UNIVERSITY OF KALYANI

Syllabus of Mathematics(NEP)

B.Sc. Mathematics (Major)
SEMESTER-III
Course Code: MATH-M-T-03
Course title: Real Analysis-I
Major Course; Credit-6; Full Marks-75

COURSE CONTENT: 6 Credits (5+1) (Theory + Tutorial)

Unit 1. **[10L]**

- Review of algebraic and order properties of R.
- Idea of countable sets, uncountable sets and uncountability of R. Countability of Q.
- Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima.
- Completeness property of R and its equivalent properties.
- The Archimedean property, density of rational (and irrational) numbers in R, intervals.
- Intervals, ε-neighbourhood of a point in R, interior points, limit points, isolated points, open set, closed set, union and intersection of open and closed sets. Derived set, closure of a set, interior of a set.
- Illustrations of Bolzano-Weierstrass theorem for sets.

Unit 2. **[15L]**

- Sequences, bounded sequence, convergent sequence, limit of a sequence, lim inf, lim sup.
- Limit theorems. Sandwich theorem. Nested interval theorem
- Monotone sequences, monotone convergence theorem.
- Subsequences, divergence criteria. Monotone subsequence theorem (statement only).
- Bolzano Weierstrass theorem for sequences.
- Cauchy sequence, Cauchy's convergence criterion, Cauchy's 1st and 2nd limit theorem

Unit 3. **[15L]**

- Infinite series, convergence and divergence of infinite series, Cauchy criterion.
- Tests for convergence: comparison test, limit comparison test, ratio test: D'Alembert's ratio test, Raabe's test, Cauchy's root test, Gauss test, integral test, Cauchy's condensation test with examples.
- Alternating series, Leibnitz test. Absolute and conditional convergence.

Unit 4: **[15L]**

- Limits of functions (ε - δ approach). Sequential criterion for limits. Divergence criteria. Limit theorems, one sided limit. Infinite limits and limits at infinity.
- Continuous functions, neighbourhood property. Sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval,
- Bolzano's Theorem, intermediate value theorem. Location of roots theorem, preservation of intervals theorem.
- Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.
- Differentiability of a function at a point and in an interval,

- Caratheodory's theorem,
- Algebra of differentiable functions.
- Darboux's theorem.

Unit 5. **[15L]**

- Rolle's theorem.
- Lagrange's and Cauchy's mean value theorems.
- Taylor's theorem with Lagrange's and Cauchy's forms of remainder.
- Application of Taylor's theorem to convex functions.
- Applications of mean value theorem to inequalities and approximation of polynomials.
- Relative extrema, interior extremum theorem.
- Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\log(1+x)$, $1/(ax+b)$, $(1+x)^n$.
- Application of Taylor's theorem to inequalities.

Graphical Demonstration (Teaching aid) **[5L]**

1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
5. Cauchy's root test by plotting nth roots.
6. Ratio test by plotting the ratio of nth and $(n+1)^{th}$ term.

SUGGESTED READINGS/REFERENCES:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
2. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones& Bartlett.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall.
4. S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House.
6. Courant and John, Introduction to Calculus and Analysis, Vol I, Springer.
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
8. V. Karunakaran, Real Analysis, Pearson.
9. Terence, Tao, Analysis I, Hindustan Book Agency.
10. S. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing.

B.Sc. Mathematics (Major)
SEMESTER-III
Course Code: MATH-SEC-T-03
Course title: Programming in C
Skill Enhancement Course; Credit-3; Full Marks-45

COURSE CONTENT: 2+1 Credits (T+P)

Unit 1. **[15L]**

- Brief historical development. Computer generation. Basic structure and elementary ideas of computer systems, operating systems, hardware and software.
- Positional number systems: Binary, octal, decimal, hexadecimal systems. Binary arithmetic.
- BIT, BYTE, WORD. Coding of data -ASCII, EBCDIC, etc.
- Algorithms and flow chart: Important features, ideas about complexities of algorithms. Application in simple problems.

Unit 2. **[30L]**

- Programming language and importance of 'C' programming.
- Constants, variables and data type of 'C'-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.
- Operation and expressions: Arithmetic operators, relational operators, logical operators.
- Decision making and branching: Decision making with if statement, if-else statement, nesting if statement, switch statement, break and continue statement.
- Control statements: While statement, do-while statement, for statement.
- Arrays: One-dimension, two-dimensional and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.
- User-defined Functions: Definition of functions, scope of variables, return values and their types, function declaration, function call by value, nesting of functions, passing of arrays to functions, recurrence of function.
- Application to simple problems: Evaluation of functional values, solution of quadratic equations with real coefficients, approximate sum of convergent infinite series, sorting of real numbers.

SUGGESTED READINGS/REFERENCES:

1. Yashvant Kanetkar, Let us C, BPB Publications.
2. V. Krishnamoorthy, K.R. Radhakrishnan, Programming in C, Tata McGraw Hilll.
3. Noel Kalicharan, C by Example, Cambridge Low price edition.
4. E. Balagurusamy, Programming in ANSI C, Tata McGraw Hill.
5. C. Xavier, C-Language and Numerical Methods, New Age International.
6. Byron S. Gottfried, Programming with C, McGraw Hill Education.
7. A. N. Kamthane, Programming in C, Pearson.

B.Sc. Other than Mathematics (Minor)
SEMESTER-III
Course Code: MATH-MI-T-02
Course title: Calculus & Differential Equations
Minor Course; Credit-4; Full Marks-50

COURSE CONTENT: 4 Credits (3+1) (Theory + Tutorial)

Unit 1. **[25L]**

- Real-valued functions defined on an interval, limit and Continuity of a function (using $\varepsilon - \delta$). Algebra of limits. Differentiability of a function.
- Successive derivative: Leibnitz's theorem and its application to problems of type $e^{ax+b}\sin x, e^{ax+b}cosx, (ax+b)^n sinx, (ax+b)^n cosx$.
- Partial derivatives. Euler's theorem on homogeneous function of two and three variables.
- Curvature, rectilinear asymptotes.
- Indeterminate Forms: L'Hospital's Rule (Statement and Problems only).
- Statement of Rolle's Theorem and its geometrical interpretation. Mean value theorems of Lagrange and Cauchy. Statements of Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainders. Taylor's and Maclaurin's infinite series of functions like e^x, sinx, cosx, $(1+x)^n$, log(1+x) with restrictions wherever necessary.
- Application of the principle of maxima and minima for a function of a single variable.

Unit 2. **[5L]**

- Reduction formulae, derivations and illustrations of reduction formulae of the type $\int sin^n x\,dx, \int cos^n x\,dx, \int tan^n x\,dx, \int sec^n x\,dx, \int (\log x)^n dx, \int sin^n x cos^m x dx$.

Unit 3. **[20L]**

- First order equations: (i) Exact equations and those reducible to such equations. (ii) Euler's and Bernoulli's equations (Linear). (iii) Clairaut's Equations: General and Singular solutions.
- Second order differential equation: (i) Method of variation of parameters, (ii) Method of undetermined coefficients.
- Linear homogeneous equations with constant coefficients, method of variation of parameters, simultaneous differential equations.

SUGGESTED READINGS/REFERENCES:

1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
2. T. Apostol, Mathematical Analysis, Narosa Publishing House.
3. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
4. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc.
5. G. B. Thomas and R.L. Finney, Calculus, Pearson Education.
6. Santi Narayan, Integral Calculus, S. Chand.
7. S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India.

8. E. L. Ince, Ordinary Differential Equations, Dover Publications.
9. E. Rukmangadachari, Differential Equations, Pearson.
10. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.
11. G. F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill.

B.Sc. Mathematics (Multidisciplinary)
SEMESTER-III
Course Code: MATH-MD-T-03
Course title: Basic Mathematics
Multidisciplinary Course; Credit-3; Full Marks-45

COURSE CONTENT: 3 Credits (3+0) (Theory + Tutorial)

Unit 1. Set Theory: **[5L]**

- Introduction to sets and their representations. The empty set, finite and infinite sets, equal sets, subsets, power set, and Universal set.
- Venn Diagrams, operations on sets, complement of a set, problems on union and intersection of sets.

Unit 2. Complex Numbers: **[5L]**

- Polar representation of complex numbers.
- De Moivre's theorem (without proof) for rational indices and their applications.

Unit 3. Theory of Equations: **[10L]**

- Introduction and definition of equation. Types of equations.
- Relation between roots and coefficients. Descartes's rule of signs.
- Linear and quadratic equations and their solution. Nature of the roots of quadratic equations.

Unit 4. Matrix & Determinant: **[10L]**

- Definition of a Matrix. Types of Matrices. Elementary operations on Matrices.
- Determinant of a square matrix (up to third order). Properties of determinants. Cofactors and minor of a determinant.
- Transpose and Adjoint of a matrix. Symmetric and Skew Symmetric Matrices.
- Inverse of a matrix. Solution of system of linear equations (up to third order) using matrix inversion method and Cramer's Rule.

Unit 5. **[5L]**

- Definition and scope of statistics, concepts of statistical population and sample.
- Data: qualitative and quantitative, discrete and continuous data types, primary and secondary data.
- Presentation of data: tabular and graphical.
- Frequency distribution, cumulative frequency distribution and their graphical representations: histogram, frequency polygon, frequency curve, and O-gives.

Unit 6. **[10L]**

- Measures of Central Tendency: mean, weighted mean, median, mode.
- Measures of Dispersion: range, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

SUGGESTED READINGS/REFERENCES:

1. A. Kumar, S. Kumaresan, B.K. Sarma, A Foundation Course in Mathematics, Narosa Publishing House.
2. Bernard and Child: Higher Algebra, Arihant Publications.

3. I. Stewart, D. Tall, The Foundations of Mathematics. Oxford University Press.
4. M.K. Sen, S. Ghosh and P. Mukhopadhyay, Topics in Abstract Algebra, University Press.
5. K.B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
6. Shanti Narayan: A Textbook of Matrices, S Chand.
7. A.M. Goon, M.K. Gupta, B. Dasgupta, Fundamentals of Statistics, Vol. I & II, The World Press.
8. Irwin Miller, Marylees Miller, John E. Freund's Mathematical Statistics with Applications, Pearson Education, Asia.
9. A.M. Mood, F.A. Graybill, D.C. Boes, Introduction to the Theory of Statistics, Tata McGraw-Hill.

B.Sc. Mathematics (Major)
SEMESTER-IV
Course Code: MATH-M-T-04
Course title: Differential Equations
Major Course; Credit-6; Full Marks-75

COURSE CONTENT: 6 Credits (5+1) (Theory + Tutorial)

Unit 1. **[15L]**

- Differential equations and mathematical models.
- General, particular, explicit, implicit and singular solutions of a differential equation.
- Separable equations and equations reducible to this form.
- Exact differential equations and integrating factors.
- Linear equation and Bernoulli equations, special integrating factors and transformations.
- First order and higher degree differential equations, solvable for x, y and p, Clairaut's Equations: general and singular solutions.

Unit 2. **[15L]**

- Lipschitz condition and Picard's Theorem (Statement only).
- General solution of homogeneous equation of second order, principle of superposition.
- Wronskian: its properties and applications, linear homogeneous and non-homogeneous equations of higher order with constant coefficients.
- Euler's equation, method of undetermined coefficients.
- Method of variation of parameters.

Unit 3. **[15L]**

- Systems of linear differential equations.
- Types of linear systems.,
- Differential operators.
- An operator method for linear systems with constant coefficients.
- Basic Theory of linear systems in normal form.
- Homogeneous linear systems with constant coefficients, two Equations in two unknown functions.

Unit 4. **[10L]**

- Equilibrium points.
- Interpretation of the phase plane.

- Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Unit 5. **[15L]**

- Partial differential equations – Basic concepts and definitions. Mathematical problems.
- First order equations: classification, construction and geometrical interpretation, Lagrange's method, Charpit's method.
- Method of characteristics for obtaining general solution of quasi linear equations.
- Canonical forms of first-order linear equations.
- Method of separation of variables for solving first order partial differential equations.

Graphical demonstration (Teaching aid) **[5L]**

1. Plotting a family of curves which are solutions of second order differential equations.
2. Plotting a family of curves which are solutions of third order differential equations.

SUGGESTED READINGS/REFERENCES:

1. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India.
2. E.L. Ince, Ordinary Differential Equations, Dover Publications.
3. E. Rukmangadachari, Differential Equations, Pearson.
4. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.
5. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata Mcgraw Hill.
6. Belinda Barnes, Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York.
7. C.H. Edwards, D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India.
8. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press.
9. Boyce and DiPrima, Elementary Differential Equations and Boundary Value Problems, John Wiley.
10. I. N. Sneddon, Elements of Partial Differential Equations, Mcgraw-Hill International Edition.
11. K. Sankara Rao, Introduction to Partial Differential Equations, PHI, Third Edition.

B.Sc. Mathematics (Major)
SEMESTER-IV
Course Code: MATH-M-T-05
Course title: Algebra-II
Major Course; Credit-6; Full Marks-75

COURSE CONTENT: 6 Credits (5+1) (Theory + Tutorial)

Unit 1. **[20L]**

- Properties of cosets.
- Lagrange's theorem and consequences including Fermat's little theorem.
- External direct product of a finite number of groups.
- Center of a group, centralizer, normalizer.
- Normal subgroups.
- Factor groups.

- Cauchy's theorem for finite abelian groups.
- Group homomorphisms, basic properties of homomorphisms.
- Cayley's theorem.
- Properties of isomorphisms. First, second and third isomorphism theorems.
- Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups.
- Characteristic subgroups, Commutator subgroups and its properties.

Unit 2. **[10L]**

- Properties of external direct products, the group of units modulo n as an external direct product, internal direct products.
- Fundamental theorem of finite abelian groups.
- Sylow's theorems and consequences.
- Cauchy's theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests.

Unit 3. **[15L]**

- Definition and examples of rings. Properties of rings,
- Subrings.
- Integral domains and fields. Characteristics of a ring.
- Ideal, ideal generated by a subset of a ring.
- Factor rings.
- Operations on ideals.
- Prime and maximal ideals.
- Ring homomorphisms, properties of ring homomorphisms.
- Isomorphism theorems I, II and III.

Unit 4: **[15L]**

- Concept of Vector space over a field: Examples, concepts of Linear combinations, linear dependence and independence of a finite number of vectors.
- Sub- space, concepts of generators and basis of a finite dimensional vector space.
- Replacement theorem. Extension theorem. Deletion theorem and their applications.
- Row space, column space.
- Euclidean Spaces. Orthogonal and orthonormal vectors. Gram-Schmidt process of orthogonalization

Unit 5. **[15L]**

- Linear transformations. Null space. Range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations.
- Eigenvalues, eigen vectors and characteristic equation of a matrix. Matric polynomials, Cayley-Hamilton theorem and its use in finding the inverse of a matrix.
- Diagonalization, Canonical forms.

SUGGESTED READINGS/REFERENCES:

1. D. S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw-Hill.
2. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson.
3. M. Artin, Abstract Algebra, 2nd Ed., Pearson.
4. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi.

5. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag.
6. R. K. Sharma, S. K. Shah and A. G. Shankar, Algebra-I, Pearson.
7. U. M. Swamy, A.R.S.N. Murthy, Algebra, Pearson.
8. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.

B.Sc. Other than Mathematics (Minor)
SEMESTER-IV
Course Code: MATH-MI-T-02
Course title: Calculus & Differential Equations
Minor Course; Credit-4; Full Marks-50

COURSE CONTENT: 4 Credits (3+1) (Theory + Tutorial)

Unit 1. **[25L]**

- Real-valued functions defined on an interval, limit and Continuity of a function (using $\varepsilon - \delta$). Algebra of limits. Differentiability of a function.
- Successive derivative: Leibnitz's theorem and its application to problems of type $e^{ax+b}\sin x, e^{ax+b}cosx, (ax+b)^n sinx, (ax+b)^n cosx.$
- Partial derivatives. Euler's theorem on homogeneous function of two and three variables.
- Curvature, rectilinear asymptotes.
- Indeterminate Forms: L'Hospital's Rule (Statement and Problems only).
- Statement of Rolle's Theorem and its geometrical interpretation. Mean value theorems of Lagrange and Cauchy. Statements of Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainders. Taylor's and Maclaurin's infinite series of functions like e^x, sinx, cosx, $(1+x)^n$, log(1+x) with restrictions wherever necessary.
- Application of the principle of maxima and minima for a function of a single variable.

Unit 2. **[5L]**

- Reduction formulae, derivations and illustrations of reduction formulae of the type
- $\int sin^n x\,dx, \int cos^n x\,dx, \int tan^n x\,dx, \int sec^n x\,dx, \int (\log x)^n dx, \int sin^n x cos^m x dx.$

Unit 3. **[20L]**

- First order equations: (i) Exact equations and those reducible to such equations. (ii) Euler's and Bernoulli's equations (Linear). (iii) Clairaut's Equations: General and Singular solutions.
- Second order differential equation: (i) Method of variation of parameters, (ii) Method of undetermined coefficients.
- Linear homogeneous equations with constant coefficients, method of variation of parameters, simultaneous differential equations.

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2. T. Apostol, Mathematical Analysis, Narosa Publishing House.
3. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
4. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc.
5. G. B. Thomas and R.L. Finney, Calculus, Pearson Education.