M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 611 MATERIALS CHARACTERIZATION

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Introduction, Important parameters describing the materials, Need of materials characterisation, Available characterization techniques etc.

Optical Microscopy, Optical microscope, Basic principles & components, Different examination modes, Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques, Stereomicroscopy, Photomicroscopy, Colour metallography, Specimen preparation, Applications.

Thermal Analysis, Thermogravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, Thermomechanical analysis and dilatometry.

Surface Analysis, Atomic force microscopy, Scanning tunneling microscopy, Secondary ion mass spectrometry, Auger electron spectroscopy, X-ray photoelectron spectroscopy.

Optical emission spectroscopy, Atomic absorption spectroscopy, UV/Visible spectroscopy, Spark source mass spectrometry, Raman spectroscopy, Infrared spectroscopy, Fourier transform infrared spectroscopy, X-ray fluorescence, Inductively coupled plasma emission spectroscopy, Rutherford backscattering spectroscopy.

Gas chromatography, Liquid chromatography, Ion chromatography, Resonance Methods, Nuclear magnetic resonance, Mossbauer spectroscopy, Powder Characterization, Important properties of powders and measurement techniques.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Wendlandt, W.W., Thermal Analysis, John Wiley & Sons (1986).
- Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth-Heinemann, (1993).
- Gabriel, B. SEM- A Users's Manual, Plenum Press (1985).
- Smallman, R.E., and Bishop, R.J., Metals and Materials – Science, Processes, Applications, Butterworth-Heinemann (1995).
- Sibilia J.P., A Guide to Materials Characterisation and Chemical Analysis, VCH (1988).

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 612 ADVANCED MECHANICAL BEHAVIOUR OF MATERIALS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Introduction, Stiffness, Strength, and Toughness, Types of mechanical behavior, Relevance, Measurement, data, Macroscopic, continuum behavior, Physical mechanisms controlling behavior.

Elasticity, Stress, strain, compliance and stiffness tensors, Physical origin of elastic moduli, Generalized Hooke's law and its application to crystals, Designing for modulus and Composites.

Continuum Plasticity, True stress-true strain, Necking and Considere's Criterion, Yield Criteria and yield locus, Normality, Isotropic and kinematic hardening, Plastic stress-strain relations.

Microstructural Aspects of Plasticity, Theoretical shear strength, Dislocations and Burger's vector, Elastic properties and energy of dislocations, Forces between dislocations, Partial dislocation and stacking faults, Dislocation-dislocation interactions, The Peierls-Nabarro Stress, Origin and multiplication of dislocations, Crystallography of Slip and Independent Slip systems, Slip plane rotation, Twinning and twin geometry, Twinning in HCP crystals.

Strengthening Mechanisms, Work hardening, Taylor's and Kuhlmann-Wilsdorf Theories, Grain boundary strengthening, Hall-Petch and Cottrell theories, Solid solution strengthening, Point defect - dislocation interaction energy, Yield point phenomenon, Precipitation hardening, Dislocation-precipitate interactions.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Callister, W.D., Materials Science and Engineering: An introduction, Wiley (2001).
- Dieter, G.E., Mechanical Metallurgy, McGraw Hill (1989).
- RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons
- MF Ashby and DRH Jones, Engineering Materials 1, Butterworth- Heinemann
- D Hull and DJ Bacon, Introduction to Dislocations, Pergamon

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 613 PHASE TRANSFORMATION OF MATERIALS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Thermodynamics and Kinetics of solid state Phase transformation, Atomic models of Diffusion, Functions of alloying elements, Allotropy of Iron and Fe – C Phase diagram, Importance of Austenite Grain size.

Formation of Austenite, TTT and CCT Diagrams. Homogeneous and Heterogeneous nucleations, Strain energy effects, Pearlitic, Bainiatic and Martensitic Transformation (Mechanisms, Kinetics and Morphologies).

Pearlitic transformation, Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation of growth, Orientation relationship.

Bainite transformation, Mechanism of transformation, Nucleation and growth, Orientation relationship, Surface relief, Classical and non-classical morphology, Effect of alloying elements.

Martensitic Transformation, Characteristics of transformation, Thermodynamics and kinetics, Nucleation and growth, Morphology, Crystallography, Stabilization, Annealing (Full, Homogenising, Spherodization and Stress-relieving annealing), Normalising, Comparison of Annealing and Normalizing, Hardening and Tempering of steel, Aims and stages of tempering, Effect of Carbon and alloying elements, Tempering of alloy steels and Multiply tempering.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- D A Porter & K E Easterling, Phase Transformation in Metals and Alloys, CRC Press.
- V Raghvan, Solid State Phase Transformation, PHI.
- V Sing, Heat Treatment of Metals, Standard Publishers.
- J W Christian, The Theory of Transformations in Metals and Alloys, Pergamon Press.
- J E Hilliard, Phase Transformations, ASM.
- S H Avner, Introduction to Physical Metallurgy, Tata McGraw – Hill.
- R E Reed Hill, Physical Metallurgy Principles, East – West Press.
- A K Jena and M C Chaturvedi, Phase Transformation in Materials, Prentice Hall.

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 614 ADVANCED MATERIALS PROCESSING

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Solidification from Liquid and Vapour Phase, Nucleation and growth, Homogeneous and heterogeneous nucleation, Interface stability, Development of micro structure, Faceted and non faceted structure, Super cooling, Equilibrium phase diagrams, Eutectic and peritectic solidifications and their microstructures, Foundry techniques such as sand casting, Permanent mould casting, Investment casting and die casting, Casting defects and their inspection.

Forming Processes, Fundamentals of metal forming, Hot working process, Rolling, Forging, Extrusion, Piercing, Cold working processes; Bending, Shearing, Squeezing etc.

Metals Processing, Welding, Brazing, and soldering, Conventional and Laser techniques and their application.

Ceramic Processing / Powder Processing, Synthesis of common ceramic powders such as Al_2O_3, ZrO_2, Si_3N_4, and SiC, Powder characterization, Binders, Lubricants, Defloculants and flocculants as processing aids, Shaping techniques such as powder compaction, Extrusion, Injection moldings, Slip casting, Solid state and liquid phase sintering, Machining of ceramic components, Common applications such as cutting tools, Ferrites and piezoelectric.

Processing of Polymers, Classification of polymers, Rheology, Polymer fabrication techniques: Injection moulding, Compression moulding, Transfer and blow moulding, Extrusion, Calendaring, Casting, Coating.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Chalmner, B, Principles of Solidification, Wiley (1977)
- Degarmo, EP, Black, JT Kosher RA, Materials and Processing in Manufacturing, PHI (1986)
- Martin, DH & Jones, Polymer Processing, Chapman and Hall (1989)
- Fleming, MC, Solidification Processing, McGraw Hill (1974)
- Richerson, BW, Modern Ceramic Engineering: Properties, Processing and Use in Design, Marcel Dekker (1983)

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 615 COMPOSITE MATERIALS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, Review of current developments, Design fabrication and economic considerations.

Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix, Discontinuous and particulate reinforcement, Fibres and resin materials, Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation, Matrix and Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers C, B, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres.

Review of the principal thermosetting and thermoplastic polymer matrix systems for composites , Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs), Types, Manufacturing, Processing methods, Interfaces, Properties, Applications, Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, Recycling.

Matrix Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface, The nature of fiber surfaces, wetting and adhesion, Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites, Strengths of unidirectional composites, Multiple fracture in Laminates.

Macroscopic fracture and energy dissipating processes, Application of fracture mechanics to composite materials. Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix debonding, Fiber Pullout Buckling and Post-Buckling, Failure criteria.

Fatigue and Creep in composites, Environmental effects in Composites, Green composites, Synthesis and Properties of Nanocomposites, Green Composites.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Chawla, Composite Materials: Science and Engineering, Springer, 2ndEd. 1998.
- Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman & Hall, 1994.
- Hull, An Introduction to Composite Materials, Cambridge, 2nd Edt. 1997.

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 616 FRACTURE MECHANICS AND FAILURE ANALYSIS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

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

Fracture mode transition, Plane stress versus plane strain, Crack opening displacement, Plane strain fracture toughness (KIC) testing, Fracture toughness determination with elastic plastic analysis (JIC), Concept of R-curve and fracture toughness measurement using it, Microstructural aspect of fracture toughness, Optimizing microstructure and alloy cleanliness to enhance fracture toughness.

Fatigue stress life approach, Basquin's equation, Fatigue strain life approach, Low cycle fatigue, Cofin-Manson's equation, Fatigue total strain life relation, Fatigue life calculation using this approach, Neuber's analysis for notched specimens.

Fatigue crack growth rate, Paris law, Fatigue life calculation using this approach, Mechanism of fatigue crack nucleation and propagation, Factors affecting fatigue crack growth rate, Influence of load interaction, Short fatigue crack.

Stress corrosion cracking and KISCC determination, Corrosion fatigue, Temper embrittlement, Hydrogen embrittlement, Liquid metal embrittlement, Neutron embrittlement.

Fractographic analysis of ductile, brittle, fatigue and high temperature fractured surfaces, Steps involved in Failure Analysis, Case studies of some engineering failures.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials - (John Wiley & Sons Pub)
- Metal Hand Book, Failure Analysis & Prevention (Vol - X) - ASM Publication
- Das AK, Metallurgy of Failure Analysis, Tata McGraw Hill (1986)
- GE Dieter, Mechanical Metallurgy by Mc-Graw Hill (1988)
- D Broek, Elementary Fracture Mechanics - Martinus Nijho Publisher
- N Perez, Fracture Mechanics, Klwer Academic Publishers

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 617 PHYSICAL METALLURIGY LAB

Internal Assessment/Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

LIST OF EXPERIMENTS

1. Determination of crystal structure and lattice parameters using X-rays diffraction technique.
2. Study of phase diagrams using cooling curves.
3. Determination of crystal structure and lattice parameter from electron diffractions.
4. Study of viscoelastic transition in polymers employing ultrasonic technique.
5. Production of coloured glasses and study of their absorption spectra.
6. Estimation of degree of crystallinity and glass transition temperature of thermoplast.
7. N D T ultrasonic flaw detection.
8. Thermal analysis of alloys.
9. Analysis of fractured surface of metallic, ceramic and polymeric materials.
10. To study the thermal expansion coefficient of various specimen using dilometer.

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 618 MECHANICAL METALLURGY LAB

Internal Assessment/Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

LIST OF EXPERIMENTS

1. To study the stress-strain curves of different metallic samples using tensometer.
2. Thermo-mechanical behaviour of rubber.
3. Mechanical behaviour/strength of glass.
4. Young's modulus and strength of fiber, Rockwell, Brinell hardness of metallic samples.
5. Effect of heat treatment on yield strength and creep resistance of metallic wire.
6. Decomposition of austenite as a function of cooling rate and the tempering the martensite as a function of temperature in 0.8% carbon steel.
7. Hardness of a specimen by Vicker micro hardness tester.
8. Inspection of surface defects occurred during solidification of a given metallic sample.
9. Rolling a given metallic specimen and discussing the rolling defects.
10. Forging a given metallic specimen and discussing the forging defect.
11. Study the fracture surface of brittle and ductile materials under SEM.
12. Studying the fracture surface of a material failed under cyclic loading.
13. Observation of wear surface and subsurface and evaluating the mode of failure.
14. Observation of corroded metallic material to evaluate the form of corrosion.

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 621 ADVANCES IN IRON AND STEEL MAKING

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Blast Furnace Route for Iron Making, The blast furnace and its accessories, The burden and its preparation, Physical and Chemical processes in a blast furnace, Blast furnace slag and its control, Control of hot metal composition, Blast furnace plant and accessories, Modern trends in blast furnace practice, Control of irregularities in the blast furnace, Alternative Methods, Need for alternative methods, Sponge iron production by using solid and gaseous reductants, Smelting reduction processes.

A critical appraisal of hybrid blowing process, Ultra high power electric arc furnace and induction furnace with respect to raw materials, energy consumption, productivity and product quality, special grade steels.

Development of secondary steel making and their importance under Indian conditions, sources of inclusions, sulphur, phosphorus and gases in steel, Secondary steel making technologies, inert gas purging, vacuum degassing – RH/DH, OD, VAD etc., ladle furnace; powder injection system – powder dispenser, lance etc. physicochemical and fluid dynamic aspects of powder injection and stirring processes, role of slag and powders in inclusion control, desulphurization, cored wired feeding, production of ultra low Sulphur, ultra low phosphorus and inclusion free steels, ultra-low carbon steels, modification of inclusion morphologies.

Production of stainless steel through VOD, AOD, CLU processes, Production of Ultraclean steel through post solidification treatments (VAR, ESR processes),Refractory for secondary steel technology-slide gate, porous plug, ladle lining etc., properties and selection of refractories.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- A Ghosh and A Chatterjee, Iron Making & Steel Making Theory and Practice –Prentice – Hall of India Pvt Ltd, 2008
- A Ghosh, Secondary Steel Making – Principle & Applications, CRC Press, 2001
- Tupkary, RH, Tupkary, VR, An Introduction to Modern Iron Making, Tata McGraw Hill (2005)
- AK Biswas, Principles of Blast Furnace Iron Making –SBA Publication, 1999
- DH Wakelin, The Making, Shaping and Treating of Steel (Iron making volume), The AISE Steel Foundation, 2004
- RJ Fruehan (Ed), The Making, Shaping and Treating of Steel (Steel making volume), The AISE Steel Foundation, 2004

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MSE – 624 DESIGN OF EXPERIMENTS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Introduction, Objectives for experimental designs, Basic design concepts, Steps for the design of experiments, types of experimental designs, Analysis of Means, Experimental designs and six sigma.

Statistical Inference: Generation of hypotheses, Testing of hypotheses, OC curve, Tests on means, Tests on variances, Assessing normality, ANOVA rationale, Confidence limits on means, Components of variance.

Completely Randomized Design: Model for a completely randomized design with a single factor, ANOVA for a completely randomized design, Randomized block design, Incomplete block design, Latin square design, One way, Two way ANOVA, Balanced ANOVA.

Full and Fractional Factorial Designs with Two Levels: Nature of Factorial Designs. Deleterious effects of Interactions, Effect Estimates, The 2^3 Design, Built-in-Replication, Role of expected mean squares in experimental design, 2^{k-1} Designs, Effect Estimates and Regression Coefficients, 2^{k-2} Designs, Basic Concepts, Design Efficiency, John's 3/4 Designs.

Robust Designs, DOE and Taguchi Approach, Experimental Design using orthogonal arrays, Experimental Designs with Two-Level Factors only, Experimental Designs with Three and Four Level Factors, Analysis using Signal to Noise Ratios, Some case studies, Response Surface Methodology, Response surface experimentation, Process improvement with Steepest Ascent, Analysis of Second-order response surfaces, Central Composite Designs, Box -Behnken Designs, Analyzing the fitted surface, Design-Expert Software.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Modern Experimental Design by Thomas P Ryan; John Wiley Publishers; NY; 2003
- Design of Experiments using the Taguchi Approach by Ranjit K Roy; John Wiley; NY; 2006
- Fundamental Concepts in Design of Experiments; Charles R Hicks; Oxford University Press; NY; 1999
- Modern Experimental Design by Thomas P Ryan John Wiley
- Response Surface Methodology by Myers R H and Montgomery Dc John Wiley
- Anthony M Graziano; Michael L Raulin; “Rsearch Methods”; Amazoncom

M TECH: MANUFACTURING SYSTEMS ENGINEERING

MSE – 627 RESEARCH METHODOLOGY

Internal Assessment/Evaluation: 50 Marks

Introduction to Educational Research, Concept, types – basic, applied and action, Need for educational research, Reviewing Literature, Need, Sources – Primary and Secondary, Purposes of Review, Scope of Review, steps in conducting review.

Identifying and defining research problem, Locating, analyzing stating and evaluating problem. Generating different types of hypotheses and evaluating them.

Methods of Research: Descriptive research design - survey, case study, content analysis, Ex-post Facto Research, Co relational and Experimental Research, Design and development of measuring instruments, Tests, questionnaires, checklists, observation schedules, evaluating research instruments, selecting a standardized test.

Data Collection: Procedure of data collection, Aspects of data collection, coding data for analysis, Statistical Methods of Analysis.

Descriptive statistics: Meaning, Graphical representations, mean, Range and standard deviation, characteristics and uses of normal curve, Inferential statistics: t-test, Chi-square tests, correlation (rank difference and product moment), ANOVA (one way), Selecting appropriate methods.

Procedure for writing a research proposal: Purpose, types and components of research proposal, Procedure for writing a research report, Audiences and types of research reports, Format of research report and journal articles.

Strategies for evaluating, Research disseminating and utilizing research – An Overview

Practice Tasks:

- Define a research problem in engineering education/industry after studying problem situation and literature
- Given the purpose, objectives of research, write hypotheses
- Select research designs for the given research objectives
- Identify the measuring instruments for the given research objectives/hypotheses
- Identify the appropriate statistical methods of analysis for the given research proposal.
- Critically analyse the given research reports on various aspects such as hypothesis, design, measuring tools, statistical analysis, interpretation etc. to identify the gaps or weaknesses in the study.

Recommended Books:

- Borg; W and Gall; M Educational Research: An Introduction; New York; Longman2003
- Cohen; L Educational Research in Classrooms and Schools! A Manual of Materials and Methods NY: Harper and Row Publishers2000
- CPSC: Developing Skills in Technician Education Research Modules 1 to 11 Singapore; Colombo Plan Staff College for Technician Education
- Garrett; HE and Woodworth; RS Statistics in Psychology and Education; Educational

Research; Bombay: Vakils Fetter and Simons Ltd 2003
- Gay; LR; Educational Research; Ohio: Charles E Merril Publishing Company2000
- Wiersma William Research Methods in Education – An Introduction London; Allyn and Bacon; Inc2000

M TECH: MANUFACTURING SYSTEMS ENGINEERING

MSE – 629 DISSERTATION (PHASE-I)

Internal Assessment/Evaluation: 100 Marks

The primary objective of this course is to enhance the student ability to analyze and carry out independent investigations etc. Each student will carry out independent work which should involve creativity; innovation and ingenuity. A dissertation supervisor (s) having at least post- graduate qualification; from industry/research organization shall be assigned to the student approved by the competent authority. *In no case; the candidate can have more than two dissertation supervisors.* Industry oriented projects may be encouraged for the purpose.

The whole Dissertation work will be carried out and reported in two phases in 5^{th} semester and 6^{th} semester. Dissertation work (Phase-I) in 5^{th} semester shall comprise of literature survey; problem formulation; finalization of goals to be achieved; outlines of the methodology to be used for achieving the targeted goals and final decision about S/W; H/W tools to be used for dissertation work in 6^{th} semester. The entire work will be documented in the form of report.

Internal assessment of dissertation (Phase-I) in 5^{th} semester will be made by the committee evaluating the report (50% weightage); oral presentation and response of the student in the discussion / presentation (50% weightage). The dissertation supervisor (s) shall be the member (s) of the committee.

M TECH: MANUFACTURING SYSTEMS ENGINEERING

MSE – 630 DISSERTATION (PHASE-II)

Internal Assessment/Evaluation: 50 Marks
External Examination: 250 Marks

The complete dissertation work shall comprise of literature survey; problem formulation; methodology used; S/W; H/W tools used; Results and discussion followed by the conclusions & further scope of work in that area. The submission of dissertation in 6th semester shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any; and certified in the report) in the relevant refereed journal/ conference.

The final dissertation external examination in 6th semester shall be taken by a panel of examiners comprising of concerned Supervisor (s); one external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation; one for each supervisor (s); examiner and the university/ department; are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 711 COMPUTATIONAL METHODS FOR MATERIALS SCIENCE

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Algorithms, Flow charts, Problem solving methods, Need for computer language, C-character set, Identifiers and keyword, Data types, Declarations, Expressions, statements and symbolic constants, Input-output statements, Preprocessor commands, Preparing and running a complete C-programme, Arithmetic, Unary, Logical, Bit-wise, Assignment and conditional operators, Library functions.

Control Statements, While, Do-while, For statements, Nested loops. If else, Switch, Break, continue and goto statements, Comma operator.

Functions, Defining and accessing, Passing arguments function prototypes, Recursion, Use of library functions, Storage classes: Automatic, External and Static variables,Arrays and Strings, Defining and processing, Passing to a function, Multi dimensional arrays, Operations on strings.

Introduction of Modeling, Concept of model, Modeling in materials science, Simulation vs. modeling, Numerical solution of differential equations, Monte Carlo Methods, Metropolis Monte Carlo algorithm, Ising model, Resident time algorithm, Diffusion.

Molecular Dynamics, Interatomic potentials, Equations of motion, Integration, Correlation functions, and their examples, Phase-field Models, Allen-Cahn model, Energy functional, Numerical solution methods, examples.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Kemighan, B W and Ritchie, D M , The C programming Language, PHI (1988)
- Wolfson, M M and Pert, G J , An Introduction to Computer Simulation, Oxford University Press (1999)
- Raabe, D , Computational Materials Science, Wiley-VCH (1998)
- Koonin, S E and Meredith, D C , Computational Physics, Addison-Wesley (1990)

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 712 ELECTROCERAMICS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Solid State and Vapor Phase Processing, Solid state reactions: Calcinations and sintering, Kinematics of solid state reaction, Solid state and liquid phase sintering, Vapour-phase reactions.

Colloidal Processing, Introduction to surface tension, Surface activity, Contact angles, Surfactant structure, Colloid stability, Clectrostatic stabilization, Steric stabilization and flocculation kinetics, polymeric transformation; Rheology of colloidal suspensions.

Sol-Gel Processing, gels, Colloidal gels, Polymeric gels, Metal alkoxides for sol-gel process, Hydrolysis, Condensation and gelation, Aging, Drying of gels, Hypercritical drying, Structural changes during drying, Gel densification during firing, Sol-gel preparation techniques, Spplications of sol-gel processing, Thin film and coatings, Fibers, Monolithic ceramics and glasses.

Electroceramics and their Applications, Electronic and ionic conductivity, Solid oxide fuel cells, Ceramic semiconductors (PZT, BaxSr1TiO3) and other materials based sensors, Actuators, Capacitors and fibers, PTCR effect in ferroelectric materials and their applications.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Moulson A J and Herbert, J M , Electroceramics: Materials, Properties and Applications, Wiley (2003)
- Richerson, D W , Modern Ceramics Engineering-properties, Processing and Use in Design CRC, (2005)
- Rahaman, M N , Ceramic Processing and Sintering, CRC, (2003)
- Reed, J S Principles of Ceramic Processing, John Wiley & Sons, (1995)

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 713 ADVANCED METALLURGICAL THERMODYNAMICS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

First, second and third laws of thermodynamics, Maxwell's relations, Clausius-Clayperon equation, Solution models, regular, sub-regular, cluster variation models, multi-parameter models, quasi-chemical theory, statistical thermodynamics, multicomponent systems.

Unary, binary and multicomponent systems, phase equilibria, evolution of phase diagrams, metastable phase diagrams, calculation of phase diagrams, thermodynamics of defects.

Thermodynamics of Phase Transformations, Melting and solidification, precipitation, eutectoid, massive, spinodal, martensitic, order disorder transformations and glass transition, First and second order transitions.

Heterogeneous Systems, Equilibrium constant, Ellingham diagrams and their application to commercially important reactions.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Physical Chemistry of Metals, L S Darken and R W Gurry
- Thermodynamics of Solids, R A Swalin
- Phase Transformations in Metals and Alloys, D A Porter and K E Easterling
- Principles of Extractive Metallurgy, H S Ray

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 714 ADVANCED CERAMICS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction to oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, nonstoichiometry and typical properties.

Powder Preparation, Physical methods (different techniques of grinding), chemical routes - coprecipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).

Basic principles and techniques of consolidation and shaping of ceramics, powder pressing-uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering, Sintering, different mechanisms and development of microstructure (including microwave sintering),Preparation of single crystal, thick and thin film ceramics.

Mechanical behaviour, fracture mechanics and tribology, Engineering applications at room and high temperatures (including armour application).

Electrical behaviour, insulating (dielectric, ferroelectric, piezoelectric, pyroelectric), semiconducting, conducting, superconducting and ionically conducting, specific materials and their applications.

Magnetic behaviour, basic principles, materials and their applications, Transparent ceramics, coatings and films, preparation and applications.

Porous ceramics and ceramic membrane, fabrication techniques and applications in separation technology, Bio-medical applications of ceramic materials, Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support).

Ceramics matrix composites, different types, their preparation and properties (including nanocomposites), Exotic ceramics, functionally graded, smart/ Intelligent, bio-mimetic and nano- ceramics - basic principles, preparation and applications.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Fundamental of Ceramics by Michel W Barsoum, McGraw Hill International edition
- Modern Ceramic Engineering by David W Richerson, Mercel Dekker, NY 1992
- Ceramic Processing and Sintering by M N Rahman, Mercel Dekker, 2003
- Handbook of Advanced Ceramics by S Somiya, Academic Press 2003
- Handbook of Advanced Ceramics, Parts 1 and 2, S Somiya, Aacdemic Press, 2006

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 715 ENVIRONMENTAL POLLUTION IN METALLURGICAL INDUSTRIES

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Various types of solid, liquid and gaseous pollutants and their harmful effects, Environmental impact assessment in metallurgical industries, Pollutant emissions from integrated iron and steel plants, sponge iron plants, etc., Environmental aspects of coal and metal mines, Management of solid, liquid and gas wastes generated during iron and steel making operations, Pollutant emissions from Al, Zn and Pb industries, Preventive measures to reduce atmospheric pollution from these industries, Scope of alternative energy sources to combat pollution from metallurgical industries, Environmental legislation related to metallurgical industries.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- C S Rao, Environmental pollution controls engineering, Willey Eastern Ltd., 1991.
- R C Gupta, Proceedings of the International Conference on Environmental Management in Metallurgical Industries, EMMI – 2000, 14 – 16th December, 2000, Editor – Allied Publisher Ltd., Kolkata.
- G N Pandey and G C Carney, Environmental Engineering, Tata McGraw Hill Publishing Co., 1989.

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 716 NANO STRUCTURED MATERIALS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction to Nanomaterials, Features of nanosystems, Characteristic length scales of materials and their properties, Density of states in 1-D, 2-D and 3-D bands, Variation of density of states and band gap with size of crystal.

Quantum Size Effect, Electron confinement in infinitely deep square well, Confinement in one dimensional well, Idea of quantum well structure, Formation of quantum well, Quantum dots and quantum wires.

Synthesis and Characterization on Nanoscale Materials, Cluster beam evaporation, Ion beam deposition chemical bath deposition with capping techniques and ball milling, Cluster assembly and mechanical attrition determination of particle size, Increase in width of XRD peaks of nanoparticles, Shift in photoluminescence peaks, Electron microscope, Raman microscopy and surface analysis.

Effect of Nanoscale on Properties, Fullerenes, Nanotubes and nanostructured carbon coatings, Nanostructured materials-nanoparticles, Nanomaterials nanocoatings and nanocomposites, Thin film chemical sensors-gas sensors, Vapour sensors and biosensors, Photonic crystals, Smart materials, Fuel and solar cells, Drug deliveries and optoelectronic devices.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Bimerg, D, Grundmann, M , and Ledentsov, N N , Quantum Dot Heterostructures, John Wiley (1999)
- Jain, K P, Physics of Semiconductor Nanostructures, Narosa (1997)
- Fendler, J H , Nano particles and Nano-structured Films, John Wiley &Sons (1998)
- Timp, G , Nanotechnology, Springer-Verlag (1999)

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 721 X-RAY & ELECTRON METALLOGRAPHY

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Stereograohic 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, Indxing of spots by Greninger 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.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- BD Cullity – Elements of X-ray diffraction – Addison Wesley publications (for X-rays)
- Edited by EMetacalfe- Microstructural Characterisation- The institute of Metals, USA (For SEM and TEM)
- ASM Metals Handbook, 9th edition, Volume 10- Materials Characterization – ASM International publication
- BL Gabrial – SEM-A User manual for material science- Americal Society of Metals
- Metals and Materials Science, process, applications- Smallman and Bishop

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 722 ADVANCED FOUNDRY TECHNOLOGY

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Critical review of some foundry operations, Various casting processes, Mould reinforcements, Mould factors in Metal flow, Moulding factors in casting design, Limitations in controlling some moulding factors in casting design, Effect of process variables on property of core and Mould making sand.

Properties of Liquid Metals, Thermal properties, Viscosity, Surface tension and Density of Liquid metals and their role in Foundry Technology, Gases in Liquid Metals, Simple gases in Metals, Complex gases in Metals, Gas-defects and their control, Solidification of Metals and Alloys, Plane front solidification, Interface stability, Dendritic growth, Cellular growth, Independent nucleation, Structure of casting as influenced by alloy constituents, Thermal conditions, Inherent nucleation and growth condition in the liquid like Temperature gradient, Liquidus temperature profile and G/R ratio, Brief discussion on control of cast structure.

Principles of Gating and Risering, The concept of yield, Directionality in solidification, Freezing characteristics of different alloys, Measures for obtaining a solid-casting through directionality in solidification, Chworinov rule, Design of gating system, Wlodawer system of determining the feeder head requirements.

Feeder head efficiency, concept of feeding range, Use of supplementary techniques and introduction of design modifications for increasing feeder-head efficiency, Special Casting Processes, Investment casting, Die casting, Centrifugal Casting, Full-mould casting, Vaccum-shield casting, etc.

Industrial Melting Practices, Aim of Melting and post melting treatment, Brief idea about various melting units and their working, Industrial Melting practice as adopted in case of a few Metals and alloys like CI Steel, Cu, Al, etc.

Casting Defects and their Remedies, Shaping faults arising in pouring, Inclusions and sand defects, Gas defects, Shrinkage defects during solidification in liquid phase, Contraction defects after solidification, Dimensional errors, Compositional errors and segregation.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- P R Beeley, Foundry Technology, 2001 edition, Publisher – Butterworth & Co
- P C Mukherjee, Fundamentals of Metal Castiang Technology
- P D Webster, Fundamentals of Foundry Technology

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 723 ELECTRONIC AND OPTO-ELECTRONIC MATERIALS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Physical Basis of Semiconductors, Review of energy bands, Effective mass, Fermi level in intrinsic and extrinsic semiconductors, Effect of temperature, Carrier concentration and mobility on Fermi level, Hall effect, Drift and diffusion currents, Elinstein relation, Element and compound semiconductor materials, Classification of semiconductors into element, Binary, Ternary and quaternary compounds, Conduction mechanisms, Amorphous semiconductors, Oxide and magnetic semiconductors.

Junctions and Junction Devices, Contact potential explanation based on band structure, M-S contact and its properties, Barrier layer, P-N junction, Potential barrier and barrier width, Forward and reverse saturation current junction capacitance.

Processing of Semiconductor Materials, Purification, Zone refining and zone floating methods, Czochralski and Bridgemann techniques, Epitaxial growth methods, Liquid phase, Vapour phase and molecular beam epitaxy, Introduction of impurities, Junction, Successive doping method, Epitaxial and diffusion methods, MESA and planar structure doping of amorphous semiconductors.

Optical Processes in Semiconductors, Radiative and non-radiative recombination, Absorption in semiconductors. Luminescence from quantum well, Photo luminescence and phosphorescence, Phototransistors electro luminescence process LED's their structures and choice of materials, Polymer LEDS.

Organic Semiconductors, Materials for molecular electronics, Semiconductor Lasers, Homojunction and heterojunction.

Materials for Optical Communication, Optical fibers, Single and multimode electro-optic effect, Kerr and pockels effect, liquid crystal displays and display materials, TN and STN effect.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Sze, S M, Physics of Semiconductor Devices, Wiley (2007)
- Bhattacharya, P, Semiconductor Opto-electronic Devices, PHI (2006)
- Wilson, J & Hawkes, J F B, Optoelectronics- PHI (1988)

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 724 ADVANCED WELDING TECHNOLOGY

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Welding as a Fabrication and repair process, Solidification structures in weld joints, alloying, diffusion and dilution, Metallurgical Changes in material during arc and gas Welding.

Pressure welding processes, solid phase bonding, friction welding, friction stir welding, Cold welding, ultrasonic welding, explosive welding, diffusion bonding and adhesive bonding.

Resistance welding, spot, seam and projection welding, Flash and upset butt welding, percussion welding, HFRW & HFIW, Electron beam and laser welding, Controls and applications of these processes.

Welding equipment, weld joint design, operations, techniques metal fusion and weld penetration, electrodes and their motion, Applications of GRAW for welding low steels, structures, Welding of Stainless Steels and Aluminium in automotive, aeronautical and nuclear Industry.

Basic principle and welding variable and electrodes used joint design, Applications, Metal transfer, modes of metal transfer parameters affecting it and weld characteristics, Metal surfacing and spraying, selection of a surfacing process, materials of substate like, low alloy steels, plain 'C' steel with C O-45% classification & characteristics of surfacing materials – ironbase, Ni-base cobalt-base, Copper base alloys, carbides of Tungsten, Chromium surfacing techniques, Metal spraying & substate, caramic coatings, IS codes and specifications for welding materials & practices.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- RS PARMAR (1995) Welding processes and technology
- PATON, BE (Editor (1983) Electroslag welding and surfacing Vol I to Z, MIR Pub Moscow
- SMITH, DAVE, Welding I (1986) Skills and technology, McGraw Hill book Co Sincapore, 1986
- TRENT, BM (1984) : Metal cutting, Buter worths, London 2nd Edn
- MM MANKO (1979) Solders and Soldering, McGraw Hill
- B NIKALAEV (1979) Brasing and soldering of metals, Mir Pub Moscow
- KEASTERLING, Introduction to Physical Metallurgy of Welding, Butterworths Publication, 1983
- Sindo Kou Welding Metallurgy, John Wiley, 1987
- SADavid, Ed, Advances in Welding Science and Technology, American Society for Metals, Ohio, 1986

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 725 ELECTRO-MAGNETIC PROPERTIES OF MATERIALS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Review of quantum mechanical concepts, Inadequacies of free electron theory, Electron in metals-consequences of interaction with lattice, Brillouin zones and nearly free electron model, Tight binding model for d-states.

Electrical resistivity of metals, Alloys, Multiphase solids and Mattheissen rule, Nordheims Rule, Kondu and spin glass alloys, Ionic and superionic conductors, Properties and their applications.

Review of polarization, Clausius Mosotti equation, Mechanisms of polarization, Dielectric permittivity and loss (in brief), Dielectric break down in materials, High K dielectric, Non-linear dielectrics: Ferroelectric, Piezoelectric pyroelectric phenomena, Materials properties including case studies, Ferroelectric thin films, Integrated ferroelectrics, Actuators and Smart materials.

Classification of magnetic materials, Terromagnetism and Exchange interactions, Ferromagnetic domains, Magnetic anisotropy, Magnetic behaviour of polycrystalline materials, Hard and soft magnetic metallic and Intermetallic materials and their characteristics, Ultrafine grain size materials, Garnets, soft and hard ferrites, their properties and applications, Magnetic properties of superconductors and Polymer magnets.

Spintronics, Multi ferroic materials, Magneto-electric coupling phenomena and their materials characteristics.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- Solymar, L and Walsh, Lectures on Electrical Properties of Materials, Oxford University Press (2004)
- Kasap, S O , Principles of Electrical Engineering Materials and Devices, McGraw Hill Hummel, R E , Electronic Properties of Materials, Springer Verlag (2004)
- Ashcroft, N W and Mermin, N D , Solid State Physics, Thomson (2007)

M TECH: METALLURGICAL AND MATERIALS ENGINEERING

MME – 726 ADVANCES IN CORROSION ENGINEERING

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Electrochemical Concepts governing corrosion mechanisms, prevention and passivity-Corrosion Control, Eh-pH diagrams, Electrochemical principles and Electrode kinetics.

Mixed potential theory, Tafel plots and polarisation phenomena, Cathodic protection, Microbiological principles governing Biofouling and Microbially-induced corrosion.

Microorganisms as agents promoting corrosion-Bioelectrochemistry. Industrial situations such as oil exploration - nuclear power generation and oil,water pipelines. Diagnosis, Design and Control to identify and mitigate microbial corrosion: Prevention strategies.

Note: The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.

Recommended Books:

- M G Fontana: Corrosion Engineering,McGraw-Hill
- S W Borenstein Microbiologically influenced corrosion handbook,Woodhead Pub Cambridge,1994
- J D A Miller, Microbial Aspects of Metallurgy, Medical&Tech Pub Lancaster(1971)