

**FACULTY OF ENGINEERING**

**Syllabus for the**

**M. E. (Metallurgical Engineering – Physical Metallurgy)**

**(w. e. f. 2008 – 2009 )**

**UNIVERSITY OF PUNE**

**THE SYLLABUS IS PREPARED BY:**

**BOS – Metallurgical Engineering,**

**University of Pune.**

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**Note :- This syllabus is subjected to change without prior notice by the concerned BOS.**

**UNIVERSITY OF PUNE**  
**Structure of M. E. (PHYSICAL) METALLURGY 2008 Course**

**SEMESTER I**

CODE	COURSES	EXAMINATION SCHEME							CREDITS
		Lect	Pr.	Paper	TW	Oral	Pr	Total	
505101	Advanced Numerical Methods & Computational Techniques	3	-	100	-	-	-	100	3
505102	Technology Control and Management	3	-	100	-	-	-	100	3
505103	Advanced Powder Technology	3	-	100	-	-	-	100	3
505104	Elective I	3	-	100	-	-	-	100	3
505105	Elective II	3	-	100	-	-	-	100	3
505106	Lab Practice I	-	6	-	50	-	-	50	3
505107	Seminar 1	-	4	-	50	-	-	50	2
Total of First Term		15	10	500	100	-	-	600	20

**SEMESTER II**

CODE	COURSES	EXAMINATION SCHEME							CREDITS
		Lect	Pr.	Paper	TW	Oral	Pr	Total	
505108	Phase Transformation of Metals & Alloys	3	-	100	-	-	-	100	3
505109	X Ray & Electron Metallography	3	-	100	-	-	-	100	3
505110	Mechanical Properties of Metals & Alloys	3	-	100	-	-	-	100	3
505111	Elective III	3	-	100	-	-	-	100	3
505112	Elective IV	3	-	100	-	-	-	100	3
505113	Lab Practice II	-	6	-	50	-	-	50	3
505114	Seminar II	-	4	-	50	-	-	50	2
Total of Second Term		15	10	500	100	-	-	600	20

### SEMESTER III

CODE	COURSES			EXAMINATION SCHEME					CREDITS
		Lect	Pr.	Paper	TW	Oral	Pr	Total	
605115	Seminar III	-	4	-	50	-	-	50	2
605116	Project Stage I	-	18	-	50	-	-	50	6
Total of Third Term		-	22	-	100	-	-	50	8

### SEMESTER IV

CODE	COURSES			EXAMINATION SCHEME					CREDITS
		Lect	Pr.	Paper	TW	Oral	Pr	Total	
605117	Project Stage II	-	18	-	150	50	-	200	12
Total of Fourth Term		-	18	-	150	50	-	200	12

\* The Term Work of Project Stage II of Semester IV should be assessed jointly by the pair of internal and external examiners, along with the oral examination of the same.

Note – The contact hours for the calculation of load of the teacher      Seminar – 1 Hr / week/student & Project – 2 Hrs / week/student

Elective I		Elective II	
505104 A	Instrumentation and Control	505105 A	Science & Technology of Modern Materials
505104 B	Surface Processing of Materials	505105 B	Joining of Metals & Failure Analysis

Elective III		Elective IV	
505111 A	Structural Metallurgy	505112 A	Corrosion and its Prevention
505111 B	Selection of Materials	505112 B	Open Elective (Self Study)

\*\* Open Elective subject - BOS Metallurgical Engineering will declare the list of subjects, which can be taken under open elective

**505101: Advanced Numerical Methods & Computational Techniques**

**Marks 100**

Statistical Quality Control: Basic concepts of quality, Quality assurance, Control Charts for variables and attributes. Some cost aspects of quality decision, Quality Circles, ISO 9000, 9001, 9002 series of quality systems.

Systems Reliability: Review of probability theory including Bayes Theorem, basic concept of reliability and their models. The failure distribution and reliability functions. MTTF and hazard rate failure model, Analysis of failure rate, Data collection and Imperical methods for reliability testing, Availability and maintaining of systems.

Numerical Solutions to Partial Differential Equations: Formation of difference equations, types of difference equations and their solutions. Laplace and Poissons equations. Iterative methods for solutions of parabolic, elliptic and hyperbolic types of Partial Differential Equations and their applications to Metallurgical Engg. problems.

Integral Transforms: general integral transforms, Hankel and Melin transforms and their inversions. Application to Metallurgical Engg. problems. Introduction to fast Fourier transforms.

Calculus of variations: Introduction to maxima and minima, variational notations, functional and Euler's equations, constraints and Lagrangin multipliers, Hamiltonion principles, Sturm-Liouville equations with orthogonal character of solutions for different values of physical problems involving different equation from field of Metallurgy such as mechanical working of metals, foundry, etc.

Finite Element theory: Introduction to finite element theory, generalization of finite element concept, variational approaches, steady state field problems such as heat conduction, electrical and magnetic potential, fluid flow, failure mechanics, etc.

**Reference Books.**

1. Statistical Quality Control Theory and Applications – B. L. Hansen –McGraw Hill.
2. Statistical Quality Control – M. Mahajan-Dhanpat Rai.
3. Reliability and Mentability – C. E. Ebeling – McGraw Hill.
4. Introduction to Reliability Engg. E. E. Lewis-Wiley.
5. Numerical Methods – Salvadori-Baron-McGraw Hill.
6. Introduction to Numerical Methods. – S. S. Sastry- Prentice-Hall
7. Introduction to Integral Transforms – Fon Sneddon, McGraw Hill.
8. Calculus of Variation – A. R. Forsythe , Cambridge University Press.
9. Finite Element Method (Vol. I) R.L. Taylor –McGraw Hill.

**505102: Technology, Control and Management.**

**Marks : 100**

Management Science: Introduction Scientific Management, Management and its Functions, Important Principles of Management, Role of Communication and Coordination in Management.

Business Organizations: Introduction, Forms, Sole Proprietorship, Partnership Firms, Cooperatives, State Govt. Ownership Organization, Organization Structures in Industry.

Plant Location: Introduction, Decision regarding Location, Factors Governing Plant Location, Survey of Site Location, Urban and Rural Site Location, Introduction to Plant Layout. Objectives and Principals of a Good Plant Layout. Types of Layouts, Cost Analysis of Basic Forms of Layout.

Work Study, (Method Study): Introduction, Method Study, Basic Procedure of Method Study, Recording Techniques, Process Charts, Diagrams, Templates and Models, Micromotion Study, Motion Economy.

Work Study, (Work Measurement): Introduction, Uses of Work Measurement, Data Techniques of Work Measurement, Time Study, Procedural Steps in Time Study, Performance Rating, Allowances,

Personnel Management: (Functions and Responsibilities) Role of People in Organization, Evolution of Personnel Management Activities/Functions, Responsibilities of Departments, Personnel Department Organization.

Personnel Management (Recruitment): Recruitment, Selection and Placement: Introduction, Sources of recruitment, steps in recruitment and selection.

Personnel Management (Training): Introduction, steps, training within organization, induction training, cost of training etc.

Personnel Management (Motivation, Job Evaluation and Merit Rating): Introduction, objectives, steps, theories of motivation in practice, job analysis, description, merit rating, performance appraisal, essentials of sound performance systems, methods of merit rating.

Personnel Management (Employee remuneration, incentive schemes): Meaning, Methods of wage payment, incentive wage, tailors differential, price rate method, Merrick Differential Price Rate method, Bonus scheme, Emerson's efficiency plan, Halsey System, Rowan System, Bedaux Point System, Priestman Production Plan, Scanlon Plan, Method and form of payment of remuneration.

Linear programming ( Identification and Formulation ) : Introduction, Terminology of Linear programming, its advantages and limitations. Assumptions and stages of linear programming, Problems and examples of formulation of linear programming.

Different methods of linear programming - Introduction to Graphical and Simplex Method underlying principals, terminologies steps, advantages and limitations, solving of different types of problems related to metallurgical industries using these techniques.

Transportation models – Introduction, terminology of Transportation model, theory and steps of Transportation models, Least Cost Method, North West Corner Rule, Vogel’s Approximation methods.

Critical Path Analysis – Introduction, PERT and CPM Charts, their applications, Network Logic, Procedural steps, activity identification and relationship, Network construction, Node labeling, activity time estimation, Network time analysis, activity float analysis, Probability aspects of Project Planning, Cost analysis and crashing activities, Project monitoring computer application in Project management.

Production Function and Organisation: Introduction, Operation concept of production as the conversion process, objectives of production management, components of production function, Organisation for production, Qualities and responsibilities of production manager.

Product Development and Design of New Product: Introduction, Quality Research, Development and Design, Requirements of a good project, Stages in the designing of a project, Factors influencing Design of the product, Manufacturing cost, Design variety, Design and Value, Design and Quality.

Control of Quality: Introduction, Concept of Quality and reliability, Achievement of Quality, Quality of design, Quality of conformance, Quality standard, Tolerances, the cost of Quality, Relationship between Quality cost and Manufacturing capability, Reliability.

Materials Handling: - Introduction, Importance of material handling, Symptoms of poor material handling, Objective of material handling, Engineering and Economic factors, Relationship between Plant and Material handling, Principles of material handling, Selection of the material handling equipment.

Manufacturing Processes: - Introduction, Classification, Project production, Jobbing production, Batch production, Mass and flow production, Process production, Factors influencing choice of manufacturing process, Selection of manufacturing process.

### **Reference Books**

1. Quantitative Techniques for Managerial Decision, Vol. I and II – L. C. Jhamb.
2. Fundamentals of Production Management D. P. Bhivpathaki.

**505103: Advanced Powder Technology**

**Marks: 100**

Manufacture of metal powders : Conventional methods and modern methods of metal powder manufacture. Purity of metal powders. Blending techniques.

Powder characterization: problem of size determination. Method of size analysis and surface area assessment. Apparent density and flowability measurement.

Powder compaction: Mechanical, thermal and thermomechanical compacting processes. Presses used for transmission. Die design and tooling for consolidation of powders. New methods of consolidation. E.g. Powder rolling, Powder forging, Isostatic pressing. Advantages and limitations of these methods.

Theories of sintering: Sintering mechanism, Role of diffusion, Recrystallization, Pore emigration, Pore-growth and coalescence. Liquid phase sintering and related processes. Effect of compacting pressure, sintering temperature and time on sintered properties. Type of sintering furnaces. Sintering atmospheres.

Manufacturing and application of important P/M components : Porous bearing, Electrical contact materials, Metallic filters, Cemented carbides, magnets, Friction materials and Composites.

**Reference Books**

1. Powder Metallurgy-ASM Vol. II
2. Powder Metallurgy-Sands and Shakespeare
3. Powder Metallurgy-Thumler
4. Powder Metallurgy-Dixtor R.H. and Clayton.
5. Powder Metallurgy-Gopal S. Upadhayay
6. Cemented Tungsten carbide Production, properties and testing-Gopal S. Upadhayay.

## **505104 A: Instrumentation & Control**

**Marks: 100**

Basic measurement/control set-up: Fundamentals of measurement, basic standards and accuracy of measurement, types of I/P quantities, generalized configuration and functional description of measuring instruments, causes and types of experimental errors

Transducers: Displacement, Velocity, Stress, Strain, Pressure, Flow, Level, Density and magnetic properties.

NDT testing: Ultrasonic, X-ray, Electromagnetic testing

Temperature transducers and measurement: Thermocouple, pyrometer, Study of hot film and hot wire anemometry.

Recorder, Data loggers and Data processing Systems.

Controllers: Two steps, Proportional, Integral, Differential and Composite controllers, Transient Response and Stability of control systems, Safety and control strategy in furnace instrumentation, material handling systems

Analytical instrumentation systems: gas analyser, Spectrophotometer, Atomic absorption, Atomic Emission, Chromatography etc.

Application of Instrumentation and control in Metallurgical Engg.

### **Reference Books**

1. Process Measurement- B.G. Ciptak
2. Process Control- B.G. Ciptak
3. Handbook of Analytical Instrumentation-R.S. Khandpur
4. Instrumentation Handbook-Considine

## **505104 B: Surface Processing of Materials**

**Marks: 100**

Importance of surface processing in modifying the properties of engineering components subjected to abrasion, wear, corrosion and fatigue, Preparation of the substrate for surface processing: Physical, chemical, electrochemical.

Various methods of surface modifications such as:

- a) Physical Vapour Deposition
- b) Chemical Vapour Deposition (Chromium, Nickel, Titanium, Copper etc.)
- c) Iron Implantation method.
- d) Coatings for high temperature performance
- e) Electrochemical and spark discharge processes
- f) Plasma coating methods.
- g) Organic and Powder coatings
- h) Thermal barrier coating
- i) Advanced electron beam techniques
- j) Laser surface processing
- k) Coating on plastics

Applications of these methods in the fields like Mechanical, Metallurgical Engg., optical, electronics and surgical instruments, medicine and biotechnology.

Comparison of solar induced surface transformation of materials (SISTM) in processing of electronic materials with other direct energy methods such as Ions, Laser, Electron beam and Thin film deposition.

### **Reference Books:**

1. Ion plating and implantation application to material-Robert. H. Hochman-ASM
2. Ion assisted surface treatment, technology and processes—The metals Society, 1982
3. Thermal spray coatings-New material, processes and application—Frank Lang-ASM for metals.
4. Coating for high temperature application—E. lang -Applied Science Publisher
5. Plating on plastics- G. Muller and D.W. Baurand
6. Thin film deposition—K Chopra, L. Malhotra – McGraw Hill.

## **505105A: Science & Technology of Modern Materials**

**Marks: 100**

Theory of Alloy phases and alloy phase structures, Free energy diagrams of binary alloys indications precipitation, monotectic systems, spinodal decomposition.

Thermal phase diagrams-Important types and classes.

Defects in Materials. Thermodynamics of defects.

Methods of observation of defects. Diffusion and internal friction in materials.

Review of modern development on any four of important modern materials as selected by the faculty, such as:

- a) Advanced Magnetic materials.
- b) Creep behavior and high temperature alloys
- c) High Temperature Superconductors
- d) Shape memory alloys
- e) Alloys by rapid solidification and nano-crystalline alloys
- f) Mechanically alloyed materials
- g) Super-plastic materials
- h) Metal matrix composites.
- i) Thermoelectric materials
- j) High Technology Ceramics.
- k) Functionally graded materials.
- l) Damage Tolerant Materials.

### **Reference Books**

1. Advanced Materials and Processes, ASM International.
2. ASM Handbook of Composite
3. ASM Handbook Of Plastics
4. Advances in materials and their applications, Editor P. Ramarao, Wiley Eastern Ltd.
5. Metals and Materials Science, process, applications-Smallman and Bishop
6. Shape Memory Materials- K. Otsaka and C.M. Waymar-Cambridge
7. Material Science for Engineers Vth Edition –J.F. Shakelford, Pantice Hall
8. Composite Materials Handbook-II Edition

## **505105 B: Joining of Metals and Failure Analysis**

**Marks: 100**

Welding : Principles of Solid phase welding and fusion welding, Welding processes-gas welding, arc welding, submerged arc welding, TIG, MIG, resistance welding. Metallurgy and weldability welding of steels, stainless steels. Copper and other alloys and metals, welding defects. Factors considered for selection of welding processes.

Brazing and soldering: Material, Process details and application, Recent advances in joining techniques, Joining processes for nonmetallic materials, soldering of electronic joints.

Modern Welding techniques: Welding of plastics, welding of ceramics, dissimilar material joining.

Methodology of Failure Analysis, Tree analysis.

Failure analysis: Ductile to brittle failure, Fatigue failure, corrosion failure, creep failure, stress corrosion cracking, failure of weldments.

Typical case studies of failure of important components such as gears, shafts, pressure vessels etc.

### **Reference Books:**

1. Welding- A.C. Davies-Cambridge Low Price Edition
2. Welding Handbook-AWS-Welding, Cutting and Related Processes.
3. Metal Handbook- ASM-Welding
4. Metal Handbook-ASM – Failure Analysis and Prevention

## **505106: Laboratory Practice I**

**Marks: 50**

Any Seven experiment of the following:

1. Inclusion rating in Ferrous and Non –ferrous alloys.
2. Estimation of phases in Ferrous and Non- ferrous alloys.
3. Measurement of case depth and plating thickness.
4. Advanced techniques for chemical analysis:
  - a. Vacuum emission spectroscopy.
  - b. Atomic absorption spectroscopy.
  - c. Carbon-sulphur analyzer.
5. Study of Vacuum melting and casting of metals.
6. Characterization of metal powders.
7. Measurement and control of parameters like temperature, resistivity, dimensional change etc.
8. Precipitation heat treatment of Aluminium alloys.
9. Thermal analysis of steels.

## **505108: Phase Transformation of Metals and Alloys**

**Marks: 100**

Classification of transformations: Phase Transformation of first degree and second degree, Energy aspects of first degree and second degree, Energy aspects of homogeneous and heterogeneous nucleation, nucleation ratio, fraction transformed at constant rates of nucleation and growth, Nucleation in solids.

Austenite-Pearlite transformation, role of diffusion and temperature on lamellar spacing.

Bainite transformation: Nature of carbide in bainite, upper and lower bainite, isothermal transformation in austempered ductile iron.

Martensitic transformation: Crystallographic aspects and mechanism of atom movements, comparison between twinning and martensitic transformation, effect of grain size, Plastic deformation, arrested cooling on kinetics.

Order-Disordered transformations: Common structures in ordered alloys, Variation of order with temperature, Determination of degree of ordering, Effect of ordering on properties, applications

Precipitation hardening: Structural changes, Mechanism and integration of reactions, Effect of retrogression, Double peaks, Spinoidal decomposition.

Recovery, recrystallization and grain growth: property changes, Driving forces, N-G aspects, annealing twins, textures in cold worked and annealed alloys, polygonization.

### **Reference Books:**

1. Phase Transformation- V. Raghavan
2. Phase Transformation-Porten and Easterting.
3. Phase Transformation-R.W. Cahn
4. Modern Physical Metallurgy – R. E. Smallman
5. Principals Of Physical Metallurgy-Reedhill R.E.

## **505109: X-Ray & Electron Metallography**

**Marks: 100**

Stereographic projection. Application problems in twins, pole rotation, indexing of planes

Reciprocal lattice. Relation of reciprocal and Bravais lattice. Diffraction in terms of reciprocal lattice. Application in diffraction in electron microscopy.

Intensity of diffracted beam from a crystal. Structure factor and its applications. Laue method. Indexing of spots by Gouy chart and Wulff net. Use of X-rays in phase diagrams, internal stresses, textures and preferred orientation.

Transmission Electron Microscopy. Types of Electron sources. Focussing systems for parallel beams and probes. Image contrast and interpretation of images. Specimen preparation techniques, Contrast theory for electron microscopes Kikuchi lines.

Scanning Electron Microscope-Back Scattered and secondary electron imaging. Images by X-Rays, current magnetic and other approaches channelling patterns, Specimen preparation techniques, Microanalysis.

Modern techniques such as scanning transmission electron microscope. High voltage Electron microscopy. Techniques of EELS, XPS, AES, Tunnelling and related methods.

### **Reference Books:**

1. B.D. Cullity – Elements of X-ray diffraction – Addison Wesley publications (for X-rays)
2. Edited by E.Metcalfe- Microstructural Characterisation- The institute of Metals, USA (For SEM and TEM)
3. ASM Metals Handbook, 9<sup>th</sup> edition, Volume 10- Materials Characterization – ASM International publication
4. B.L. Gabriel – SEM-A User manual for material science- American Society of Metals.
5. Metals and Materials Science, process, applications- Smallman and Bishop

## **505110: Mechanical properties of Metals and Alloys**

**Marks : 100**

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

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

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

Fracture mechanics and fracture toughness evaluation: Strain energy release rate, stress intensity factor, fracture toughness and design,  $K_{IC}$  Plain toughness testing, crack opening displacement, probabilistic aspects of fracture mechanics, toughness of materials.

Fatigue of metals: Stress cycle, S-N curve, statistical nature of fatigue, low cycle fatigue, structural features of fatigue, fatigue crack propagation, effect of stress concentration on fatigue, size effect, surface effects and fatigue, effect of metallurgical variables on fatigue, corrosion fatigue, effect of temperature on fatigue.

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

### **Reference Books:**

1. Theory of Plasticity: Dr.S. Singh, Khanna Publishers.
2. Mechanical Behavior of Materials- T.H. Courtney, McGraw Hill
3. Physical Metallurgy Part I- R.W. Cahn, P. Haasen, North Holland Publishing.
4. Physical Metallurgy Principle: R. Reedhill, East – West Press.

**505111 A: Structural Metallurgy**

**Marks : 100**

Plastic deformation of single crystal: Lattice defects, Slip in perfect lattice, easy glide, slip by dislocation movement, Critical resolved shear stress for slip, deformation by twinning, Stacking faults, Strain hardening of single crystal.

Dislocation Theory : Methods of observation of dislocations, Elastic properties of dislocations, strain energy of dislocations. Forces on and between dislocations, Dislocations in FCC and other crystal structures. Multiplication of dislocations. Dislocation pileups, Strengthening of dislocations. Work hardening.

Diffusion in solids : Fick's laws of diffusion, Solutions of Fick's law and their applications to metallurgical problems, Kirkendall effect, Atomic movements in diffusion.

Strengthening mechanisms : Strengthening by grain boundaries, Yield point phenomenon, Strain ageing, Solid solution strengthening from fine particles, fiber strengthening, strengthening due to point defects, Cold Working.

Study of Phase Transformations: Nucleation and growth considerations, Homogeneous and heterogeneous nucleation. Martensitic transformations, Order-disorder changes, Precipitation hardening, Solution treatment Aging treatment, Nucleation of precipitates, Theories of structural changes during ageing, Study of Al-Cu system, Theories of precipitation hardening.

Fractures: Theoretical strength of materials, Types of fractures, Griffith theory of brittle fracture, ductile to brittle transition, ductile fracture, Notch effects.

**Reference Books.**

1. Dieter George E. – Mechanical metallurgy, McGraw Hill.
2. Hayden, Moffat and Wulff – The structure and properties of materials, Vol. III (Mechanical behaviour) Wiley Eastern Pvt. Ltd. New Delhi.
3. Reed – Hill Robert E. – Physical Metallurgy Principles, Affiliated East-West Press Pvt. Ltd. New Delhi.
4. Brophy, Rose and Wulff – Thermodynamics of Structure, Vol. II, Wiley Eastern Pvt. Ltd. New Delhi.
5. Smallman R. E. –Modern Physical Metallurgy, The English Language Book Society, and London Butterworths.
6. Derek Hull – Introduction to Dislocations, Pergamon Press.

## **505111 B: Selection of Materials**

**Marks : 100**

Basic principals involved in the Selection of Materials (Ferrous and Non-ferrous materials), Selection processes, determination of performance requirements, evaluation of alternatives, methods of selection of Materials viz. weighted properties, digital logic, cost per unit properties, incremental return, limits on properties, use of computers in material selection, factors affecting material prices, economics of material utilization – material systems, material substitution, functional requirements of engineering materials, selection of materials for strength, resistance to fatigue, corrosion, wear, economics of manufacturing processes and materials.

Steel selection, commercial aspects of the steel industries, compromises in steel selection, design of steel components for special requirements, Weldability, Forgability, Formability, Selection of Materials and Process for tools and few components of Automobile engines, machine tools etc.

Non-ferrous metal selection for wrought and cast components, commercial aspects, design of Copper, Aluminium, Nickel base alloy components for special requirements, Castability, Weldability, Forgability, Formability etc.

Composite Materials – General use, selection and evaluation of Composites, comparison of General metals and Composites for the applications in Aircraft industries, Space and Missile systems, Marine applications, Sports and Recreational equipments.

### **Reference Books**

1. F A Crane & J A Charles – Selection and Use of Engineering Materials.
2. M F Ashby & Jhones - Engineering Materials
3. Farag – Materials and Process Selection in Engineering
4. Engineering Materials Handbook – Vol I, A S M International
5. W F Smith – Principals of Material Science and Engineering, Mcgraw Hill International

**505112 A: Corrosion and its Prevention**

**Marks : 100**

Cathodic Processes: Electro deposition of metals and alloys, electrowinning, Different types of corrosion viz. Galvanic corrosion, Crevice corrosion, Pitting corrosion, Intergranular corrosion, selective leaching, erosion corrosion, hydrogen damage etc.

Principals of Oxidation: Wangers theory, Pilling Bedworth ratio, Kinetics of metal – Gas, reaction at high temperature, Prevention of corrosion, Principals of protection, Inhibition, Cathodic Protection, Surface treatment, design of components, Minimum three practical application details (case studies)

Thermodynamic theory of corrosion, Pour Baix diagrams, their application and limitations, Environmental effects, Electrode kinetics – Polarisation curves, concept of over potential, Kinetics of passivity and Trans passivity.

Corrosion testing: Surface preparation, exposure technique, measurement of corrosion rates, selection of material for specific corrosion application such as marine industry, petrochemical industry, chemical industry, high temperature services.

Anodic metallurgical processes: Anodizing and Hard Anodizing, process variables, testing of Anodic layer, mechanism of Anodising, sealing, coloring, Electrolytic cleaning, Electrolytic polishing, Electroetching, Electrochemical grinding and machining.

**Reference Books**

Corrosion Engineering – M. Fontana and N D Green, McGraw Hill ed. 1967.

**505113: Laboratory Practice II**

**Marks : 50**

Any Seven experiment of the following:

1. XRD studies of Cubic metals.
2. Residual stress analysis in cast, wrought, welded and heat treated components by X-Ray diffraction techniques
3. X-ray radiography of various finished components.
4. Quantification of retained austenite in hardened components by X-ray diffraction techniques
5. Studies of fracture by SEM.
6. Wear testing of surface treated components by Pin On-Disc techniques.
7. Low cycle fatigue test and fracture toughness measurement.
8. Selection of materials and processes, failure analysis case studies.