CSIR NET Mathematical Sciences — syllabus checklist

4 units · 85 subtopics · full version with video lectures at netmaths.in/syllabus

Unit 1: Analysis & Linear Algebra · ~60 marks

1.1 The Real Line

- [ ] Elements of set theory: operations, De Morgan and difference
- [ ] Completeness, sup/inf, Archimedean property
- [ ] Sequences: convergence, monotone, Bolzano–Weierstrass, Cauchy
- [ ] limsup, liminf and subsequential limits
- [ ] Series: comparison, ratio, root, Raabe, condensation, alternating, rearrangements

1.2 Continuity and Differentiation

- [ ] Continuity, uniform continuity, Lipschitz
- [ ] Differentiability, mean value theorems, Taylor, L'Hôpital

1.3 Integration

- [ ] Riemann integration and criteria
- [ ] Improper integrals and convergence tests

1.4 Sequences and Series of Functions

- [ ] Pointwise vs uniform convergence, M-test, Dini
- [ ] Power series, radius of convergence, Abel's theorem
- [ ] Arzelà–Ascoli and equicontinuity

1.5 Functions of Several Variables

- [ ] Partial derivatives, differentiability, chain rule
- [ ] Inverse and implicit function theorems, extrema

1.6 Metric Spaces

- [ ] Open/closed sets, limit points, closure, interior
- [ ] Compactness: open covers, sequential, Heine–Borel
- [ ] Completeness and Baire category
- [ ] Connectedness and path-connectedness

1.7 Lebesgue Measure and Integration

- [ ] Measurable sets and functions
- [ ] Lebesgue integral, MCT, DCT, Fatou
- [ ] L^p spaces essentials

1.8 Vector Spaces and Linear Maps

- [ ] Bases, dimension, rank–nullity
- [ ] Linear transformations, matrix representation, change of basis

1.9 Eigenvalues and Canonical Forms

- [ ] Eigenvalues, characteristic & minimal polynomials, Cayley–Hamilton
- [ ] Diagonalisability criteria
- [ ] Jordan canonical form
- [ ] Rational canonical form

1.10 Inner Product Spaces and Forms

- [ ] Gram–Schmidt, orthogonal/unitary/normal matrices, spectral theorem
- [ ] Quadratic forms, positive definiteness, Sylvester's law

1.11 Determinants and Matrix Tricks

- [ ] Determinants, trace, block matrices, rank inequalities

Unit 2: Complex Analysis, Algebra & Topology · ~50 marks

2.1 Analytic Functions

- [ ] Cauchy–Riemann equations, harmonic functions
- [ ] Power series and analyticity

2.2 Cauchy Theory

- [ ] Cauchy's theorem and integral formula
- [ ] Liouville, Morera, maximum modulus principle

2.3 Singularities and Residues

- [ ] Laurent series, classification of singularities, Casorati–Weierstrass
- [ ] Residue theorem and standard contour integrals

2.4 Zeros and Mappings

- [ ] Argument principle, Rouché's theorem, open mapping
- [ ] Conformal maps, Möbius transformations, Schwarz lemma

2.5 Groups

- [ ] Subgroups, cosets, Lagrange, cyclic groups
- [ ] Normal subgroups, quotients, isomorphism theorems
- [ ] Permutation groups: cycles, sign, conjugacy in S_n and A_n
- [ ] Group actions, class equation, p-groups
- [ ] Sylow theorems and groups of small order
- [ ] Finite abelian groups

2.6 Rings and Fields

- [ ] Ideals, quotient rings, prime & maximal ideals, CRT
- [ ] Euclidean, PID, UFD hierarchy
- [ ] Polynomial rings and irreducibility tests
- [ ] Field extensions, splitting fields, finite fields
- [ ] Galois theory essentials

2.7 Topology

- [ ] Topological spaces, bases, subspace/product/quotient
- [ ] Continuity, homeomorphism, separation axioms
- [ ] Compactness and Tychonoff
- [ ] Connectedness and components
- [ ] Standard spaces: cofinite, cocountable, Sorgenfrey, Cantor set

Unit 3: ODE, PDE & Applied Mathematics · ~45 marks

3.1 Ordinary Differential Equations

- [ ] Existence–uniqueness, Picard, Lipschitz
- [ ] Linear ODE, Wronskian, variation of parameters, systems
- [ ] Sturm–Liouville problems and Green's functions
- [ ] Stability and phase portraits

3.2 Partial Differential Equations

- [ ] First-order PDE: Lagrange, Charpit, characteristics
- [ ] Classification and canonical forms
- [ ] Laplace, heat and wave equations: separation of variables

3.3 Numerical Analysis

- [ ] Root finding: bisection, Newton–Raphson, fixed point, order of convergence
- [ ] Interpolation and numerical integration with error terms
- [ ] Numerical ODE: Euler, Runge–Kutta

3.4 Calculus of Variations

- [ ] Euler–Lagrange equation and standard functionals
- [ ] Isoperimetric problems

3.5 Linear Integral Equations

- [ ] Fredholm and Volterra equations
- [ ] Separable kernels and resolvent kernels

3.6 Classical Mechanics

- [ ] Lagrangian formalism and generalised coordinates
- [ ] Hamiltonian formalism and conservation laws

Unit 4: Probability, Statistics & Linear Programming · ~45 marks

4.1 Probability

- [ ] Axioms, conditional probability, independence, Bayes
- [ ] Random variables, distributions, moments, MGF
- [ ] Standard discrete and continuous distributions
- [ ] Joint distributions, transformations, order statistics

4.2 Limit Theorems and Markov Chains

- [ ] Modes of convergence, WLLN, SLLN, CLT
- [ ] Markov chains: classification of states, stationary distributions

4.3 Estimation

- [ ] Sufficiency, completeness, UMVUE, Cramér–Rao
- [ ] MLE and method of moments

4.4 Hypothesis Testing

- [ ] Neyman–Pearson lemma and UMP tests
- [ ] Likelihood ratio and standard tests

4.5 Linear Models and Multivariate

- [ ] Gauss–Markov, regression, ANOVA basics
- [ ] Multivariate normal distribution

4.6 Sampling and Design of Experiments

- [ ] SRS, stratified and systematic sampling
- [ ] CRD, RBD, LSD essentials

4.7 Linear Programming

- [ ] Linear programming, simplex and duality
