# Dr B R Ambedkar University Delhi (AUD)

## Syllabus for Entrance Exam
## MPhil in Mathematics and PhD in Mathematics

**Section 1: Linear Algebra**

Finite dimensional vector spaces, Linear transformations and their matrix representations, rank, systems of linear equations, eigenvalues and eigenvectors, minimal polynomial, Cayley-Hamilton Theorem, diagonalisation, Jordan-canonical form, Hermitian, Skew-Hermitian and Unitary matrices, Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, self-adjoint operators, definite forms.

Reference:


1. Kenneth Hoffman, Ray Kunze, *Linear Algebra*, 2nd Edition, Prentice-Hall Inc., 1971.
2. David S Dummit and Richard M Foote, *Abstract Algebra*, 3rd Edition, Wiley and Sons, 2003.
3. I N Herstein, *Topics in Algebra,* Wiley Student Edition, 2006.
4. Paul R Halmos, *Linear Algebra Problem Book,* Mathematical Association of America, 1995.


**Section 2: Complex Analysis**

Analytic functions, conformal mappings, bilinear transformations complex integration: Cauchy's integral theorem and formula, Liouville's theorem, maximum modulus principle, Zeros and singularities, Taylor and Laurent's series, Contour Integration, residue theorem and applications for evaluating real integrals.

Reference:


1. John B Conway, *Functions of One Complex Variable I*, 2nd Edition, Springer, 1978.
2. Lars V Ahlfors, *Complex Analysis, An Introduction to the Theory of Analytic Functions of One Complex Variable*, 3rd Edition, McGraw-Hill, 1979.


**Section 3: 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, Weierstrass approximation theorem, Countable Sets, Null Set, Cantor's Ternary Set, Lebesgue measure, measurable functions, Lebesgue integral, Fatou's lemma, dominated convergence theorem.

Reference:


1. Halsey Royden and Patrick Fitzpatrick, *Real Analysis*, 4th Edition, Pearson Education Asia, 2010.
2. Kenneth A Ross, *Elementary Analysis*: *The Theory of Calculus*, 2nd Edition, Springer, 2000.
3. Walter Rudin, *The Principles of Mathematical Analysis*, 3rd Edition, McGraw Hill, 1976.
4. James Stewart, *Essential Calculus*: *Early Transcendentals*, Thompson Brooks/Cole, 2007.
5. A J Weir, *Lebesgue Integration and Measure*, Cambridge University Press, 1973.


**Section 4: Ordinary Differential Equations**

First order ordinary differential equations, existence and uniqueness theorems for initial value problems, 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 (power series, Frobenius method), Legendre and Bessel functions and their orthogonal properties.

Reference:

1. Tyn Myint-U, *Ordinary Differential Equations*, Elsevier North-Holland, 1978.
2. G F Simmons, *Ordinary Differential Equations with applications and Historical notes*, McGraw-Hill, 1991.
3. S L Ross, *Differential Equation*, Wiley India, 2004.

**Section 5: Algebra**

Groups, subgroups, normal subgroups, quotient groups and homomorphism theorems, automorphisms, cyclic groups and permutation groups, group action and applications, conjugacy, class equation, Sylow's theorems and their applications, direct product, finitely generated abelian groups, Groups of small order, *p*-groups, basic concepts of nilpotence, solvability, Rings, ideals, prime and maximal ideals, characteristics of rings, quotient rings, homomorphism theorems, unique factorization domains, Principle ideal domains, Euclidean domains, polynomial rings and irreducibility criteria.

Reference:

1. David S Dummit and Richard M Foote, *Abstract Algebra*, 3rd Edition, Wiley and Sons, 2003.
2. Thomas W. Hungerford, *Abstract Algebra An Introduction*, 3rd Edition, Brooks-Cole, Cengage Learning, 2014.
3. John B Fraleigh, *A First Course in Abstract Algebra,* Addison-Wesley, 1994.

**Section 6: Galois Theory and Module Theory**

Fields and their extensions, splitting fields, the algebraic closure of a field, separability, automorphisms of field extensions, the fundamental theorem of Galois theory, roots of unity, finite fields, primitive elements, Galois theory of equations, the solution of equations by radicals.
Modules, basic concepts, quotient module and module homomorphism, direct product and direct sums, exact sequences, free modules, modules over P.I.D., chain conditions.

Reference:

1. David S Dummit and Richard M Foote, *Abstract Algebra*, 3rd Edition, Wiley and Sons, 2003.
2. Thomas W Hungerford, *Algebra*, 8th Edition, Springer Verlag, 2003.
3. C Musili, *Introduction to rings and modules,* Narosa Publishing House, 1994.

**Section 7: Functional Analysis**

Normed linear spaces, Banach spaces, Hahn-Banach extension theorem, open mapping and closed graph theorems, principle of uniform boundedness, Inner-product spaces, Hilbert spaces, orthonormal bases, Riesz representation theorem, bounded linear operators.

Reference:

1. Erwin Kreyszig, *Introduction to Functional Analysis with Applications*, John-Wiley and Sons, 1978.
2. G Bachman and L Narici, *Functional Analysis*, Dover Publication, New York, 2000.
3. R Bhatia, *Notes on Functional Analysis*, Hindustan Book Agency, India, 2009.
4. M Schechter, *Principles of Functional Analysis*, AMS, 2002.

**Section 8: 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, numerical solution of systems of linear equations: direct methods (Gauss elimination, LU decomposition), iterative method,
(Jacobi and Gauss-Seidel), numerical solution of ordinary differential equations: initial value problems: Euler's method, Modified Euler's Method, Runge-Kutta methods of order 2 and 4, Picard iteration method, Predictor-Corrector Method.

Reference:

1. Richard L Burden and J Douglas Faires, *Numerical Analysis*, 7th Edition, Cengage Learning, India Edition, 2001.
2. M K Jain, SRK Iyengar, R K Jain, *Numerical Methods: For Scientific and Engineering Computation*, New Age Publishers, 2012.

**Section 8: 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 in two dimensional Cartesian coordinates, Interior and exterior Dirichlet problems in polar coordinates, Separation of variables method for solving wave and diffusion equations in one space variable, Fourier series and Fourier transform and Laplace transform methods of solutions for the above equations.

Reference:

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists and Engineers,* 4th edition, Springer, Indian reprint, 2006
2. K Sankara Rao, *Introduction to Partial Differential Equations*, Phi Learning Private Limited, 2010.

**Section 9: Topology**

Metric spaces, complete metric spaces, basic concepts of topology, bases, subbases, order topology, subspace topology, closed sets and limit points, Hausdorff Spaces, $T_1$ axiom, continuous functions, product topology, metric topology, quotient topology, connectedness, compactness.

Reference:

1. James Munkres, *Topology*, 2nd Edition, Prentice Hall, 2000.
2. Mícheál O'Searcoid, *Metric Spaces*, Springer Verlag, 2007.

**Section 10: Number Theory**

Diophantine equation, statement of prime number theorem, linear congruence, complete set of residues, Chinese Remainder Theorem, Fermat's little theorem, Wilson's theorem, Number Theoretic functions, Euler's theorem, Primitive roots, Legendre symbol, Quadratic reciprocity Law, Cryptography.

Reference:

1. David M Burton, *Elementary Number Theory*, 7th Edition, McGraw-Hill Education, 2012.
2. Ivan Niven, Herbert S Zuckerman, Hugh L Montgomery, *An Introduction to the Theory of Numbers,* Wiley, 1991.