing of Materials</td>
<td>3-1-0</td>
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<tr>
<td>CPMT6309</td>
<td>Iron Making and Ferro-Alloys</td>
<td>3-1-0</td>
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<td>CPMT6310</td>
<td>X-Ray and Metal Physics</td>
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<td>CPMT9305</td>
<td>Testing of Metals Lab.</td>
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<td>Design Project</td>
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**L-Lecture, T-Tutorial, P-Practical**
5th Semester

METALLURGICAL AND MATERIALS ENGINEERING

HSSM 4301 OPTIMIZATION IN ENGINEERING (3-0-0)

Course Objective: The course aims at acquainting the students to mathematical modeling of engineering design, operation and maintenance problems and their optimization algorithms.

Module – I (10 hours)
Formulation of engineering optimization problems: Decision variables, objective function and constraints. Example of typical design, operation and maintenance problems in engineering: Design of a water tank, design of a truss, design of a network (electrical, communication sewerage and water supply networks), product mix problem, transportation and assignment problems, shift scheduling of employees, design of reliable devices, design of reactors, shortest route problem, set covering problem, traveling salesman problems. Only physical problems and their mathematical models to be discussed.
Linear Programming Problem: Formulation, Graphical solution, Simplex method, Duality theory, Dual simplex method, Formulation and solution of engineering problems of planning and scheduling.

Module – II (10 hours)
Sensitivity Analysis, Transportation Problem, Assignment Problem, Network Models: Minimal Spanning Tree Problem, Maximal Flow Problem, Shortest Route Problem, Minimum Cost Flow Problem. Algorithms and applications to be covered.

Module – III (10 hours)

Module – IV (12 hours)
Queueing theory, Game theory, Simulation, Decission theory & Sequencing Problem

REFERENCES:
4. B.E Gillett, Introduction to operations research, TMH

CPMT 6301 MINERAL ENGINEERING AND FUEL TECHNOLOGY (3-1-0)

Module- I (10 hours)
Introduction to mineral beneficiation, sampling, liberation studies and its importance.

Comminution: Fundamentals of comminution, crushing-construction and operational features of jaw, gyratory, cone and roll crushers.
Grinding: Theory of ball mill, rod mill, critical speed of the mill, open circuit and closed circuit, circulating load.

Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening.

Classification: Movement of solids in fluids, free settling and hindered settling of particles, different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry.

**Module- II**

Concentration: Gravity separation, concentration criteria, jiggling, flowing film concentration and tabling, dense media separation.

Froth flotation: Theory, reagents used in flotation processes, machines and practice.

Magnetic and electrostatic separation: Theory and application of magnetic and electrostatic separation techniques in mineral industry.

Flow sheets: Typical flow sheets for beneficiation of iron, gold, copper, lead-zinc sulphide ores, rock phosphate, beach sand, uranium and other industrial minerals.

**Module-III**

Agglomeration techniques: Sintering, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates.

**Module- IV**


**Books for reference**

5. Ore Dressing by S.K. Jain.
8. Elements of Fuel Technology by G.W. Himus.

**CPMT 6302 PRINCIPLES OF EXTRACTIVE METALLURGY (3-1-0)**

**Module I** (12 hours)

Unit processes in pyrometallurgy: Calcination and roasting, sintering, smelting, converting, reduction, smelting-reduction, metallothermic and hydrogen reduction; distillation and other physical and chemical refining methods – their thermodynamic and kinetic treatment with appropriate examples.

**Module- II** (12 hours)

Unit processes in hydrometallurgy: Leaching, purification of leach liquor, solvent extraction, ion-exchange process, potential-pH diagrams, different metal recovery processes from aqueous phase, bacteria leaching.
Module-III
Electrometallurgy: Faraday’s Laws of Electrolysis, concept of overvoltage, limiting current density, total cell voltage, series and parallel electrical circuits in refining, aqueous and fused salt electrolysis, electro refining of common metals like Cu, Zn, Ag, Au, Ni, Mn, Al, Mg etc…

Module-IV
Numerical problems relevant to different pyro-, hydro- and electrometallurgical processes.

Books for Reference:-
1. Principles of Extractive Metallurgy by Ahindra Ghosh and H. S. Ray
3. Metallurgical Problems by A. Butts
4. Electrochemical Engineering by C. L. Mantell

CPMT 6303 POLYMERIC, CERAMIC AND SEMICONDUCTING MATERIALS (3-0-0)

Module-I
Polymeric Materials: Concept of polymeric materials, Types of polymer, Molecular structure, topology and architecture, Isomerism and tacticity, polymer morphology, Elastomers, Plastics, Films, Fibers, Adhesive.
Polymerization reactions and manufacturing technology: Brief concepts.
Physical states of polymers: Amorphous, semi-crystalline, crystalline polymers and liquid crystalline polymers.
Rheological behavior of polymer melts, Polymer additives and compounding;
Processing and Fabrication of Plastics: Extrusion, Injection, Calendaring and Thermoforming.
Manufacturing methods of composites.
Physical and Mechanical properties of polymers.

Module-II
Thermal, mechanical, chemical, biological, optical, magnetic, ferroelectrics and electrical properties of ceramics and glasses. Ceramics for electronic applications. Coatings of glasses and ceramics.

Module-III
Semiconducting Materials: Bonds and bands, concept of electron, hole and electron fields, energy band and wave behavior.
Defects-their classification and effect on electronic properties.
Crystal growth techniques, doping, thermal diffusion and ion implantation.

Module-IV
Transport properties and effect of temperature on optical and opto-electronic properties.
Contacts, barriers and junctions. Metallisation and phase diagram.
Piezo, pyro and ferroelectric materials, ferrites and garnets-properties and applications.
Conducting polymers, semiconductors, electroceramics and superconducting materials for case studies.
p-n junction and schottky barrier diodes, transistors.

Books for Reference
1. Elements of Materials Science & Engineering by L.H. Van Vlack
2. Materials Science and Engineering by V. Raghavan
4. Principles of Materials Science and Engineering by W.F. Smith
5. Strengthening of Ceramics: Treatments, Tests and Design Application by H.P. Kirchner
7. Clays and Ceramic Raw Materials by W.E. Worrell
CPMT 6304 REFRACTORIES AND FURNACES (3-1-0)

Module-I (12 hours)

Refractories:
Classification of refractories, raw materials, manufacture, testing and properties of heavy and special refractories, silica, silicous aluminosilicate, high alumina, magnesite, chrome, chrome-magnesite, dolomite, forsterite, chemically bonded basic, carbon and insulating refractories and special purpose oxides, carbide nitride refractories.

Binary phase diagrams of $\text{Al}_2\text{O}_3-\text{SiO}_2$, $\text{CaO-MgO}$, $\text{Cr}_2\text{O}_3-\text{MgO}$ and $\text{MgO-SiO}_2$ systems.

Refractory mortars and cements, Refractory castables, selection of refractories for coke oven, iron blast furnace, copper convertor, soaking reheating furnaces and heat treatment furnaces, electric arc furnace.

Module-II (12 hours)

Furnace Technology:
Classification of furnaces: basis and uses.

Mechanism of combustion, ignition temperature.

Flames: Flame propagation, flame speed and inflammability limits, types of flames; premixed and diffusion flames and their characteristics. Combustion control; variables of control, viz.: temperature, pressure and gas ratio control, modes or combustion control. Theoretical, adiabatic & true flame temperature.

Available heat and factors affecting it.


Liquid and gaseous fuel burners: methods of atomization, types of liquid fuel burners and principle of design. Low pressure, high pressure and injection type gaseous fuel burners and principles of their design.

Module-III (10 hours)

Waste heat recovery:
Recuperators; types and availability. Temperature distribution in different types of recuperators, AMTD and LMTD. Heat transfer and principle of design.

Regenerators: Temperature distribution heat transfer and principles of design.


Module-IV (10 hours)

Basic design for generation of low pressure, rotary mechanical pumps and diffusion pumps. Pressure measuring gauges.

Laboratory furnaces; oil fired furnaces, muffle furnaces, salt and lead bath furnaces. Heating of bodies in furnaces.

Types of drafts, natural, induced and forced. Chimney calculations.

Description, operation, instrumentation and control of soaking pits, reheating furnaces, and annealing furnaces (hood annealing and continuous annealing).

Books for Reference:
1. Fuels, Furnaces and Refractories by J.D. Gilchrist.
2. Refractories manufacture properties and uses by M.L. Mishra
3. Steel Plant Refractories by Chester
4. Refractories by Norton
5. Industrial Furnace, Vol -I & II, by Trinks & Mawhinney
6. Modern Furnace Technology by Erhrington
7. Science of Flames and Furnaces by Thring
8. Fuels & Combustion by Smith & Stinson
9. Industrial Electric Furnaces and Applications by Pasckis & Pearson
Module-I

Momentum transfer (fluid flow): Newtonian and non-Newtonian fluids, factors affecting viscosity, estimation of viscosity of gases, gas mixtures, liquid metals and slags; equations of fluid flow and their metallurgical applications, overall energy balance approach for turbulent flow, friction factor; flow through packed and fluidized beds, interaction of gas jets and liquid metals; theory of similarity, dimensional analysis.

Module – II

Heat transfer: Factors affecting thermal conductivity of gases, liquids, solid metals and alloys and composites; equations and correlations of convective heat transfer and their metallurgical applications, laws of radiative heat transfer, view factor, radiative heat exchange in furnaces containing transparent and absorbing media; conductive heat transfer in solid materials under steady state and unsteady state conditions, heat transfer with change of state (melting/solidification).

Module – III

Mass transfer: Mass transfer by diffusion, factors affecting diffusivity in solid and liquid metals and gases, diffusion through porous materials; general equation of mass transfer with diffusion, convection and chemical reaction, mass transfer co-efficient and its models, mass transfer correlations and their applications; gas-solid reaction.

Module – IV

Application of transport phenomena in modeling and simulation: theory of similarity and dimensional analysis, case studies; some case studies of mathematical modeling in metallurgical systems – gas stirred ladle, continuous casting etc…

Books for Reference:
3. Rate Phenomena in Process Metallurgy by J. Szekely and N. J. Themelis
4. Rate Processes in Metallurgy by A. K. Mohanty, PHI

PRACTICALS

CPMT 9301 MINERAL ENGINEERING LAB. (0-0-3) 2

1. Physical examination and identification of minerals.
2. Crushing of ore/ coal in a jaw crusher and to study the size analysis of the product.
3. Crushing of ore/ coal in a roll crusher and to study the size analysis of the product.
4. Crushing of ore/ coal in a gyratory crusher / pulveriser and to study the size analysis of the product.
5. Crushing of ore/ coal in a cone crusher and to study the size analysis of the product.
6. To study the effect of grinding with grinding time in cylindrical ball mill and rod mill.
7. To separate coal from a mixture of coal and stones or quarts by zigging and determine the weight fractions of the products.
8. To separate a mixture of two minerals of different densities by gravity concentration using Wilfley Table and determine the weight and density of each fraction of the products.
10. To separate a mixture of iron and sand using magnetic separator and determine its efficiency.
11. Screening of ore/ coal using vibrating screen and determine its effectiveness.
CPMT 9302 FUEL TESTING LAB. (0-0-3)  2

1. Proximate analysis of coal and coke.
2. To determine calorific value of coal and coke using bomb calorimeter.
3. To determine bulk density of coal sample.
4. To determine true density of coal sample.
5. To determine shatter and abrasion indices of coal and coke.
6. To determine flash point and fire point of a given sample such as kerosene oil, diesel, petrol by Pensky-Marten’s apparatus or Cleveland open cup apparatus.
7. To determine viscosity of oil by Engler viscometer and the water number in the apparatus.
8. To determine effect of temperature on kinematic viscosity of glycerene by Redwood viscometer.

CPMT 9303 MATERIALS CHARACTERIZATION LAB. (0-0-3)  2

1. Determination of Cu in Brass Sample.
2. Determination of Fe in Iron Ore.
3. Determination of Mn in Steel.
4. Determination of Cr in steel.
5. Determination of Si in cast iron.
7. Determination of Ca in Limestone.
8. To determine the hardnesses of ferrite, pearlite and carbides in a steel using microhardness tester.
9. To determine the thickness of a steel sample using ultrasonic technique.
10. To determine electrical resistivity of alloy / semiconductor.
11. To determine electrical conductivity of ionic solid.
12. To find out the size distribution of metal powders.
13. To determine the apparent density, tap density and flow rate of powders.
14. To determine the compressibility of powders.
Objective: This course aims at acquainting all engineering graduates irrespective of their specializations the basic issues and tools of managing production and operation functions of an organization.

Module I

Module II
5. Forecasting : Principles and Method, Moving Average, Double Moving Average, Exponential Smoothing, Double Exponential Smoothing, Winter’s Method for Seasonal Demand, Forecasting Error Analysis.

Module III


Module - IV


10. Modern Trends in Manufacturing: Just in Time (JIT) System; Shop Floor Control By Kanbans, Total Quality Management, Total Productive Maintenance, ISO 9000, Quality Circle, Kaizen, Poke Yoke, Supply Chain Management

Reference:


CPMT 6306 PHASE TRANSFORMATION AND HEAT TREATMENT (3-1-0) 4

Module-I

Introduction: Component, phase, phase rule and thermodynamics of phase equilibrium and phase changes; Definition, utility, order and classification of phase transformations.

Diffusion: Definition of Fick’s law on steady and non-steady state diffusion and their solutions; Mechanism of diffusion in solids; Chemical diffusion and Darken’s equation; Kirkindall effect; Effect of pressure and temperature on diffusivity.

Nucleation and growth: Formation of nucleus; Homogeneous and Heterogeneous nucleation; Mechanism and kinetics of thermally activated growth; Interface and diffusion control growth regimes.

Phase equilibrium and phase diagrams: Important phase changes in unary and binary systems; Types and interpretation of phase diagram; Utility of phase diagrams, Lever rule; Important phase diagrams in metallic and ceramic systems; Ternary phase diagram.

Liquid-solid transformation: Solidification, nucleation and growth mechanisms and kinetics; Alloy solidification – cellular and dendritic morphology; Eutectic and peritectic solidification. Application of solidification.

Module- II

Solid state diffusive transformation: Classification of solid-solid transformations; Nucleation in solids; Precipitate growth; Age hardening; Spinodal decomposition; Precipitate coarsening. Order-disorder change, polymorphic change. Recrystallization, grain growth. Eutectoid transformation. Application of solid state precipitation. Pearlitic and bainitic transformations in steel; Matensite and martensitic changes in ferrous materials.
Module-III


Module-IV


Books for reference

1. Phase Transformation in Materials by R. C. Sharma
3. Physical Metallurgy Principles by R. E. Reed-Hill
5. Introduction to Materials Science and Engineering by J. F. Shackelford

CPMT 6307 DEFORMATION BEHAVIOUR OF MATERIALS (3-1-0) 4

Module – I

Introduction: Scope of the subject, elastic, plastic and visco-elastic deformation.

Continuum mechanics: Concepts of stress and strain in 3D stress and strain tensor, principal stresses and strains and principal axes, mean stress, stress deviator, maximum shear, equilibrium of stresses, equations of compatibility.

Module – II

Elastic behaviour of materials: Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor, effect of crystal structure on elastic constants.


Module – III

Microscopic basis of plastic deformation: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations.

Plastic deformation of single crystals: Critical resolved shear stress, deformation by twinning, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials.

Module – IV

Plastic deformation of polycrystalline materials: Role of grain boundaries in deformation, strengthening by grain boundaries, yield point phenomenon, strain ageing, strengthening by solutes, precipitates, dispersoids and fibres.

Deformation in non-metallic materials: structure and deformation of polymers, concept Super-lattice dislocations in intermetallics, concept of charge associated with dislocations in ceramics.
Books for reference:
3. Mechanical behaviour of materials by M. A. Meyers and k. K. Chawla
4. Mechanical behaviour of materials by T.H. Courtney

CPMT 6308 MECHANICAL WORKING AND TESTING OF MATERIALS (3-1-0) 4

Module- I
Classification of forming processes.
Rolling - Classification & processes , load, torque, power, variables controlling process, defects .

Module – II
Forging - Classification & processes, load for circular & rectangular plate.
Extrusion - Classification & processes, force & variables affecting it.
Sheet metal Forming- Forming methods, Forming limit criterion, Special Forming techniques and defects in formed products

Module – III
National and International Standards for Mechanical tests
Hardness tests- Brinell, Rockwell, Vickers, Meyer, Knoop, etc., relationship with flow curve.
Tension test- Engineering & true stress-strain curves, evaluation of tensile properties, Tensile instability, Effect of strain-rate & temperature on flow properties.
Compression Test- Comparison with tension, phenomenon of buckling & barreling.
Torsion Test- Stresses for elastic & plastic strain, Torsion vs. Tension.
Bend Test- Pure bending & flexure formula.
Impact test- Notched bar impact tests, transition Temperature & metallurgical factors affecting it.

Module- IV
Creep- Creep & Stress rupture tests, Mechanism of creep deformation, Deformation mechanism Maps, Development of creep resistant alloys, Prediction of long time properties.
Fatigue – Stress cycles & S-N curve, effect of mean stress, stress concentration, surface, size, metallurgical factors etc. on endurance limit, Cyclic stress-strain curve, Low cycle fatigue, Paris law.
Fracture- Energy based criterion, Strain energy release rate, stress intensity factor, fracture toughness estimation and design of engineering component.

Books for reference :
2. Testing of Metallic materials by C. Suryanarayana:
3. An Introduction to principles of Metal working by G. W. Rowe
5. Practical Non Destructive Testing by Baldev Raj.
CPMT 6309 IRON MAKING AND FERRO-ALLOYS (3-1-0)

Module – I

General overview of iron and steel making in India and abroad. General layout of an integrated steel plant.
Raw materials and their properties: Iron ores agglomerates and coke:
Preparation of ore: Sintering and palletizing process and bonding mechanisms. Blast furnace burdening and distribution; testing of raw materials for the blast furnace.
Design: Blast furnace profile, stove and gas cleaning units; instrumentation; refractories used in blast furnace and stove.

Module – II

Operation: Blowing in, blowing out and blast furnace; concept of cohesive zone reactions, thermodynamic equilibrium in stack, bosh and hearth.
Slags: Formation of primary and Bosh slag; hearth slag, slag composition; effect of Al2O3, MgO and SiO2; slag control, metal slag reaction.

Module – III

Modern developments: Bell-less charging system, use of super fluxed sinter, high top pressure, humidified and oxygen enriched blast and auxiliary fuel injection through tuyers and their effect on productivity and coke rate; on line computer control. Charge calculations and materials balance.

Module- IV

Ferro-alloys: Production of Fe-Mn, Fe-Si, Fe-Cr and their uses in metallurgical industries.
Alternative route of iron making: Direct reduction process, coal based processes such as SLRN, ACCAR etc, Gas based process such as Midrex, Hyl etc. Use of DRI in iron and steel industries.
Smelting Reduction process Viz: Corex and Romelt, DIOS, HiSmelt. Pollution control in iron and steel industries.

Books for reference:

CPMT 6310 X-RAY AND METAL PHYSICS(3-0-0)

Module –I

Introduction to x-ray and properties of x-ray: Continuous characteristics x-ray, absorption, filter, production and detection of x-rays. Diffraction of x-rays; special topics on crystallography, directions and intensities of diffracted beams.

Module – II

Experimental methods in x-ray analysis; Laue methods, powder photographs diffractometer and spectrometer measurements. Applications: orientation of single crystal, crystal structures of polycrystalline materials, precise lattice parameter measurements.
Module – III  
(10 hours)
Application: Phase diagram, order-disorder transformation, chemical analysis, residual stress, texture.

Module – IV  
(12 hours)
Metal Physics: Electron Theory of metals: Uncertainty principle, dual nature of matter, free electron theory, density of states, zone theory, dependence of energy on wave number, conductors and insulators, semiconductors – intrinsic and impurity, important semiconductors and their band structures.

Books for reference:
5. An Introduction to Solid State Physics by C. Kittel.
PRACTICALS

CPMT 9304 PHASE TRANSFORMATION AND HEAT TREATMENT LAB. (0-0-3)

1. Annealing treatment of a cold worked steel and comparison of the annealed microstructure with the cold worked structure.
2. Normalizing treatment of steel and comparison of the microstructure with annealed structure.
3. To study the quenched structures of steel – quenched in oil, water and brine solution.
4. To study the quenched and tempered structures of steel –
   (i) low temperature tempering.
   (ii) medium temperature tempering.
   (iii) high temperature tempering.
5. To study the recrystallization behaviour of pure metal (iron / copper).
6. To study the effect of time and temperature on grain size of a metal (grain growth) (iron/copper).
7. To study the nucleation rate and growth rate of pearlite in eutectoid steel.
8. To study the susceptibility of a steel to harden by quenching (hardenability) by Jominy test.
9. Pack carburizing of 0.2% carbon steel and to measure the diffusion coefficient of carbon in steel.

CPMT 9305 TESTING OF METALS LAB. (0-0-3)

1. To determine the Vickers Hardness Number of the given Samples.
2. To determine the Brinell Hardness Number of the given Samples.
3. To determine the Rockwell Hardness of the given samples.
4. To determine the impact strength of the given samples by Charpy and Izod Impact Tests.
5. To determine the tensile properties of the given materials using Universal Testing Machine (UTM) – yield strength, tensile strength, % elongation, % reduction of area.
6. To determine the compression strength of the given sample.
7. To determine the fatigue strength of the given sample.
8. To determine the drawability of aluminium / steel sheet by Erichsen cup test.
9. To study the ultrasonic flaw detector and determine the cracks within a sample.
10. To determine the cracks in a sample using the magnetic crack detector.
## COURSE STRUCTURE
### FOURTH YEAR B.TECH PROGRAMME
#### METALLURGICAL & MATERIALS ENGINEERING

<table>
<thead>
<tr>
<th>7th Semester</th>
<th>8th Semester</th>
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<tr>
<td><strong>Theory</strong></td>
<td><strong>Contact Hrs. Credit</strong></td>
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<td>L-T-P</td>
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<td>HSSM4403 Environmental Engg.</td>
<td>3-0-0 3</td>
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<tr>
<td>CPMT6301 Steel Making</td>
<td>3-1-0 4</td>
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<tr>
<td>CPMT6402 Non-Ferrous Extractive Metallurgy</td>
<td>3-1-0 4</td>
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<tr>
<td>CPMT6403 Fabrication of Materials</td>
<td>3-1-0 4</td>
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<tr>
<td>PEMT6401 Powder Metallurgy / Composite Materials</td>
<td>3-0-0 3</td>
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<tr>
<td>PEMT6402 Metallurgy of Metal Joining/</td>
<td>3-0-0 3</td>
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<tr>
<td>PEMT6403 Casting Processes and Solidification</td>
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<td><strong>Practicals/Sessionals</strong></td>
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<td>CPMT9402 Seminar</td>
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<td>CPMT9403 Process Metallurgy Lab</td>
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<td>CPMT9407 Comp. Viva Voce</td>
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<td><strong>Total</strong></td>
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**L-Lecture** | **T-Tutorial** | **P-Practical**
---|---|---
35 | | |
Objective: This course introduces the students to the environmental consequences of industries, development actions etc. and the methods of minimizing their impact through technology and legal systems.

Module – I
Chemistry and Microbiology in Environmental Engineering: Physical and chemical properties of water, Atmospheric chemistry, Soil chemistry, Microbiology, Chemical and biochemical reactions, Material balances and Reactor configurations.

Module – II
Water Pollution: water quality standards and parameters, Assessment of water quality, Aquatic pollution, Freshwater pollution, Estuarine water quality, Marine pollution, Organic content parameters, DO and BOD demand in streams, Transformation process in water bodies, Oxygen transfer by water bodies, Turbulent mixing, Water quality in lakes and preservers, Ground water quality.
Air Pollution: Air pollution and pollutants, criteria pollutants, Acid deposition, Global climate change – green house gases, non-criteria pollutants, emission standard form industrial sources, air pollution metereology, Atmospheric dispersion.

Module – III

Solid Waste Management
Source classification and composition of MSW: properties and separation, storage and transportation, MSW Management, Waste minimization of MSW, Reuse and recycling, Biological treatment, Thermal treatment, Landfill, Integrated waste management.

Industrial Air Emission Control:

Characterization of air stream, Equipment selection, Equipment design, Special Methods: Flue gas desulphurization, NOx removal, Fugitive emissions.

Module – IV (8 hours)

Environment impact Assessment, Origin and procedure of EIA, Project Screening for EIA, Scope studies, Preparation and review of EIS.

Reference:

3. Environmental Science, Curringham & Saigo, TMH,
4. Principles of Environmental Science, Curringhum
5. Introduction to Environmental Science, Y. Anjaneyalu, B. S. Publication.

CPMT 6301 STEEL MAKING (3-1-0)

Module-I (10 hours)

Slag theories: Molecular and ionic theories; interpretation of the above reactions in terms of ionic theory of slags.

Open Hearth steel making practices.

Module – II (12 hours)


OBM/Q-BOP process: Concept and operation of the process.

Mixed Combined blowing processes: Oxygen top blowing with inert gas purging at bottom; oxygen top blowing with inert and oxidizing gases at bottom, oxygen top and bottom: status in India.

Module – III (10 hours)

Electric arc furnace: Advantages charging melting and refining practices for plain carbon and alloy steel; uses of DRI in arc furnace and its effect on performance. UHIP electric arc furnace with D.C supply, single graphite electrodes, oxygen lancing, oxyfuel burner, water cooled panel and computer
control. Combination of blast furnace. EAF Duplex processes of stainless steel making using VOD. AOD. and CLU.

Induction Furnace: Special features, advantages and limitation.

Module – IV


Secondary refining of steel: Objectives; principles of degassing different industrial process such as DH, RH, VAD, SD, LF, and ESR; limitations and specific application.

Continuous Casting of steel: Advantages; types of machines; mould lubrication and reciprocation. Development in C.C. Technology with respect to productivity, quality and energy conservation; Near Net Shape Casting.

Books for reference:
4. Basic Open Hearth Steel Making by G.Derge, AIMME, N.Y.1964

CPMT 6402 NON-FERROUS EXTRACTIVE METALLURGY (3-1-0)

Module - I

Thermodynamic considerations and process selection in pyrometallurgical extraction of metals like Cu, Ni, Pb, and Zn from sulfide ores, extraction of Sn and Mg from oxide ores, extraction of Ti and Zr through halide route.

Module – II

Refining by oxidation, chemical transport reactions, zone refining, distillation etc. Newer processes like. Noranda, Mitsubishi Q-s and WORCRA in Cu extraction, ISP in Zn extraction. Kinetics, mechanism and processes for leaching of pure metals, oxide and sulfide ores; bioleaching.

Module – III

Thermodynamics of reduction by gases for obtaining metals from solution. Ion exchange and solvent extraction processes-their application in extraction processes of Zr, V, Th, Nb, Ta etc.
Module – IV
(12 hours)
Electrowinning and electro refining of metals-aqueous (Cu, Ni, Au, Ag) and fused salt (Al and Mg).

Books for reference:

CPMT 6403 FABRICATION OF MATERIALS (3-1-0)

Module-I
(12 hours)
Introduction to metal casting, Moulding methods, materials and processes, with special reference to patterns, sand and binders. Solidification of short & long freezing range alloy castings, Gating and Risering of castings.

Module – II
(12 hours)

Module – III
(10 hours)
Introduction to metal joining processes. Metallurgical principles involved in welding of carbon and alloy steels and important nonferrous alloys.

Module – IV
(10 hours)

Books for reference:
3. Principles of Metal Casting by Heine, Loper, Rosenthal,
4. Introduction to Powder Metallurgy by F.V.Lenel
5. Powder Metallurgy Science by R.M.German
6. Welding by Little, TMH.

PEMT 6401 POWDER METALLURGY (3-0-0)

Module – I
(10 hours)
Introduction: Development of powder metallurgy-scope of powder metallurgy, characterization of metal powders, physical properties-particle size and shape determination, technological properties-apparent density, flow rate, compressibility etc. and chemical properties.

Module – II
(10 hours)
Powder manufacture: Mechanical fabrication techniques – machining, milling, other impaction techniques, mechanical alloying, Electrolytic fabrication techniques, chemical fabrication techniques –
decomposition of a solid by a gas, thermal decomposition, precipitation from a liquid, precipitation from a gas, Atomization fabrication techniques – gas atomization, water atomization, centrifugal atomization, other atomization approaches.

Mixing and blending approaches, friction in a powder mass – mixing efficiency, powder lubrication.

**Module – III** (12 hours)


**Module – IV** (10 hours)

Powder metallurgy products: Bearing, filters, friction parts, hard metals, refractory metals, contact materials, magnetic materials, structural parts, dispersion strengthened materials.

**Books for reference:**
1. Introduction to Powder Metallurgy by F.V.Lenel
2. Powder Metallurgy Science by R.M.German
3. Treaties on Powder Metallurgy by Goetzel, Vol-I&II
4. Powder Metallurgy by R.Lsande & C.R.S.Shakespere
5. Powder Metallurgy by A.K.Sinha, Dhanpat Rai

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**PEMT 6402 COMPOSITE MATERIALS (3-0-0)**

**Module – I** (10 hours)

Introduction, classification, strengthening mechanism in composites, types of reinforcement-metallic and nonmetallic fibers, whiskers and particulates;

**Module – II** (12 hours)

Metal matrix and ceramic matrix composites:

Technology for production of composites - liquid metal route, powder metallurgy and mechanical working for metal matrix and ceramic matrix composites - processing routes including reaction sintering combustion synthesis, infiltration and in-situ processes; Processing of intermetallic composites, Comparison of MMCs and CMCs.

**Module – III** (10 hours)

Polymer composites:
Matrices, thermoplastic and thermosetting; Reinforcements - continuous and discontinuous fibres - glass, aramid, polyester, and carbon fibres; surface characteristics; hybridisation techniques, Fillers and their uses, autoclave, hand lay-up techniques etc.,

Fabrication methods of polymer matrix composites:
Filament winding; Resin injection moulding; extrusion, calendering, pultrusion, degradation of fibers.

**Module – IV** (10 hours)

sandwich structures, foam core type arrangements; Honey comb structures.

Application of composites: Aerospace, marine, automobile, dental products.
Design aspects, carbon-carbon and carbon - epoxy based composites, mechanical properties.
Books for reference:

PEMT 6403 METALLURGY OF METAL JOINING (3-0-0)
Module – I
(12 hours)
Theory and classification of welding processes Gas, arc, resistance, pressure, submerged arc, TIG, MIG, plasma arc and electron beam welding including spot welding laser welding and diffusion welding.

Module – II
(12 hours)
Mass and heat flow in fusion welding. Metallurgical effects of the weld thermal cycles.
Metallurgy of fusion welding of ferritic and austenitic steels, cast iron etc. welding pool solidification, structure of welds, heat treatment and transformation.

Module – III
(10 hours)
Metallurgical principles of welding nonferrous alloys, Cu alloys, Al alloys etc., welding pool solidification, structure of welds, heat treatment and transformation.

Module – IV
(10 hours)
Residual welding stresses and stress relieving treatments.

Books for reference:
1. Welding by Little, TMH.
2. Welding by A.C. Davies, Cambridge University Press.
5. Welding Hand Book, Vol-I &II.

PEMT 6404 CASTING PROCESSES AND SOLIDIFICATION (3-0-0)
Module – I
(12 hours)
Introduction: Importance of solidification in metal casting processes, heat flow and heat evolution, shrinkage during cooling and solidification.
Plane front solidification: Solidification of single phase alloys, directional solidification, crystal growth etc.

Module – II
(10 hours)
Nucleation and interface kinetics: Homogeneous nucleation, heterogeneous nucleation, grain refining, lateral growth, continuous growth, instability at the solid/liquid interface.

Module – III
(10 hours)
Solidification microstructure: Cells, dendrites, solidification of polyphase alloys, eutectic and peritectic solidification, growth of graphite in cast iron, segregation in castings, inclusions in castings etc.
Module – IV

(10 hours)

Special casting techniques: Ceramic shell, investment casting, Rheo & thixocasting, squeeze casting, high and low pressure die casting, continuous casting, cast metal matrix components.

Books for reference:
5. Foundry Technology by Beeley P.R., Butterworth, London.

PRACTICALS

CPMT 9403 PROCESS METALLURGY LAB. (0-0-3)

1. Kinetic studies of oxidation of copper.
2. Kinetic studies of reduction of iron ores.
5. To study the flow of gases through beds of solid particles.
7. Leaching of sulphide ores.
8. Compression moulding of polymers and polymer based composites.
9. Compaction of metal powders and determination of green density.
10. Sintering of metal powders and determination of sintered density.
8th SEMESTER
HSSM 4404 MARKETING MANAGEMENT (3-0-0)

Objective of the Course: The course aims at introducing the basic concepts of marketing to the undergraduate students in engineering. The learning shall help the students in better designing, manufacturing and selling product/service packages keeping competitive market, customers and cost in view.

Module – I (9 hours)
Marketing Management: Concept, Process, Functions and relevance in the current context.


Competition Analysis: Factors contributing to competition, Competition analysis tools, Competitive arena mapping, Segmentation matrix.


Module II (10 hours)
Market Research and Information Systems: Research Process, The Internet and World Wide Web based Information collection and processing, Database, Data Warehouses and Data Mining, Global Market Research, Competitive Intelligence.

Consumer Behaviour: Importance of buyer and his/her role in purchasing. Influence of buyer behaviour, Buyer behaviour study tools. Organizational buying behaviour.


Market Demand Forecasting: Key Terms, Forecasting Tools: Short term tools: Moving average and Exponential smoothing methods, Long-term forecasting Tools: Time series analysis, Econometrics methods, Qualitative tools: Buying Intention Survey, Sales Force Opinion and Delphi Techniques.

Module – III (11 hours)


Module -IV

Channels of Distributions : Designing Distribution Channels, Wholesaling and Physical Distribution, Retailing, Supply Chain Management (Basic only). Personal selling, Direct Marketing, Managing Sales Force.


REFERENCES :

CPMT 6404 CHARACTERIZATION OF MATERIALS (3-1-0)

Module – I


Optical & X-ray spectroscopy: Atomic absorption spectroscopy, X-ray spectrometry, infrared spectroscopy and Raman spectroscopy.

Module – II

Mass spectroscopy: Principles and brief account.

Metallographic techniques: Optical metallography, image analysis, quantitative phase estimation.

Diffraction methods: X-ray diffraction, X-ray topography, residual stress measurement techniques, small angle X-ray and neutron scattering.

Module – III

Electron optical methods: (a) Scanning electron microscopy and X-ray microanalysis including electron probe microanalysis, electron optics, electron beam specimen interaction, image formation in the SEM. X-ray spectral measurements: WDS and EDS, quantitative X-ray analysis; application of SEM and EPMA to solid samples and biological materials; type of data base required to process the results.

(b) Analytical transmission electron microscopy: Electron diffraction, reciprocal lattice, analysis of SAD patterns; different electron diffraction techniques, atomic resolution microscopy, analytical devices with TEM, field ion microscopy, scanning tunneling microscopy, advanced techniques.

Module – IV

Methods based on sputtering or scattering phenomena: Field ion microscopy, atom probe microanalysis, low energy ion scattering spectroscopy, Rutherford back scattering spectroscopy, ion channeling and secondary ion mass spectroscopy.

Chromatography: Principles of gas chromatography, mass spectrometry, liquid and ion chromatography.
Books for reference:
2. Elements of X-ray diffraction by Cullity B.D., Addison-Wesley, 1978
4. Differential Thermal Analysis by R.C. Machenzie
5. Modern Metallographic Techniques and their application by Victor A. Phillips

CPMT 6405 CORROSION AND DEGRADATION OF MATERIALS (3-1-0)

Module – I
Technological importance of corrosion study, corrosion as non equilibrium process, corrosion rate expressions, electrochemical principles of corrosion-cell analogy, concept of single electrode potential, reference electrodes, e.m.f. and galvanic series-their uses in corrosion studies, polarization, passivity.

Module – II
Different forms of corrosion-uniform attack, galvanic, crevice, pitting, intergranular, selective leaching, erosion, stress corrosion cracking-their characteristic features, causes and remedial measures.
Principles of corrosion prevention-material selection, control of environment including inhibitors, cathodic and anodic protection, coatings and design considerations. Corrosion testing methods.

Module – III
Introduction to high temperature corrosion, Pilling-Bedworth ratio, oxidation kinetics, oxide defect structures, Wagner-Hauffe valence approach in alloy oxidation, catastrophic oxidation, internal oxidation.
Considerations in high temperature alloy design, prevention of high temperature corrosion -use of coatings.

Module – IV
Liquid metal attack - liquid metal embrittlement, preventive measures.
Chemical degradation of non-metallic materials like rubbers, plastics, ceramics etc.
Hydrogen damage-types, characteristics, mechanism and preventive measures.

Books for reference:
2. Introduction to Metallic Corrosion by Evans.
3. Introduction of Electrochemistry by S. Glasstone
5. Microbiologically influenced corrosion handbook by Borenstein.
PEMT 6405 ALTERNATIVE ROUTES OF IRON MAKING (3-0-0)

Module – I (12 hours)

Direct Reduction Processes:
Reduction of Iron bearing materials in shaft furnace, rotary kiln, retort and fluidized bed with special reference to reductant, energy consumption and operational problems.

Module – II (11 hours)

Commercially available processes like SL-RN, ACCAR, Krup-CODIR, Kinglon Meter, MIDREX, HYL Purofer Iron Carbide, etc.

Module – III (10 hours)

Uses of DRI in steel making, iron making and foundries; effect on DRI on EAF performance and product characteristics.

Module – IV (10 hours)

Smelting Reduction Processes:
COREX, ROMELT, DIOS, HI Smelt etc. Present status of alternative methods of iron making in India.

Books for reference:
1. Direct Reduction of Iron . Editors: Jerome Feinman & Donald R. Mac Rae, Allied Publishers Ltd.
2. Beyond the Blast Furnace, by Amit Chatterjee.

PEMT 6406 FERRO-ALLOY TECHNOLOGY (3-0-0)

Module – I (10 hours)

Survey of Ferro-alloy industries in India and their future prospects.
Physico-chemical principles of ferro-alloy making, principles of carbothermic and metallothermic reduction.

Module – II (10 hours)

Ferro-alloy furnaces: Submerged arc furnaces, selection for transformer capacity, secondary voltage and current, furnace dimensions, size and spacing of electrodes, mechanical equipments, charging devices and dust collection system.
Electrodes used in ferro-alloy furnaces: graphitised and self baking electrodes, properties and uses.
Module – III

Production of ferro-manganese, ferrochrome, ferrosilicon and silico-calcium by carbothermy, production of FeCr, FeTi, FeB, FeNb, FeMo, and FeV by metallothermy. Recovery of vanadium from ores and production of FeV.

Module – IV

Charge calculation in production of ferro-alloys.
Use of plasma arc for production of ferro-alloys.
Use of ferro-alloys in Iron and Steel industries (deoxidation and alloy making).

Books for reference:
1. Production of Ferro-Alloys by Riss and Khodorovasky.
2. Production of Ferro-Alloys by V.P. Elyutin.

PEMT 6407 METALS AND ALLOYS (3-0-0)

Module – I

Carbon and alloy steels: mechanical behaviour of steels, structure and property relationship in steels, high strength low alloy structural steels, medium-high carbon ferrite-pearlite steels, common alloy steels.

Tool steels: classification, composition, structure, properties, heat treatment and uses of different types of tool steels.
Stainless steels: classification, heat treatment and uses of stainless steels.
Special steels: heat resisting steels, Hadfield manganese steels, ultra high strength steels- maraging steels, TRIP steels.

Module – II

Cast irons: classification; microstructure, properties, heat treatment and uses of different types of cast irons; alloy cast irons such as Ni-hard, Ni-resist and high silicon cast irons.

Aluminium and its alloys: heat treatment and uses of Al-Si, Al-Cu, Al-Mg, Al-Zn alloys. Magnesium alloys; and Zinc alloys.

Module – III

Special and high temperature alloys: Ti alloys, alloying behaviour of titanium, alpha grades of titanium, alpha-beta alloys and beta alloys, physical and mechanical properties, thermo-mechanical treatment of Ti-alloys.
High temperature alloys: Fe based super alloys, Ni based alloys, effects of alloying elements; Haste alloys, Inconel, Nimonic alloys and their engineering application; Co based alloys, effects of alloying elements, engineering application at elevated temperatures.

**Module – IV**  
(10 hours)

Refractory metals and alloys: structure, properties and applications of Zirconium, Molybdenum, Tungsten, Tantalum, Niobium and their alloys.

Intermetallic compounds: crystal structures, basic mechanical properties, and lattice defects of intermetallic compounds; magnetic, electrical and optical properties and applications of Intermetallic compounds – Ni3Al, NiAl, gamma TiAl, Ti3Al, Al3Ti, FeAl and Fe3Al, and their alloys, and Zr3Al - nuclear reactor structural material. Silicides and their applications. Intermetallics as precipitates and dispersoids in high-strength alloys.

**Books for reference:**

2. Intermetallic Compounds, Volume 1- 4, by J. H. Westbrook (Editor), R. L. Fleischer (Editor), Wiley.
4. Physical Metallurgy Principles by R. E. Reed-Hill
6. Introduction to Materials Science and Engineering by J. F. Shackelford

**PEMT 6408 FRACTURE MECHANICS AND FAILURE ANALYSIS (3-0-0)**

**Module – I**  
(12 hours)

**Fracture Mechanics:**

Stress intensity factor, stress analysis of cracks, Derivation of the relationship between strain energy release rate and stress intensity factor. Crack- tip plastic zone, Dugdales's plastic strip model.

Fracture mode transition: Plane stress versus plane strain, Crack opening displacement, Plain strain fracture toughness KIC testing, fracture toughness determination with elastic plastic analysis (JIC).

**Module – II**  
(10 hours)


Stress corrosion cracking, Kiscc determination, Corrosion fatigue, Temper embrittlement, Hydrogen embrittlement, SEM fractography of ductile (Dimple), brittle (cleavage), Fatigue fractured surface.
Module – III

(10 hours)

Failure Analysis:

Classification of different types of failures; Description and origin of processing defects: Metal working defects, casting defects, heat treatment defects and weld defects; Failure due to environmental degradation.

Module – IV

(10 hours)

Procedures of failure analysis: stages of analysis, preliminary examination of the failed part; Fracture surface and fracture path analysis to characterize failure mechanism and to locate origin of fracture; Overview of mechanical test parameters and non-destructive testing; Selection, Presentation and clearing of fractured surfaces, Macro examination, Micro examination (Metallography and Fractography), Chemical analysis, Simulated service testing, Analysing the evidence; Generalized procedure for analysis of common failures; Fault tree technique for failure analysis; Case studies.

Books for reference:

4. Mechanical behaviour of materials by T.H. Courtney

CPMT 9406 ENTREPRENEURSHIP PROJECT (0-0-3)

1. The project will be for 2 credits and 3 periods per week is to be devoted for the project.
2. The teacher has to give elementary idea about entrepreneurship through classroom teaching before a project report is prepared by the student.
3. The teacher will first cover the following topics through lecturer and exercises on motivation and games.

- Entrepreneurship concept, EDP in India, Indian middle class value.
- Entrepreneurial qualities, motivation perception, risk taking etc.
- Market survey, Business opportunity guidance
- Role of DIC, SFC, Bank etc.
- Decision making, Leadership, Communication skill
- Preliminary Project Report, preparation for a specific product and submission of the report.
4. Evaluation
   
   (a) The teacher has to conduct tests/ motivational exercises to assess entrepreneurial capability of the student (20%)

   (b) The teacher has to test the knowledge of the student on the above topic through a written test. (20%)

   (c) The teacher has to evaluate the report submitted by the student (i.e. Project report within 50 pages) (60%).

REFERENCE BOOKS:

1. Entrepreneurship of Small Industries, M. V. Deshpande, Deep and Deep Publication