



NATIONAL INSTITUTE OF TECHNOLOGY TIRUCHIRAPPALLI - 620015

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING SYLLABUS FOR WRITTEN TEST

Section 1: Engineering Mathematics

Linear Algebra

Matrices and Determinants, Systems of linear equations, Eigen values and Eigen vectors.

Calculus

Limit, Continuity and Differentiability; Partial derivatives; Maxima and minima; Sequences and series; Test for convergence; Fourier series.

Vector Calculus

Gradient; Divergence and Curl; Line, Surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations

Linear and non-linear first order ODEs; Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms; PDEs – Laplace, one dimensional heat and wave equations.

Probability and Statistics

Definitions of probability and sampling theorems, conditional probability, Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Analysis of experimental data; linear least squares method.

Numerical Methods

Solutions of linear and non-linear (Bisection, Secant, Newton-Raphson methods) algebraic equations; integration by trapezoidal and Simpson's rule; single and multi- step methods for differential equations.

Section 2: Metallurgical Thermodynamics

Laws of Thermodynamics

First law – energy conservation, Second law - entropy; Enthalpy, Gibbs and Helmholtz free energy; Maxwell's relations; Chemical potential; Applications to metallurgical systems, solutions, ideal and regular solutions; Gibbs phase rule, phase equilibria, binary phase diagram and lever rule, free-energy vs. composition diagrams; Equilibrium constant, Activity, Ellingham and phase stability diagrams; Thermodynamics of point defects,

surfaces and interfaces, adsorption and segregation phenomena.

Electrochemistry

Single electrode potential, Electrochemical cells, Nernst equation, Potential-pH diagrams.

Section 3: Transport Phenomena and Rate Processes

Momentum Transfer

Concept of viscosity, shell balances, Bernoulli's equation, mechanical energy balance equation, flow past plane surfaces and through pipes.

Heat transfer

Conduction, Fourier's Law, 1-D steady state conduction. Convection: Heat transfer coefficient relations for forced convection.

Radiation

Black body radiation, Stefan-Boltzman Law, Kirchhoff's Law.

Mass Transfer

Diffusion and Fick's laws, Mass transfer coefficients.

Dimensional Analysis

Buckingham Pi theorem, Significance of dimensionless numbers.

Basic Laws of Chemical Kinetics

First order reactions, reaction rate constant, Arrhenius relation, heterogeneous reactions, oxidation kinetics.

Electrochemical Kinetics

Polarization.

Section 4: Mineral Processing and Extractive Metallurgy

Comminution techniques, Size classification, Flotation, Gravity and other methods of mineral beneficiation; Agglomeration: sintering, pelletizing and briquetting.

Material and Energy balances in metallurgical processes; Principles and processes for the extraction of non-ferrous metals – aluminium, copper and titanium.

Iron and Steel Making

Material and heat balance in blast furnace; Structure and properties of slags and molten salts – basicity of slags; sulphide and phosphate capacity of slags; Production of metallurgical coke. Other methods of iron making (COREX, MIDRE)

Primary Steel Making

Basic oxygen furnace, process dynamics, oxidation reactions, electric arc furnace.

Secondary Steel Making

Ladle process – deoxidation, argon stirring, desulphurization, inclusion shape control, principles of degassing methods; Basics of stainless steel manufacturing.

Continuous Casting

Fluid flow in the tundish and mould, heat transfer in the mould, segregation, inclusion control.

Section 5: Physical Metallurgy

Chemical Bonding

Ionic, covalent, metallic, and secondary bonding in materials, Crystal structure of solids – metals and alloys, ionic and covalent solids, and polymers.

X-ray Diffraction

Bragg's law, optical metallography, principles of SEM imaging.

Crystal Imperfections

Point, line and surface defects; Coherent, semi-coherent and incoherent interfaces.

Diffusion in Solids

Diffusion equation, steady state and error function solutions; Examples- homogenization and carburization; Kirkendall effect; Uphill diffusion; Atomic models for interstitial and substitutional diffusion; Pipe diffusion and grain boundary diffusion.

Phase Transformation

Driving force, Homogeneous and heterogeneous nucleation, growth Kinetics Solidification in isomorphous, eutectic and peritectic systems, cast structures and macrosegregation, dendritic solidification and constitutional supercooling, coring and microsegregation.

Solid-state Transformations

Precipitation, spinoidal decomposition, ordering, massive transformation, discontinuous precipitation, eutectoid transformation, diffusionless transformations; Precipitate coarsening, Gibbs-Thomson effect.

Principles of heat treatment of steels, TTT and CCT diagrams; Surface hardening treatments; Recovery, recrystallization and grain growth; Heat treatment of cast iron and aluminium alloys.

Electronic, magnetic and optical properties of materials.

Basic forms of corrosion and its prevention.

Section 6: Mechanical Metallurgy

Strain tensor and stress tensor, Representation by Mohr's circle, elasticity, stiffness and compliance tensor, Yield criteria, Plastic deformation by slip and twinning.

Dislocation Theory

Edge, screw and mixed dislocations, source and multiplication of dislocations, stress fields around dislocations; Partial dislocations, dislocation interactions and reactions.

Strengthening Mechanisms

Work/strain hardening, strengthening due to grain boundaries, solid solution, precipitation and dispersion.

Fracture behaviour, Griffith theory, linear elastic fracture mechanics, fracture toughness, fractography, ductile to brittle transition.

Fatigue

Cyclic stress strain behaviour - low and high cycle fatigue, crack growth. Mechanisms of high temperature deformation and failure; creep and stress rupture, stress exponent and activation energy.

Section 7: Manufacturing Processes

Metal Casting

Mould design involving feeding, gating and risering, casting practices, casting defects.

Hot, Warm and Cold Working of Metals

Metal forming – fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming.

Metal Joining

Principles of soldering, brazing and welding, welding metallurgy, defects in welded joints in steels and aluminium alloys.

Powder Metallurgy

Production of powders, compaction and sintering.

Non-destructive Testing (NDT)

Dye-penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle inspection methods.