GATE Syllabus

Metallurgical Engineering

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METALLURGICAL ENGINEERING

Subject Code: MT

Course Structure

Sections/Units	Topics
Section A	**Engineering Mathematics**
Unit 1	Linear Algebra
Unit 2	Calculus
Unit 3	Vector Calculus
Unit 4	Differential Equations
Unit 5	Probability and Statistics
Unit 6	Numerical Methods
Section B	**Thermodynamics and Rate Processes**
Section C	**Extractive Metallurgy**
Section D	**Physical Metallurgy**
Section E	**Mechanical Metallurgy**
Section F	**Manufacturing Processes**

Course Syllabus

Section A: Engineering Mathematics

Unit 1: Linear Algebra

- Matrices and Determinants
- Systems of linear equations
- Eigen values and Eigen vectors

Unit 2: Calculus

- Limit, continuity and differentiability
- Partial derivatives
- Maxima and minima
- Sequences and series
- Test for convergence
- Fourier series

Unit 3: Vector Calculus

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

Unit 4: 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

Unit 5: Probability and Statistics

- Definitions of probability and sampling theorems
- Conditional probability
- Mean, median, mode and standard deviation
- Random variables
- Poisson, normal and binomial distributions
- Correlation and regression analysis

Unit 6: 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 B: Thermodynamics and Rate Processes

- Laws of thermodynamics, activity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, Ellingham and phase stability diagrams, thermodynamics of surfaces, interfaces and defects, adsorption and segregation
- Basic kinetic laws, order of reactions, rate constants and rate limiting steps
- Principles of electro chemistry- single electrode potential, electrochemical cells and polarizations, aqueous corrosion and protection of metals, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, oxidation and high temperature corrosion – characterization and control
- Heat transfer – conduction, convection and heat transfer coefficient relations, radiation, mass transfer – diffusion and Fick's laws, mass transfer coefficients
- Momentum transfer – concepts of viscosity, shell balances, Bernoulli's equation, friction factors

Section C: Extractive Metallurgy

- Minerals:
  - Minerals of economic importance
  - Comminution techniques
  - Size classification
  - Flotation
  - Gravity and other methods of mineral processing
- Agglomeration, pyro-, hydro-, and electro-metallurgical processes
- Material and energy balance
- Principles and processes for the extraction of non-ferrous metals:
  - Aluminium
  - Copper
  - Zinc
  - Lead
  - Magnesium
  - Nickel
  - Titanium and other rare metals
- Iron and steel making:
  - Principles
  - Role structure and properties of slags
  - Metallurgical coke
  - Blast furnace
  - Direct reduction processes
  - Primary and secondary steel making
  - Ladle metallurgy operations including deoxidation

- Desulphurization
- Sulphide shape control
- Inert gas rinsing
- Vacuum reactors

- Secondary refining processes including
  - AOD
  - VAD
  - VOD
  - VAR
  - ESR
- Ingot and continuous casting
- Stainless steel making, furnaces and refractories

Section D: Physical Metallurgy

- Crystal structure and bonding characteristics of metals, alloys, ceramics and polymers, structure of surfaces and interfaces, Nano-crystalline and amorphous structures
- Solid solutions
- Solidification
- Phase transformation and binary phase diagrams
- Principles of heat treatment of steels, cast iron and aluminum alloys
- Surface treatments
- Recovery, recrystallization and grain growth
- Structure and properties of industrially important ferrous and non-ferrous alloys
- Elements of x-ray and electron diffraction
- Principles of optical, scanning and transmission electron microscopy
- Industrial ceramics, polymers and composites
- Introduction to electronic basis of thermal, optical, electrical and magnetic properties of materials
- Introduction to electronic and opto-electronic materials

Section E: Mechanical Metallurgy

- Elasticity, yield criteria and plasticity
- Defects in crystals
- Elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, stress fields around dislocations, partial dislocations, dislocation interactions and reactions
- Strengthening mechanisms
- Tensile, fatigue and creep behavior

- Superplasticity
- Fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle transition, fracture toughness
- Failure analysis
- Mechanical testing – tension, compression, torsion, hardness, impact, creep, fatigue, fracture toughness and formability

Section F: Manufacturing Processes

- Metal casting:
  - Patterns and moulds including mould design involving feeding
  - Gating and risering
  - Melting
  - Casting practices in sand casting
  - Permanent mould casting
  - Investment casting and shell moulding
  - Casting defects and repair
- 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:
  - Soldering
  - Brazing and welding
  - Common welding processes of shielded metal arc welding
  - Gas metal arc welding
  - Gas tungsten arc welding
  - Submerged arc welding
- Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints
- Powder metallurgy:
  - Production of powders
  - Compaction
  - Sintering
- NDT using dye penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods