

## **Syllabus for GATE Mathematics (MA)**

**Linear Algebra:** Finite dimensional vector spaces; Linear transformations and their matrix representations, rank; systems of linear equations, eigen values and eigen vectors, minimal polynomial, Cayley-Hamilton Theorem, diagonalisation, Hermitian, Skew-Hermitian and unitary matrices; Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, self-adjoint operators.

**Complex Analysis:** Analytic functions, conformal mappings, bilinear transformations; complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle; Taylor and Laurent's series; residue theorem and applications for evaluating real integrals.

**Real Analysis:** Sequences and series of functions, uniform convergence, power series, Fourier series, functions of several variables, maxima, minima; Riemann integration, multiple integrals, line, surface and volume integrals, theorems of Green, Stokes and Gauss; metric spaces, completeness, Weierstrass approximation theorem, compactness; Lebesgue measure, measurable functions; Lebesgue integral, Fatou's lemma, dominated convergence theorem.

**Ordinary Differential Equations:** First order ordinary differential equations, existence and uniqueness theorems, systems of linear first order ordinary differential equations, linear ordinary differential equations of higher order with constant coefficients; linear second order ordinary differential equations with variable coefficients; method of Laplace transforms for solving ordinary differential equations, series solutions; Legendre and Bessel functions and their orthogonality.

**Algebra:** Normal subgroups and homomorphism theorems, automorphisms; Group actions, Sylow's theorems and their applications; Euclidean domains, Principal ideal domains and unique factorization domains. Prime ideals and maximal ideals in commutative rings; Fields, finite fields.

**Functional Analysis:** Banach spaces, Hahn-Banach extension theorem, open mapping and closed graph theorems, principle of uniform boundedness; Hilbert spaces, orthonormal bases, Riesz representation theorem, bounded linear operators.

**Numerical Analysis:** Numerical solution of algebraic and transcendental equations: bisection, secant method, Newton-Raphson method, fixed point

iteration; interpolation: error of polynomial interpolation, Lagrange, Newton interpolations; numerical differentiation; numerical integration: Trapezoidal and Simpson rules, Gauss Legendre quadrature, method of undetermined parameters; least square polynomial approximation; numerical solution of systems of linear equations: direct methods (Gauss elimination, LU decomposition); iterative methods (Jacobi and Gauss-Seidel); matrix eigenvalue problems: power method, numerical solution of ordinary differential equations: initial value problems: Taylor series methods, Euler's method, Runge-Kutta methods.

**Partial Differential Equations:** Linear and quasilinear first order partial differential equations, method of characteristics; second order linear equations in two variables and their classification; Cauchy, Dirichlet and Neumann problems; solutions of Laplace, wave and diffusion equations in two variables; Fourier series and Fourier transform and Laplace transform methods of solutions for the above equations.

**Mechanics:** Virtual work, Lagrange's equations for holonomic systems, Hamiltonian equations.

**Topology:** Basic concepts of topology, product topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

**Probability and Statistics:** Probability space, conditional probability, Bayes theorem, independence, Random variables, joint and conditional distributions, standard probability distributions and their properties, expectation, conditional expectation, moments; Weak and strong law of large numbers, central limit theorem; Sampling distributions, UMVU estimators, maximum likelihood estimators, Testing of hypotheses, standard parametric tests based on normal,  $\chi^2$ ,  $t$ ,  $F$  – distributions; Linear regression; Interval estimation.

**Linear programming:** Linear programming problem and its formulation, convex sets and their properties, graphical method, basic feasible solution, simplex method, big-M and two phase methods; infeasible and unbounded LPP's, alternate optima; Dual problem and duality theorems, dual simplex method and its application in post optimality analysis; Balanced and unbalanced transportation problems,  $u$ - $v$  method for solving transportation problems; Hungarian method for solving assignment problems.

**Calculus of Variation and Integral Equations:** Variation problems with fixed boundaries; sufficient conditions for extremum, linear integral equations of Fredholm and Volterra type, their iterative solutions.

## **Pattern of Question Papers and Marking Scheme**

### **Pattern of Question Papers**

In all the papers, there will be a total of 65 questions carrying 100 marks, out of which 10 questions carrying a total of 15 marks are in General Aptitude (GA).

In the paper bearing the codes MA the General Aptitude section will carry 15% of the total marks and the remaining 85% of the total marks is devoted to the subject of the paper.

### **GATE would contain questions of two different types in various papers:**

(i) Multiple Choice Questions (MCQ) carrying 1 or 2 marks each in all papers and sections. These questions are objective in nature, and each will have a choice of four answers, out of which the candidate has to mark the correct answer(s).

(ii) Numerical Answer Questions of 1 or 2 marks each in all papers and sections. For these questions the answer is a real number, to be entered by the candidate using the virtual keypad. No choices will be shown for this type of questions.

### **Marking Scheme**

For 1-mark multiple-choice questions,  $1/3$  marks will be deducted for a wrong answer. Likewise, for 2-marks multiple-choice questions,  $2/3$  marks will be deducted for a wrong answer. There is no negative marking for numerical answer type questions.

### **General Aptitude (GA) Questions**

In all papers, GA questions carry a total of 15 marks. The GA section includes 5 questions carrying 1 mark each (sub-total 5 marks) and 5 questions carrying 2 marks each (sub-total 10 marks).

### **Question Papers**

These papers would contain 25 questions carrying 1 mark each (sub-total 25 marks) and 30 questions carrying 2 marks each (sub-total 60 marks). The question paper will consist of questions of multiple choice and numerical answer type. For numerical answer questions, choices will not be given. Candidates have to enter the answer (which will be a real number, signed or

unsigned, e.g. 25.06, -25.06, 25, -25 etc.) using a virtual keypad. An appropriate range will be considered while evaluating the numerical answer type questions so that the candidate is not penalized due to the usual round-off errors.

**Note on Negative Marking for Wrong Answers**

For a wrong answer chosen for the multiple choice questions, there would be negative marking. For 1-mark multiple choice questions, 1/3 mark will be deducted for a wrong answer. Likewise, for 2-mark multiple choice questions, 2/3 mark will be deducted for a wrong answer. However, there is no negative marking for a wrong answer in numerical answer type questions.