

FACULTY OF ENGINEERING

Syllabus for the

M. E. (Metallurgical Engineering – Process 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. (PROCESS) METALLURGY 2008 Course

SEMESTER I

CODE	COURSES	EXAMINATION SCHEME							CREDITS
		Lect	Pr.	Paper	TW	Oral	Pr	Total	
505201	Advanced Numerical Methods & Computational Techniques	3	-	100	-	-	-	100	3
505202	Industrial Engineering	3	-	100	-	-	-	100	3
505203	Advanced Powder Technology	3	-	100	-	-	-	100	3
505204	Elective I	3	-	100	-	-	-	100	3
505205	Elective II	3	-	100	-	-	-	100	3
505206	Lab Practice I	-	6	-	50	-	-	50	3
505207	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	
505208	Phase Transformation of Metal Alloys	3	-	100	-	-	-	100	3
505209	Advanced Metal Castings	3	-	100	-	-	-	100	3
505210	Mechanical Working of Metals	3	-	100	-	-	-	100	3
505211	Elective III	3	-	100	-	-	-	100	3
505212	Elective IV	3	-	100	-	-	-	100	3
505213	Lab Practice II	-	6	-	50	-	-	50	3
505214	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	
605215	Seminar III	-	4	-	50	-	-	50	2
605216	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	
605217	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	
505204 A	Special Manufacturing Processes	505205 A	Advanced experimental Techniques
505204 B	Joining of Metals and Failure Analysis	505205 B	Instrumentation and Control

Elective III		Elective IV	
505211 A	Surface Engineering	505212 A	Value Engineering
505211 B	Corrosion and its Control	505212 B	Open Elective (Self Study)

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

505201: 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.

505202: Industrial Engineering

Marks : 100

Management science: Introduction, Scientific management, Management and its functions, Principles of management, Role of communication and co-ordination in management.

Work Study – Introduction to method study, Basic procedure of method study Recording Techniques, Process charts, diagrams, Micromotion study, Uses of work measurement data, work measurement techniques, Time study procedure, steps in time study, Performance rating, allowances, etc.

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 principles, 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.

Applications drawn from production industries involving Castings, Forgings, Heat treatment, Welding, Rolling etc.

Reference Books

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

505203: 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 migration, 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.

505204 A: Special Manufacturing Processes

Marks: 100

Review of conventional manufacturing processes.

Recent forming techniques: High energy rate forming, Superplastic forming, explosive forming, explosive forming and squeeze casting techniques.

Unconventional machining processes: Jet machining, ultrasonic machining, electrochemical machining, electric discharge machining, electron beam and plasma arc machining.

Laser processing: production and properties of lasers, applications of lasers in cutting, drilling, machining, welding and heat treatment.

Current developments in manufacturing processes, manufacture of magnetic tapes and thin films, superplastic forming, problems of fabrication in high temperature superconductors.

Modern processes of casting, liquid forming, near-net shape forming techniques, rapid solidification technique for amorphous and nanocrystalline materials.

Reference Books:

1. Surface Finishing Systems-G.Rudzki, ASM, 1985.
2. Super Alloys, Source Book – ASM, 1985.
3. Superplastic Forming – S.P. Agarwal, ASM, 1986
4. Phosphating and Metal Pre-Treatment-D.B. freeman, Industrial Press.
5. Thermal Spray Technology-D. Houck, ASM, 1991

505204 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

505205A: Advanced Experimental Techniques

Marks: 100

X-Ray Methods- Use of Stereographic Projection and Wulf Net applications of indexing of planes, Twins etc.

Nature of X-Ray diffracted beam and its intensity as affected by electron scattering, atomic scattering and the structure factor, Use of Reciprocal lattice in diffraction.

Laue Method. Indexing of spots. Use of Powder method in phase diagrams, internal stresses, texture of pole figures etc. Application of X-Rays for lattice parameter, determination of cubic metals, particles size measurement.

Transmission electron microscopy and its applications. Interpretation of crystal defects in TEM images. Kikuchi lines.

Scanning electron microscopy and its applications. Microanalysis. Channelling pattern, Imaging by various methods. Field Ion Microscopy and utilities.

Introduction to modern techniques such as EELS, STEM, HVEM, AES, XPS, Tunneling microscopes and related methods.

Reference Books:

1. B.D. Cullity-Elements of X-ray diffraction-Addison Wesley Publications (For X-Ray)
2. E. Metcalfe-Microstructural Characterisation-The Institute of Metals, USA (For SEM And TEM).
3. ASM Metals Handbook, 9th Edition Volume 10- Materials characterization-ASM International publication.
4. B.L. Gabbitas-SEM-A Users manual for material science-American Society for Metals.
5. Metals and Material Science, process, applications-Smallman and Bishop.

505205 B: 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

505206: 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 Aluminum alloys.
9. Thermal analysis of steels.

505208: 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.

505209: Advanced Metal Casting

Marks: 100

Casting design consideration, Optimization of design, Methoding of a casting, engineering aspects of casting geometry, Limitation on moulding and coring.

Solidification behavior of castings: Nucleation aspects and inoculation, effect of cooling rates and solute distribution factor on structure, Dendrite arm spacing, Solidification shrinkage and feeding of casting, Feeder design performance, Effect of modulus (V/A ratio) on feeding Segregation behavior of alloying elements.

Foundry lay-out, Machinery for sand conditioning and handling, Mechanized moulding and pouring techniques.

Defect in casting and remedial measures, Processes factors for sands, moulds and pouring practice related to casting defects, Factor governing gas porosity and its nucleation and growth, Effect of chills, Conductive moulds. Use of insulating sleeves in feeder and casting design.

Modern developments in casting manufacture squeeze casting, Low-pressure die casting, Full mould process.

Review of recent research in foundry technology based on study of selected papers as guided by faculty.

Reference Books

1. Metallurgical Principles of Foundry-V. Kondic Edward Arnold Publisher Ltd. London, 1969
2. Solidification Processing –Flemings- McGraw Hill Book Company Ltd., NY.
3. Analysis of casting Defects-AFS
4. Casting Design Handbook-ASM

505210: Mechanical Working of Metals

Marks: 100

Plastic deformation of metals, deformation mechanism maps, superplasticity

Fracture: Types of fractures in metals, Griffith theory of brittle fracture, metallographic aspects of fractures, fractography, dislocation theories of brittle fractures, ductile fractures.

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

Fundamentals of metal forming: Classification of forming processes, mechanics of metal working, flow stress determination, temperature in metal working, metallurgical structure, friction and lubrication, workability.

Forging: Classification of forging processes, forging equipments, forging in plain strain, open die forging, closed die forging, forging defects.

Rolling of metals: Classification of rolling processes, rolling mills, rolling variables, problems and defects in rolled products.

Extrusion: Classification of extrusion processes, extrusion equipments, hot extrusion, deformation lubrication and defects in extrusion, hydrostatic extrusion, extrusion of tubing, production of seamless pipes and tubing.

Rod and wire drawing: Analysis of wire drawing, residual stresses in rods, wires.

Sheet metal forming: Forming methods, shearing and blanking, blending, deep drawing.

Reference Books:

1. Process and Materials of Manufacture –R.A. Lindberg-Printice Hall.
2. Manufacturing Process and Systems-P.F. Ostawald, Jastro Munoz
3. Theory of Plasticity-Dr. Sandhu Singh, Khanna Publishers.
4. Manufacturing Engineering and Technology –S.R. Schmid, S. Kalpaljian, IV Edition, Addison Westley, Delhi.

505211 A: Surface Engineering

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.

505211 B: Corrosion and its Control

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.

505212 A: Value Engineering.

Marks : 100

Introduction, Uses, Concept, Performance of Functions, Group Thinking and Brain-Storming in Value Engineering, Techniques used in Value Analysis.

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

Manufacturing Processes: - Introduction, classification, mass and flow production, Process production, Factors influencing choice of manufacturing process, Selection of manufacturing process.

Replacement Theory – Introduction, Types of replacement situations, Criteria for replacement of old techniques.

Reference Books

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

505213: 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.