



Indus University

IURAT Syllabus

Mathematics

UNIT - 1

- Analysis: Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum.
- Sequences and series, convergence, limsup, liminf.
- Bolzano Weierstrass theorem, Heine Borel theorem.
- Continuity, uniform continuity, differentiability, mean value theorem.
- Sequences and series of functions, uniform convergence.
- Riemann sums and Riemann integral, Improper Integrals.
- Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue integral.
- Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems.
- Metric spaces, compactness, connectedness. Normed linear Spaces. Spaces of continuous functions as examples.
- Linear Algebra: Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations.
- Algebra of matrices, rank and determinant of matrices, linear equations.
- Eigenvalues and eigenvectors, Cayley-Hamilton theorem.
- Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms.
- Inner product spaces, orthonormal basis.
- Quadratic forms, reduction and classification of quadratic forms

REFERENCE BOOKS:

1. Herstein I. N., "Topics in Algebra", Wiley Eastern Ltd., New Delhi, 1975.
2. Kwak J. H., Hong S., "Linear Algebra", (Second Edition), Birkhauser, 2004.
3. Kumaresan S., "Linear Algebra: A Geometric Approach", Prentice Hall of India, 2000.
4. Simmons G. F., "Introduction to Topology and Modern Analysis", McGraw-Hill Co., Tokyo, 1963.
5. Helson H., "Linear Algebra", (Second Edition), Hindustan Book Agency, TRIM-4, 1994.
6. Ramachandra Rao A. and Bhimasankaram P., "Linear Algebra" (Second Edition), Hindustan Book Agency, TRIM-19, 2000.
7. Seymour Lipschutz & Marc Lars Lipson, Schaum`s Outline of Linear Algebra (4th edition - 2009), McGraw-Hill Co., Tokyo.
8. Ghorpade S. R. and Limaye B. V., A Course in Multivariable Calculus and Analysis, Springer, 2010.
9. Rudin W., Principles of Mathematical Analysis, (Third Edition), Tata McGraw-Hill Publications, New Delhi, 1983.
10. Spivak M., Calculus on Manifolds, W.E. Benjamin Inc., 1965.
11. 'Functions of Several Variables' by Wendell H. Fleming, Addison - Wesley

UNIT - 2

- Complex Analysis: Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions.
- Analytic functions, Cauchy-Riemann equations.
- Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem.
- Taylor series, Laurent series, calculus of residues.
- Conformal mappings, Mobius transformations.
- Algebra: Permutations, combinations, pigeon-hole principle, inclusion-exclusion principle, derangements.
- Fundamental theorem of arithmetic, divisibility in \mathbb{Z} , congruences, Chinese Remainder Theorem, Euler's ϕ -function, primitive roots.
- Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley's theorem, class equations, Sylow theorems.
- Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain.
- Polynomial rings and irreducibility criteria.
- Fields, finite fields, field extensions, Galois Theory.
- Topology: basis, dense sets, subspace and product topology, separation axioms, connectedness and compactness.

REFERENCE BOOKS

1. Complex variables and Applications, 8th edition J. W. Brown and R. V. Churchill, McGraw Hills, International Edition 2009. ISBN: 978-007-126328-3. OR MHID: 007-126328-4.
2. Introduction to Functions of Complex Variable", C. J. Hamilton, Marcel Dekker Inc. New York.
3. "Complex Analysis", I. Stewart and David Tall, Cambridge University Press.
4. "Complex Analysis", J. C. Duncan, John Wiley & Sons, London.
5. "Functions of One Complex Variable", John B. Conway, Narosa Publishing house, 2002.
6. "Foundations of Complex Analysis", S. Ponnusamy, Narosa Publishing house, 2005.
7. "Complex Analysis", S. Lang, Springer Paperback, 2005.
8. "Complex Variable: Schaum's Outlines Series", Murray Spiegel, Seymour Lipschutz, John Schiller, Dennis Spellman, 2nd edition.
9. Munkres, J., Topology: A First Course, (Second Edition), Prentice Hall of India Pvt. Ltd. New Delhi, 2003.
10. Simmons G.F., Introduction to Topology and Modern Analysis, McGraw-Hill Co., Tokyo, 1963.
11. Willard S., General Topology, Dover Publication, 2004.
12. Kelley J., General Topology, Graduate Texts in Mathematics, Springer-Verlag, 1975.

13. Basic Abstract Algebra, P.B. BHATTARAYA, S.K. JAIN, S.R. NAGPAUL, Cambridge University Press, Second Edition.
14. Abstract Algebra, D. S. Dummit & R. M. Foote. John Wiley & Sons, third edition.

UNIT - 3

➤ Ordinary Differential Equations (ODEs):

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs.

General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

➤ Partial Differential Equations (PDEs):

Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs.

Classification of second order PDEs, General solution of higher order PDEs with constant

coefficients, Method of separation of variables for Laplace, Heat and Wave equations.

➤ Numerical Analysis:

Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Rate of convergence

Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods,

Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration,

Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

➤ Calculus of Variations:

Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema.

Variational methods for boundary value problems in ordinary and partial differential equations.

➤ Linear Integral Equations:

Linear integral equation of the first and second kind of Fredholm and Volterra type,

Solutions with separable kernels.

Characteristic numbers and eigen functions, resolvent kernel.

➤ Classical Mechanics:

Generalized coordinates, Lagrange's equations, Hamilton's canonical equations, Hamilton's principle and principle of least action,

Two-dimensional motion of rigid bodies,

Euler's dynamical equations for the motion of a rigid body about an axis,

theory of small oscillations.

REFERENCE BOOKS

1. Differential Equations with Applications and Historical Notes 3rd Edition, G. F. Simmons, Tata McGraw-Hill Publishing Co. Ltd., 2017.

2. "Introduction to Ordinary Differential Equations", A. L. Rabenstein, Academic Press, 2nd revised edition, 1972.
3. "Advanced Engineering Mathematics" (8th Edition) Erwin Kreyszig, Wiley-India, 2008.
4. "Text Book of Ordinary Differential Equations", S. G. Deo, V. Lakshmikantham and V. Raghavendra, Tata McGraw Hill Book Co., 1997.
5. "Differential Equations", S. L. Ross, John Wiley & Sons, 2004.
6. "An introduction to Differential Equations", Saber N. Elaydi, Springer Verlag, Second edition, 1995.
7. "Ordinary Differential Equations", V.I. Arnold, Prentice-Hall of India, New Delhi, 1998.
8. "Theory of ordinary differential Equations", E.A. Coddington, N. Levinson, Tata McGraw-Hill, India, 2017.
9. "Schaum's Outline of Differential Equations", Richard Bronson, Gabriel B. Costa, 4th Edition.
10. "An Elementary Course in Partial Differential Equations" (2nd Edition) by T. Amaranath, Narosa Publishing House Pvt. Ltd., 2005.
11. Elements of Partial Differential Equations: I. N. Sneddon, Mc-Graw-Hill International Editions, 2006.
12. Ordinary and Partial Differential Equations: Theory and Application - Nita H Shah, PHI Learning Pvt Ltd, 2010.
13. Partial Differential Equations: Methods, Applications and Theories - Harumi Hattori, World Scientific publication, 1st edition, 2013.
14. Elements of Partial Differential Equations (2nd Edition) - Pavel Drabek, Gabriela Holubova, DE GRUYTER, 2014.

15. Linear Partial Differential Equation for Scientists and Engineers: by TynMyint-U and Lokenath Debnath, Fourth Edition, 2004, Birkhauser Publications.
16. Methods of Mathematical Physics Vol.2, - R. Courant and D. Hilbert, Wiley Eastern Pvt. Ltd., 1975.
17. Erwin Kreyszig: Advanced Engineering Mathematics, Wiley Eastern Ltd., New Delhi. 8th Edition, 2004, ISBN: 9971512831.
18. Murray Spiegel: Advanced Mathematics for Engineering & Science: (Schaum's Outline Series), Tata - McGraw Hill Publication, 3rd Edition, 2010, ISBN: 9780071623667
19. Goldstein, H., Poole, C. and Safko, J., Classical Mechanics, (Third Edition), Pearson Education, Inc., Indian Low Price Edition, 2002.
20. Bhatia V. B., Classical Mechanics, Narosa Publishing House, 1997.
21. Sankara Rao K., Classical Mechanics, Prentice-Hall of India, 2005.
22. Schaum's outline series by Murray Spiegel, Theory & Problems of theoretical mechanics, 2017.

UNIT - 4

- Descriptive statistics, exploratory data analysis
- Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions (univariate and multivariate); expectation and moments.
- Independent random variables, marginal and conditional distributions. Characteristic functions. Probability inequalities (Tchebyshef, Markov, Jensen).

- Modes of convergence, weak and strong laws of large numbers, Central Limit theorems (i.i.d. case).
- Markov chains with finite and countable state space, classification of states, limiting behavior of n-step transition probabilities, stationary distribution, Poisson and birth-and-death processes.
- Standard discrete and continuous univariate distributions. sampling distributions, standard errors and asymptotic distributions, distribution of order statistics and range.
- Methods of estimation, properties of estimators, confidence intervals. Tests of hypotheses: most powerful and uniformly most powerful tests, likelihood ratio tests. Analysis of discrete data and chi-square test of goodness of fit. Large sample tests.
- Simple nonparametric tests for one and two sample problems, rank correlation and test for independence.
- Elementary Bayesian inference.
- Gauss-Markov models, estimability of parameters, best linear unbiased estimators, confidence intervals,
- tests for linear hypotheses. Analysis of variance and covariance. Fixed, random and mixed effects models.
- Simple and multiple linear regression. Elementary regression diagnostics. Logistic regression.
- Multivariate normal distribution, Wishart distribution and their properties. Distribution of quadratic
- forms. Inference for parameters, partial and multiple correlation coefficients and related tests.
- Data reduction techniques: Principle component analysis, Discriminant analysis, Cluster analysis, Canonical correlation.

- Simple random sampling, stratified sampling and systematic sampling. Probability proportional to size sampling. Ratio and regression methods.
- Completely randomized designs, randomized block designs and Latin-square designs. Connectedness and orthogonality of block designs, BIBD. 2K factorial experiments: confounding and construction.
- Hazard function and failure rates, censoring and life testing, series and parallel systems.
- Linear programming problem, simplex methods, duality. Elementary queuing and inventory models.
- Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.

REFERENCE BOOKS

1. "Fundamentals of Statistics" by S C Gupta, V K Kapoor, S. Chand Publications, 2014.
2. "Probability and Statistics in Engineering" 4th edition, William Hines, 2003.
3. Montgomery, Goldsman and Borror, published by Wiley (India Edition).
4. "A first course in probability" by Sheldon Ross, Pearson Education, sixth edition, 2013.
5. "Probability and Statistics for Engineers" by Richard Johnson, Prentice Hall of India Publication, 8th edition, 2011.

6. Schaum's Outline of Probability & Statistics, 4th edition, Murray R. Spiegel, John J. Schiller, R. Alu Srinivasan, 4th edition, 2012.
