

University of Kalyani



**Curriculum & Credit Framework
for
Four-Year Undergraduate Program (FYUP)
in
Mathematics**

(As per provisions of NEP 2020)

WITH EFFECT FROM THE ACADEMIC SESSION

2023-2024

FOREWORD

The draft syllabus for the Four-Year Undergraduate Programme (FYUP) in Mathematics as per NEP-2020 was prepared by the Undergraduate Board of Studies (UGBOS) in Mathematics, University of Kalyani after detailed discussions through a series of meetings of UGBOS (from 08.06.2023 to 01.08.2023). The draft syllabus is prepared by following the guidelines of the course structure (NEP-2020) as notified by the University of Kalyani (vide Ref. No: CoE/NEP/2020/01/2023 dated 06.06.2023). The Board, after a thorough perusal, recommended the same and authorized the Chairman to forward the proposed syllabus draft to the appropriate section of the University administration so that it could be finalized and introduced from the academic session of 2023-2024.

The following members of UGBOS in Mathematics, KU attended the meetings to frame the syllabus for the Four-Year Undergraduate Programme in Mathematics:

1. Prof. Samares Pal, HOD, Mathematics, KU – Chairperson
2. Prof. Pulak Sahoo, Department of Mathematics, KU – Member
3. Dr. Sahidul Islam, Department of Mathematics, KU – Member
4. Dr. Debi Prasad Acharyya, Nabadwip Vidyasagar College, Nadia – Member
5. Dr. Manob Kumar Ghosh, Kalyani Mahavidyalaya, Nadia – Member
6. Dr. Joydeb Bhattacharya, Karimpur Pannadevi College, Nadia – Member
7. Mr. Dipankar Pal, Prof. Syed Nurul Hassan College, Murshidabad – Member
8. Dr. Sudhansu Kumar Biswas, Sripat Singh College, Murshidabad – Member

Kalyani

01st Aug 2023

--Chairperson,

UGBOS in Mathematics, KU

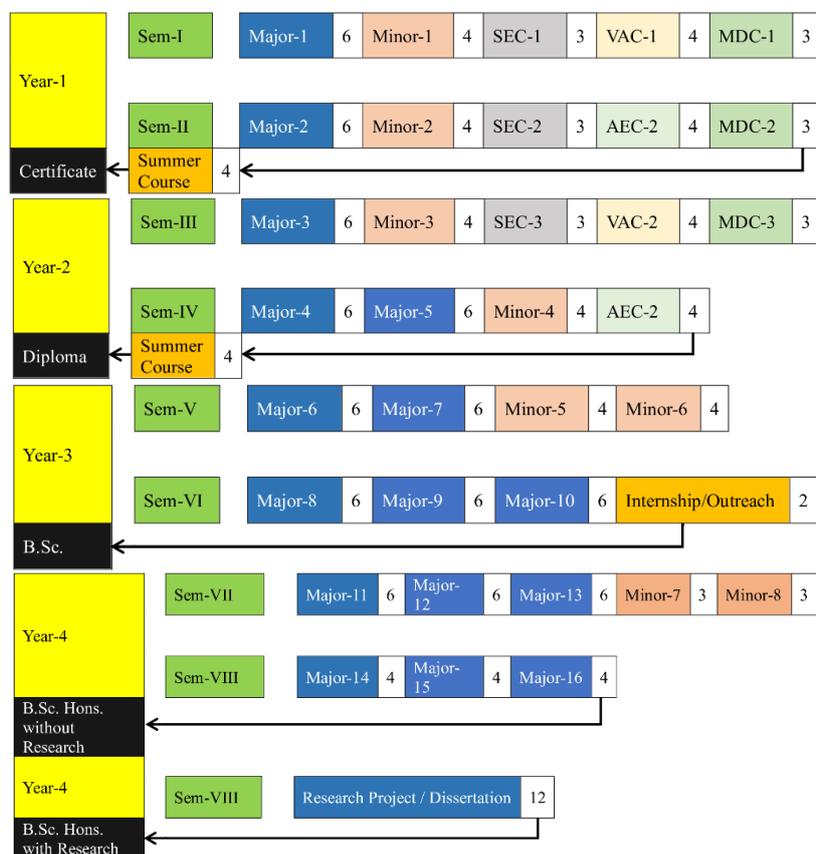
PREAMBLE

The Government of India notified National Education Policy (NEP-2020) on July 29, 2020, based on Dr Kasturirangan committee's report. The objective is to have holistic and multidisciplinary undergraduate education to produce employable graduates with integrated personalities.

The University of Kalyani recommends NEP and designed a curriculum framework for undergraduate programs (vide Ref. No: CoE/NEP/2020/01/2023 dated 06.06.2023) in semester mode under various disciplines from the academic year 2023-2024. The framework aims at making the academic programs student-oriented, flexible, interdisciplinary, and relevant to the times. The students will have ample freedom to select the electives that suit their interests, aptitude, and needs. The students are provided abundant opportunities during the program of study to accumulate credits by opting for **Major Courses, Minor Courses, Multidisciplinary Courses (MDC), Ability Enhancement Courses (AEC), Skill Enhancement Courses (SEC), and Value-Added Courses (VAC)** under various disciplines. The students will choose major, minor, multidisciplinary, and other courses at the time of their admission. The system aims to strengthen the academic potential of the students, as it provides flexibility in the choice of courses offered beyond the framework of the respective disciplines of study. The undergraduate degree programmes of either 3 or 4-year duration, has multiple entries and exit points and re-entry options, with appropriate certifications such as

- **Certificate** after completing 1 year (2 semesters) of study in the chosen fields of study.
- **Diploma** after 2 years (4 semesters) of study.
- **Bachelor** after a 3-year (6 semesters) programme of study.
- **Bachelor (Hons. with / without Research)** after a 4-year (8 semesters) programme of study.

Progression under FYUP (K.U.)



CREDIT FRAMEWORK FOR THE FOUR-YEAR UG PROGRAMME IN B.Sc.

Course (Credit)	Sem-I	Sem-II		Sem-III	Sem-IV	Sem-V	Sem-VI	Sem-VII	Sem-VIII	
									Hons.	Hons. with Research
Major (6)	1	1		1	2	2	3	3	2	-
Major (4)	-	-		-	-	-	-	-	3	3
Minor (4)	1	1		1	1	2	-	2	-	-
SEC (3)	1	1		1	-	-	-	-	-	-
AEC (4)	-	1		-	1	-	-	-	-	-
VAC (4)	1	-		1	-	-	-	-	-	-
MDC (3)	1	1		1	-	-	-	-	-	-
Summer Course (4)	-	1	(for Certificate)	-	1	(for Diploma)	-	-	-	-
Outreach / Internship (2)	-	-		-	-	-	1	-	-	-
Research Project / Dissertation (12)	-	-		-	-	-	-	-	-	1
Total Courses (Credits)	5 (20)	5 (20)		5 (20)	4 (20)	4 (20)	3 (20)	5 (26)	5 (24)	

Exit Point: Undergraduate Certificate

Exit Point: Undergraduate Diploma

Exit Point: B.Sc.

Exit Point: B.Sc. Honours with/without Research.

***Abbreviations:**

- SEC: Skill Enhancement Course
- AEC: Ability Enhancement Course
- VAC: Value-added Course
- MDC: Multidisciplinary Course

SEMESTER & COURSE-WISE CREDIT DISTRIBUTION IN B.Sc. (Mathematics)

Year-1							
SEMESTER-I							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-01	Major	Calculus & Analytical Geometry	5:1:0	6	15	60	75
MATH-SEC-T-01	Skill Enhancement	Logic & Boolean Algebra	3:0:0	3	10	35	45
*MATH-MI-T-01	Minor	Algebra & Analytical Geometry	3:1:0	4	10	40	50
*MATH-MD-T-01	Multidisciplinary	Basic Mathematics	3:0:0	3	10	35	45
VAC-01	Value Added	Environmental Studies	3:1:0	4	10	40	50
SEMESTER-II							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-02	Major	Algebra-I	5:1:0	6	15	60	75
MATH-SEC-T-02	Skill Enhancement	Graph Theory	3:0:0	3	10	35	45
*MATH-MI-T-01	Minor	Algebra & Analytical Geometry	3:1:0	4	10	40	50
*MATH-MD-T-02	Multidisciplinary	Basic Statistics	3:0:0	3	10	35	45
AEC-01	Ability Enhancement	Communicative English	3:1:0	4	10	40	50
MATH-SI-01	Summer Internship	Summer Internship (Additional for Certificate)		4			
Year-2							
SEMESTER-III							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-03	Major	Real Analysis-I	5:1:0	6	15	60	75
MATH-SEC-T&P-03	Skill Enhancement	Programming in C (Theory & Practical)	1:1:1	3	10	35	45
*MATH-MI-T-02	Minor	Calculus & Differential Equations	3:1:0	4	10	40	50
*MATH-MD-T-03	Multidisciplinary	Basic Computer Programming	3:0:0	3	10	35	45
VAC-02	Value Added	To be selected from the prescribed pool	3:1:0	4	10	40	50
SEMESTER-IV							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-04	Major	Differential Equations	5:1:0	6	15	60	75
MATH-M-T-05	Major	Algebra-II	5:1:0	6	15	60	75
*MATH-MI-T-02	Minor	Calculus & Differential Equations	3:1:0	4	10	40	50
AEC-02	Ability Enhancement	MIL	3:1:0	4	10	40	50
MATH-SI-02	Summer Internship	Summer Internship (Additional for Diploma)		4			
Year-3							
SEMESTER-V							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-06	Major	Riemann integration & Series of functions	5:1:0	6	15	60	75
MATH-M-T&P-07	Major	Numerical Analysis (Theory & Practical)	3:1:2	6	15	60	75
*MATH-MI-T-03	Minor	Linear Programming Problem	3:1:0	4	10	40	50
SEMESTER-VI							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-08	Major	Mechanics-I	5:1:0	6	15	60	75
MATH-M-T-09	Major	LPP & Game Theory	5:1:0	6	15	60	75
MATH-M-T-10	Major	Multivariate Calculus, Vector & Tensor Analysis	5:1:0	6	15	60	75
MATH-SI-03	Outreach / Internship	Outreach / Internship		2			
Year-4							
SEMESTER-VII							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-11	Major	Probability & Statistics	5:1:0	6	15	60	75
MATH-M-T-12	Major	Mechanics-II	5:1:0	6	15	60	75
MATH-M-T-13	Major	Metric Spaces & Complex Analysis	5:1:0	6	15	60	75
*MATH-MI-T-04	Minor	Dynamics of a Particle	3:1:0	4	10	40	50
SEMESTER-VIII							
Course Code	Nature of Course	Course Title	Class (L+T+P)	Credit	Evaluation		
					Internal	End-Sem	Total
MATH-M-T-14	Major	Ordinary & Partial Differential equations	3:1:0	4	10	40	50
MATH-M-T-15	Major	Classical Mechanics	3:1:0	4	10	40	50
MATH-M-T-16	Major	Operations Research	3:1:0	4	10	40	50
Honours without Research							
MATH-M-T-17	Major	Real Analysis-II & Functional Analysis	5:1:0	6	15	60	75
MATH-M-T-18	Major	Non-linear Dynamics & Biomathematics	5:1:0	6	15	60	75
Honours with Research							
MATH-SI-04	Summer Internship	Research Project / Dissertation		12			

*These courses are to be taken by students of other major subject groups.

Detailed Course & Contents of Mathematics syllabus

B.Sc. Mathematics (Major)

SEMESTER-I

Course Code: MATH-M-T-01

Course Title: Calculus & Analytical Geometry

Major Course; Credit-6; Full Marks-75

COURSE CONTENT:

6 Credits (5+1) (Theory + Tutorial)

Unit 1.

[25L]

- Hyperbolic functions and its derivative, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax + b)^n\sin x$, $(ax + b)^n\cos x$.
- Pedal equations.
- Curvature, radius of curvature, centre of curvature, circle of curvature
- Asymptotes
- Envelopes.
- Singular points, concavity and inflection points.
- Curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves.
- L'Hospital's rule, applications in business, economics and life sciences.

Unit 2.

[16L]

- Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \tan^n x dx$, $\int \sec^n x dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^m x dx$.
- Parametric equations, parameterizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution, techniques of sketching conics.

Unit 3.

[30L]

- Transformation of coordinate axes, pair of straight line, reflection properties of conics, rotation of axes and second-degree equations, classification of conics using the discriminant, polar equations of conics.
- Straight lines in 3D, sphere, cylindrical surfaces. central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Graphical Demonstration (Teaching Aid)

[4L]

1. Plotting of graphs of function e^{ax+b} , $\log(ax + b)$, $1/(ax + b)$, $\sin(ax + b)$, $\cos(ax + b)$, $|ax + b|$ and to illustrate the effect of a and b on the graph.
2. Plotting the graphs of polynomials of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves (Eg. trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining the surface of the revolution of curves.
5. Tracing of conics in Cartesian coordinates / polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using Cartesian coordinates.

SUGGESTED READINGS/REFERENCES:

1. T. Apostol, Calculus, Volumes I and II, John Wiley & Sons, Inc.

2. G. B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi.
3. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi.
4. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore.
5. Santi Narayan, Integral Calculus, S. Chand.
6. P. R. Vittal, Analytical Geometry 2D and 3D, Pearson.
7. V. A. Ilyin and E. G. Poznyak, Analytical Geometry, Mir Publishers.
8. M. Postnikov, Lectures in Geometry, Firebird Publications.
9. Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions, Ingram short title.
10. S. L. Loney, Co-ordinate Geometry, Arihant Publications.
11. M. S. Speizel, Vector Analysis, McGraw Hill Education.

B.Sc. Mathematics (Major)
SEMESTER-I
Course Code: MATH-SEC-T-01
Course Title: Logic & Boolean Algebra
Skill Enhancement Course; Credit-3; Full Marks-45

COURSE CONTENT:

3 Credits (2+1) (Theory + Tutorial)

Unit 1.

[15L]

- Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contrapositive and inverse propositions and precedence of logical operators.
- Propositional equivalence, Logical equivalences.
- Predicates and quantifiers: Introduction, quantifiers, binding variables and negations.

Unit 2.

[10L]

- Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle.
- Lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.

Unit-3

[20L]

- Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials.
- Quinn-McCluskey method, Karnaugh diagrams, logic gates, switching circuits and applications of switching circuits.

SUGGESTED READINGS/REFERENCES:

1. R. P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education.
2. P. R. Halmos, Naive Set Theory, Springer.
3. E. Kamke, Theory of Sets, Dover Publishers.
4. B.A. Davey, H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint.
6. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.

B.Sc. Other than Mathematics (Minor)
SEMESTER-I
Course Code: MATH-MI-T-01
Course title: Algebra & Analytical Geometry
Minor Course; Credit-4; Full Marks-50

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

Unit 1. [20L]

- Complex Numbers: De Moivre's theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of a^z . Inverse circular and hyperbolic functions.
- Polynomials: Fundamental theorem of algebra (Statement only). Polynomials with real coefficients, nature of roots of an equation (surd or complex roots occur in pairs). Statement of Descartes's rule of signs and its applications. Relation between roots and coefficients, transformations of equations. Cardan's method of solution of a cubic equation.
- Rank of a matrix: Determination of rank either by considering minors or by the sweep-out process. Consistency and solution of a system of linear equations (not more than 3 variables) by matrix method.
- Equivalence relations and partitions. Functions, composition of functions, invertible functions, one-to-one correspondence and cardinality of a set
- Definition and elementary properties of groups. Concepts of permutation Group, alternating group, finite groups: S_3 , V_4 . The group Z_n of integers under addition modulo n .
- Order of an element, order of a group, subgroups and examples of subgroups.

Unit 2. [30L]

- Transformations of rectangular axes: Translation, rotation and their combinations. Invariants.
- General equation of second degree in x and y : Reduction to canonical forms. Classification of conics.
- Pair of straight lines: Condition that the general equation of 2nd degree in x and y may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2+2hxy+by^2=0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.
- Polar equation of straight lines and circles. Polar equation of a conic refers to a focus as a pole. Equation of chord joining two points. Equations of tangents and normals.
- Sphere and its tangent planes. Right circular cone.

SUGGESTED READINGS/REFERENCES:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser.
2. W. S. Burnstine and A.W. Panton, Theory of Equations, Nabu Press.
3. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
4. K. B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
5. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint.
6. P. K. Saikai, Linear Algebra, Pearson.
7. K. Hoffman, R. Kunze, Linear Algebra, Pearson.
8. P. R. Vittal, Analytical Geometry 2D and 3D, Pearson.
9. S. L. Loney, Co-ordinate Geometry, Arihant Publications.



B.Sc. Mathematics (Multidisciplinary)
SEMESTER-I
Course Code: MATH-MD-T-01
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: [10L]

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

Unit 3. Theory of Equations: [15L]

- 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: [15L]

- 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.

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.

B.Sc. Mathematics (Major)
SEMESTER-II
Course Code: MATH-T-02
Course Title: Algebra-I
Major Course; Credit-6; Full Marks-75

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

Unit 1. [30L]

- Polar representation of complex numbers, n th roots of unity, De Moivre's theorem for rational indices and its applications. Direct and inverse circular form of trigonometric and hyperbolic functions. Exponential & Logarithm of a complex number. Definition of a^z .

- Relation between roots and coefficients, transformation of equation, Descartes rule of signs, solution of cubic equation (Cardan's method), solution of biquadratic equation (Ferrari's method).
- Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of mathematical induction, statement of fundamental theorem of arithmetic.

Unit 2.**[25L]**

- Equivalence relations and partitions. Functions, composition of functions, Invertible functions, one to one correspondence and cardinality of a set.
- Permutations, cycle notation for permutations, even and odd permutations.
- Definition and elementary properties of groups. Symmetries of a square, dihedral groups. quaternion groups (through matrices). Permutation group, alternating group, finite groups: S_3 , V_4 . The group Z_n of integers under addition modulo n and the group U_n of units under multiplication modulo n .
- Order of an element, order of a group, simple properties.
- Subgroups and examples of subgroups. Product of two subgroups.
- Cyclic group. Properties of cyclic groups.
- Classification of subgroups of cyclic groups.

Unit 3.**[20L]**

- Rank of a matrix, inverse of a matrix, characterizations of invertible matrices. Row reduced and echelon forms, Normal form and congruence operations.
- Solutions of systems of linear equations of the form $Ax = b$ and their applications.

SUGGESTED READINGS/REFERENCES:

1. W. S. Burnstine and A. W. Panton, Theory of Equations, Nabu Press.
2. Bernard and Child: Higher Algebra, Arihant Publications.
3. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser.
4. M. K. Sen, S. Ghosh and P. Mukhopadhyay, Topics in Abstract Algebra, University Press.
5. K. Hoffman, R. Kunze, Linear Algebra, Pearson.
6. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint.
7. K. B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
8. P. K. Saikai, Linear Algebra, Pearson.
9. Neal H. McCoy: Introduction to Modern Algebra, Brown (William C.) Co.
10. Shanti Narayan: A Textbook of Matrices, S Chand.
11. V. Krishnamurthy, V.P. Arora: An Introduction to Linear Algebra, Affiliated East-West Press.
12. L. Mirsky: An Introduction to Linear Algebra, Dover Publications.
13. J. B. Fraleigh: A First Course in Abstract Algebra, Pearson.
14. I. N. Herstein: Topics in Algebra, Wiley.

B.Sc. Mathematics (Major)
SEMESTER-II
Course Code: MATH-SEC-T-02
Course title: Graph Theory
Skill Enhancement Course; Credit-3; Full Marks-45

COURSE CONTENT: 3 Credits (2+1) (Theory + Tutorial)

Unit 1. [10L]

- Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs isomorphism of graphs.

Unit 2 [15L]

- Eulerian circuits, Eulerian graphs, semi-Eulerian graphs, Hamiltonian cycles.
- Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph,

Unit 3. [20L]

- Travelling salesman's problem, shortest path, tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm.

SUGGESTED READINGS/REFERENCES:

1. B.A. Davey, H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge.
2. R. J. Wilson, Introduction to Graph theory, Pearson.
3. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
4. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint.

B.Sc. Other than Mathematics (Minor)
SEMESTER-II
Course Code: MATH-MI-T-01
Course title: Algebra & Analytical Geometry
Minor Course; Credit-4; Full Marks-50

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

Unit 1. [20L]

- Complex Numbers: De Moivre's theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of a^z . Inverse circular and hyperbolic functions.
- Polynomials: Fundamental theorem of algebra (Statement only). Polynomials with real coefficients, nature of roots of an equation (surd or complex roots occur in pairs). Statement of Descartes rule of signs and its applications. Relation between roots and coefficients, transformations of equations. Cardan's method of solution of a cubic equation.
- Rank of a matrix: Determination of rank either by considering minors or by sweep-out process. Consistency and solution of a system of linear equations (not more than 3 variables) by matrix method.
- Equivalence relations and partitions. Functions, composition of functions, invertible functions, one to one correspondence and cardinality of a set

- Definition and elementary properties of groups. Concepts of permutation Group, alternating group, finite groups: S_3, V_4 . The group Z_n of integers under addition modulo n .
- Order of an element, order of a group, subgroups and examples of subgroups.

Unit 2.

[30L]

- Transformations of rectangular axes: Translation, rotation and their combinations. Invariants.
- General equation of second degree in x and y : Reduction to canonical forms. Classification of conics.
- Pair of straight lines: Condition that the general equation of 2nd degree in x and y may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2+2hxy+by^2=0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.
- Polar equation of straight lines and circles. Polar equation of a conic refers to a focus as a pole. Equation of chord joining two points. Equations of tangents and normals.
- Sphere and its tangent planes. Right circular cone.

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1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser.
2. W.S. Burnstine and A.W. Panton, Theory of Equations, Nabu Press.
3. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
4. K.B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
5. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint.
6. K. Hoffman, R. Kunze, Linear Algebra, Pearson.
8. P. R. Vittal, Analytical Geometry 2D and 3D, Pearson.
9. S. L. Loney, Co-ordinate Geometry, Arihant Publications.

**B.Sc. Mathematics (Multidisciplinary)
SEMESTER-II**

Course Code: MATH-MD-T-02

Course title: Basic Statistics

Multidisciplinary Course; Credit-3; Full Marks-45

COURSE CONTENT:

3 Credits (3+0) (Theory + Tutorial)

Unit 1.

[15L]

- 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 2.

[15L]

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

**Unit 3.****[15L]**

- Bivariate data: Definition, scatter diagram, correlation, Pearson's correlation coefficient.
- Two-variable linear regression, principle of least squares and fitting of polynomial curves.

SUGGESTED READINGS/REFERENCES:

1. A.M. Goon, M.K. Gupta, B. Dasgupta, Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press.
2. Irwin Miller, Marylees Miller, John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. A.M. Mood, F.A. Graybill, D.C. Boes, Introduction to the Theory of Statistics, Tata McGraw-Hill.

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 \mathbb{R} .
- Idea of countable sets, uncountable sets and uncountability of \mathbb{R} . Countability of \mathbb{Q} .
- Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima.
- Completeness property of \mathbb{R} and its equivalent properties.
- The Archimedean property, density of rational (and irrational) numbers in \mathbb{R} , intervals.
- Intervals, ε -neighbourhood of a point in \mathbb{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, \liminf , \limsup .
- 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 ($\varepsilon - \delta$ 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, $\log(1+x)$, $\frac{1}{(ax+b)}$, $(1+x)^n$.
- 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 Hill.
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 $e^{ax+b} \sin x, e^{ax+b} \cos x, (ax + b)^n \sin x, (ax + b)^n \cos x$.
- 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 $e^x, \sin x, \cos x, (1+x)^n, \log(1+x)$ 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 Computer Programming
Multidisciplinary Course; Credit-3; Full Marks-45

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

Unit 1. [8L]

- Basic structure and elementary ideas of computer system, operating systems, hardware and software, Compiler, and Interpreter.
- Machine language, High level language.
- BIT, BYTE, binary, octal, decimal, hexadecimal systems. Binary arithmetic.

Unit 2. [17L]

- Algorithms, Flowcharts, Algorithms and Flowcharts of simple problems.
- Data type: integer, floating point
- Character, Variables.
- Input, Output, for-next, do-while, if-else statements etc.
- One and two-dimensional array.

Unit 3. Applications (C/Python Programming Language) [20L]

- Addition, Subtraction, Multiplication, Division of real numbers.
- Sorting of real numbers
- Roots of a Quadratic Equation.
- Area of a Rectangle, Triangle, Trapezium, Circle.
- Addition and Subtraction of Matrices.
- Arithmetic and Geometric mean.

SUGGESTED READINGS/REFERENCES:

1. V. Raja Raman, Fundamentals of Computers, Prentice Hall of India Pvt. Ltd., New Delhi.
2. E. Balagurusamy, Fundamentals of Computers, McGraw Hill.
3. Byron S. Gottfried, Programming with C, McGraw Hill.
4. Kernighan and Dennis, The C Programming Language, Prentice Hall of India Pvt. Ltd., New Delhi.
5. Allen B. Tucker, Programming Languages, Tata McGraw Hill.
6. T. Budd, Exploring Python, McGraw Hill Education.
7. Kenneth A. Lambert, Fundamentals of Python, Cengage Learning, Inc.
8. Tony Gaddis, Starting Out with Python, Pearson
9. T. Sheetal, K. Naveen, Python Programming: A modular approach, Pearson.
10. R.N. Rao, Core Python Programming, Dreamtech Press.

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 $e^{ax+b}\sin x, e^{ax+b}\cos x, (ax + b)^n\sin x, (ax + b)^n\cos x$.
- 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 $e^x, \sin x, \cos x, (1+x)^n, \log(1+x)$ 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.

B.Sc. Mathematics (Major)
SEMESTER-V
Course Code: MATH-M-T-06
Course title: Riemann Integration and Series of Functions
Major Course; Credit-6; Full Marks-75

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

Unit 1. [20L]

- Riemann integration: inequalities of upper and lower sums, Darboux theorem, Riemann conditions of integrability, Riemann sum and definition, Riemann integral through Riemann sums.
- Equivalence of two definitions. Riemann integrability of monotone and continuous functions, properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions.
- Fundamental theorem of integral calculus.
- 1st and 2nd mean value theorems for integral calculus.

Unit 2. [25L]

- Improper integration: Type1, Type2. Necessary and sufficient condition for convergence of improper integral in both cases. Cauchy's Criterion. Cauchy's principal value.
- Tests of convergence: Comparison and μ -test. Absolute and non-absolute convergence and. Abel's and Dirichlet's test for convergence on the integral of a product.
- Convergence of Beta and Gamma functions. Relation between beta and gamma functions and related problems.

Unit 3. [25L]

- Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions.
- Series of functions. Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.
- Power series, radius of convergence, Cauchy Hadamard theorem. Differentiation and integration of power series; Abel's theorem; Weierstrass approximation theorem.

Unit 4. [5L]

- Fourier series: Definition of Fourier coefficients and series, examples of Fourier expansions and summation results for series.

SUGGESTED READINGS/REFERENCES:

1. R. G. Bartle D. R. Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) Pvt. Ltd.
2. K. A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
3. V. Karunakaran, Real Analysis, Pearson.
4. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition).
5. S. Goldberg, Calculus and mathematical analysis.

6. T. Apostol, Calculus I, II, John Wiley & Sons.
7. G. P. Tolstov, Fourier Series, Dover Publications.

B.Sc. Mathematics (Major)
SEMESTER-V
Course Code: MATH-M-T&P-07
Course title: Numerical Analysis (Theory & Practical)
Major Course; Credit-6; Full Marks-75

COURSE CONTENT: 6 Credits (4+0+2) (Theory + Tutorial + Practical)

Numerical Methods (Theory)

Unit 1. [10L]

- Algorithms, convergence, errors, relative, absolute, round-off, truncation errors.
- Interpolation, Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Central difference interpolation formula: Stirling and Bessel interpolation
- Numerical differentiation, methods based on interpolations, methods based on finite differences.

Unit 2. [10L]

- Numerical integration, Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule, Weddle's rule, Boole's rule. Midpoint rule, composite trapezoidal rule, composite Simpson's 1/3rd rule, Gauss quadrature formula.

Unit 3. [10L]

- Transcendental and polynomial equations, bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method, rate of convergence of these methods.
- System of linear algebraic equations, Gaussian elimination and Gauss Jordan methods, Gauss Jacobi method, Gauss Seidel method and their convergence analysis, LU decomposition

Unit 4. [10L]

- The algebraic eigenvalue problem, power method.
- Approximation, least square polynomial approximation.

Unit 5: [10L]

- Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

List of Practical Problems (Using C programming) [25L]

(Two experiments are to be performed in the presence of External Examiner (7.5x2) and viva: 5)

(A practical notebook must be maintained as a part of internal Assessment)

- (i) Bisection Method.
- (ii) Newton Raphson Method.
- (iii) Secant Method.
- (iv) Regula Falsi Method.
- (v) LU decomposition Method.

- (vi) Gauss-Jacobi Method.
- (vi) Gauss-Seidel Method.
- (vii) Lagrange's Interpolation
- (viii) Trapezoidal Rule.
- (ix) Simpson's $1/3^{\text{rd}}$ rule.
- (x) Euler's method.

SUGGESTED READINGS/REFERENCES:

1. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
2. M.K. Jain, S. R. K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering, New Age International Publishers.
3. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI.
4. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India.
5. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India.
6. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, PHI Learning Private Limited.
7. P. S. Das, C. Vijayakumari, Numerical analysis, Pearson.
8. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, PHI Learning Private Limited.

B.Sc. Other than Mathematics (Minor)
SEMESTER-V
Course Code: MATH-MI-T-03
Course title: Linear Programming Problem
Minor Course; Credit-4; Full Marks-50

COURSE CONTENT:

4 Credits (3+1) (Theory + Tutorial)

Unit 1. **[10L]**

- Introduction to linear programming problems, Graphical solution of LPP.
- Convex sets. Basic solutions and non-basic solutions. Reduction of B.F.S from B.S.

Unit 2 **[20L]**

- Simplex method, Big- M , two-phase method, method and their comparison.
- Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.

Unit 3. **[20L]**

- Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of initial basic solution. Algorithms for solving transportation problems.
- Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

SUGGESTED READINGS/REFERENCES:

1. Hamdy A. Taha, Operations Research, An Introduction, Prentice-Hall India.
2. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi.

3. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, John Wiley and Sons, India.
4. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, Tata McGraw Hill, Singapore.
5. S.I. Gass, Linear Programming: Methods and Applications, Dover Publications.
6. T. Veerarajan, Operation Research, University Press.
7. K. Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultanchand.

B.Sc. Mathematics (Major)
SEMESTER-VI
Course Code: MATH-M-T-08
Course title: Mechanics-I
Major Course; Credit-6; Full Marks-75

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

Unit-1: [15L]

- Motion in a straight line, motion under attractive and repulsive forces, motion under acceleration due to gravity.
- Simple harmonic motion, horizontal oscillation, composition of two S.H.M.'s, damped harmonic motion, forced oscillation, damped forced oscillation.
- Motion in a resisting medium: Vertical and curvilinear motion in a resisting medium.
- Motion of varying mass: Equations of motion.

Unit-2: [15L]

- Work, Power and Energy: Definitions. Work done in stretching an elastic string.
- Conservative forces. Conservation of energy.
- Impulse and impulsive forces: Impulse of a force. Impulsive forces. Conservation of linear momentum.
- Collision of elastic bodies: Elasticity. Impact of smooth bodies. Impact on a fixed plane. Direct and oblique impact of two smooth spheres. Loss of kinetic energy. Angle of deflection

Unit-3: [20L]

- Motion in a Plane: Velocity and acceleration of a particle moving on a plane in Cartesian and polar coordinates. Motion of a particle moving on a plane refers to a set of rotating rectangular axes. Angular velocity and acceleration. Circular motion. Tangential and normal accelerations.
- Central orbit: Characteristics of central orbits. Areal velocity. Law of force for elliptic, parabolic and hyperbolic orbits. Velocity under central forces. Orbit under radial and transverse accelerations. Stability of nearly circular orbits.
- Planetary motion: Newtonian law. Orbit under inverse square law. Kepler's laws of planetary motion. Time of description of an arc of an elliptic, parabolic and hyperbolic orbit. Effect of disturbing forces on the orbit. Artificial satellites: Orbit round the earth. Parking orbits. Escape velocity.

Unit-4: [25L]

- Degrees of freedom. Moments and products of inertia: Moment of inertia (M.I) and product of inertia (P.I.) of some simple cases. M.I. about a perpendicular axis. Routh's rule. M.I. about parallel axes. M.I. about any straight line. M.I. of a lamina about a straight line in its plane. Momental ellipsoid. Equimomental systems.

- General equations of motion: D'Alembert's principle and its application to deduce general equations of motion of a rigid body. Motion of the centre of inertia (C.I.) of a rigid body. Motion relative to C.I.
- Motion about an axis: Rotation of a rigid body about a fixed body. Equation of motion. K.E. of the body rotating about an axis. Compound pendulum and its minimum time of oscillation.
- Motion in two dimensions under finite forces: Equations of motion. K.E. and angular momentum about the origin of a rigid body moving in two dimensions. Two – dimensional of a solid of revolution down a rough inclined plane. Necessary and sufficient conditions for pure rolling.

SUGGESTED READINGS/REFERENCES:

1. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw Hill Book Company, New York.
2. I. H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. F. Chorlton, Textbook of Dynamics, John Wiley & Sons.
5. S. L. Loney, An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, New Age International Private Limited.
6. S. L. Loney, Elements of Statics and Dynamics I and II, AITBS.
7. A. S. Ramsey, Dynamics (Part I), CBS Publishers & Distributors.

B.Sc. Mathematics (Major)
SEMESTER-VI
Course Code: MATH-M-T-09
Course title: Linear Programming Problems & Game Theory
Major Course; Credit-6; Full Marks-75

COURSE CONTENT:

6 Credits (5+1) (Theory + Tutorial)

Unit 1. **[10L]**

- Introduction to linear programming problems. Mathematical formulation of LPP. Graphical solution.
- Convex sets. Basic solutions (B.S.) and non-basic solutions. Reduction of B.F.S from B.S.

Unit 2 **[20L]**

- Theory of simplex method. Optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables. Big-M method. Two-phase method.
- Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.

Unit 3. **[25L]**

- Transportation problem and its mathematical formulation, northwest-corner, row-minima, column minima, matrix-minima, and Vogel approximation methods for determination of initial basic solution. Algorithms for solving transportation problems.
- Assignment problem and its mathematical formulation, Hungarian method for solving assignment problems.
- Travelling Salesman Problems.

Unit 4.**[20L]**

- Game theory: Formulation of two-person zero sum games.
- Solving two-person zero sum games. Games with mixed strategies. Graphical solution procedure.
- Solving game using simplex algorithm.

SUGGESTED READINGS/REFERENCES:

1. Hamdy A. Taha, Operations Research, An Introduction, Prentice-Hall India.
2. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi.
3. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, John Wiley and Sons, India.
4. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, Tata McGraw Hill, Singapore.
5. S. I. Gass, Linear Programming: Methods and Applications, Dover Publications.
6. T. Veerarajan, Operations Research, University Press.
7. K. Swarup, P. K. Gupta and Man Mohan, Operations Research, Sultanchand.

B.Sc. Mathematics (Major)
SEMESTER-VI
Course Code: MATH-M-T-10
Course title: Multivariate Calculus, Vector & Tensor Analysis
Major Course; Credit-6; Full Marks-75

COURSE CONTENT:

6 Credits (5+1) (Theory + Tutorial)

Unit 1.**[20L]**

- Functions of several variables, limit and continuity of functions of two or more variables.
- Differentiability and total differentiability. Partial differentiation
- Sufficient condition for differentiability. Schwarz's theorem, Young's theorem.
- Chain rule for one and two independent parameters.
- Homogeneous function and Euler's theorem on homogeneous functions and its converse.
- Jacobians and functional dependence.
- Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

Unit 2.**[15L]**

- Double integration over a rectangular region. Double integration over non-rectangular regions. Double integrals in polar coordinates,
- Triple integrals. Triple integral over parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical coordinates.
- Change of variables in double integrals and triple integrals.

Unit 3.**[15L]**

- Introduction to vector functions, operations with vector-valued function
- Limits and continuity of vector functions,
- Directional derivatives. Gradient, divergence, curl of vector functions
- Differentiation and integration of vector functions of one variable.

- Line integrals, applications of line integrals: Mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path.
- Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The divergence theorem. Applications of Green's, Stoke's and divergence theorems.

Unit 4.**[25L]**

- A tensor as a generalized concept of a vector in E^3 and its generalization in E^n . Space of n -dimension. Transformation of coordinates. Summation convention.
- Definition of scalar or invariant. Contravariant, covariant vectors and tensors, mixed tensors of arbitrary order. Kronecker delta
- Equality of tensors, addition, subtraction of two tensors.
- Outer product of tensors, contraction and inner product of tensors.
- Symmetric and skew symmetric tensors.
- Quotient law, reciprocal tensor of a tensor.
- Metric tensor, Christoffel symbol, covariant derivative.

SUGGESTED READINGS/REFERENCES:

1. G. B. Thomas and R. L. Finney, Calculus, 9th Ed., Pearson Education, Delhi.
2. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
3. E. Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint.
4. James Stewart, Multivariable Calculus, Concepts and Contexts, Brooks /Cole, Thomson Learning, USA.
5. L. J. Goldstein, D. C. Lay and N. H. Asmar and D. I. Schneider, Calculus and its applications, Pearson.
6. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer.
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
8. Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
9. Terence Tao, Analysis II, Hindustan Book Agency.
10. M. R. Spiegel, Schaum's Outline of Vector Analysis.
11. P.K. Nayak, Vector Algebra and Analysis with Application, University Press.
12. M. S. Speizel, Vector Analysis, McGraw Hill Education.
13. Barry Spain, Vector Analysis, Von Nostrand.
14. B. Spain, Tensor Calculus: A Concise Course, Dover Publications.
15. D. C. Kay, Tensor Calculus, McGraw Hill Education.

B.Sc. Mathematics (Major)
SEMESTER-VII
Course Code: MATH-M-T-11
Course title: Probability & Statistics
Major Course; Credit-6; Full Marks-75

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

Unit 1. [20L]

- Sample space, probability axioms, real random variables (discrete and continuous).
- Probability distribution function, probability mass/density functions. Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.
- Mathematical expectation, moments, moment generating function, characteristic function.

Unit 2. [20L]

- Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions.
- Expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient. Linear regression for two variables.

Unit 3. [15L]

- Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers.
- Central limit theorem for independent and identically distributed random variables with finite variance.

Unit 4. [20L]

- Random samples, sampling distributions.
- Estimation of parameters and estimate – consistent and biased. Maximum likelihood estimation. Applications to binomial, Poisson and normal populations.
- Confidence interval. Interval estimation for parameters of normal population. Confidence intervals for mean and standard deviation of a normal population. Approximate confidence limits for the parameter of a binomial population.
- Testing of hypotheses.

SUGGESTED READINGS/REFERENCES:

1. A. Gupta, Groundwork of Mathematical Probability and Statistics, Academic publishers.
2. E. Rukmangadachari, Probability and Statistics, Pearson.
3. G. S. Rao, Probability and Statistics, University Press.
4. R.V. Hogg, J.W. McKean, A.T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia.
5. Irwin Miller, Marylees Miller, John E. Freund, Mathematical Statistics with Applications, Pearson Education, Asia.
6. Sheldon Ross, Introduction to Probability Models, Academic Press.
7. V. K. Rohatgi, A. K. Saleh, An Introduction to Probability and Statistics, Wiley.
8. S. Lipschutz, Probability: Schaum's Outlines Series, McGraw Hill Education.
9. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, Tata McGraw- Hill.

B.Sc. Mathematics (Major)
SEMESTER-VII
Course Code: MATH-M-T-12
Course title: Mechanics-II
Major Course; Credit-6; Full Marks-75

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

Unit 1. [15L]

- Coplanar forces: Reduction of a system of coplanar forces. Moment about any point as base. Equation of the line of resultant. Necessary and sufficient conditions of equilibrium. Astatic equilibrium. Case of three forces. Action at joint in a framework.
- Principle of Virtual work. Constraint forces and applied forces.
- Forces in three dimensions: Moment of a force about a line. Reduction of a system of forces in space. Poinot's central axis. Invariants of a system of forces. Equations of the central axis. Wrench and screw. Condition for a single resultant force.

Unit-2: [15L]

- Centre of gravity: Centre of gravity of areas, surfaces and volumes (variation of gravity included). Pappus theorem (statement only).
- Stable and unstable equilibrium. stability of equilibrium of two bodies other than spherical bodies. Energy test of stability. Condition of stability of equilibrium of a perfectly rough heavy body lying on a fixed body.

Unit-3: [15L]

- Real and ideal fluids. Pressure of fluid. Transmission of fluid pressure. Elasticity. Specific gravity. (* No broad question is to be set from this section)
- Pressure of heavy fluids: Magnitude of pressure at a point in a liquid. Pressure at all points at the same horizontal level in a liquid at rest under gravity. For a liquid in equilibrium under gravity, the difference of pressure between any two points is proportional to their depths. Free surface of a homogeneous in equilibrium under gravity is horizontal. Horizontal planes in a liquid in equilibrium under gravity are surfaces of equal density. Pressure at any point in the lower of two immiscible liquids in equilibrium under gravity; Surface of separation is a horizontal plane. Thrust of homogeneous liquids on the plane surface.
- Condition of equilibrium of fluids: Pressure derivative in terms of force. Pressure equation and the conditions of equilibrium. Surfaces of equal pressure. Fluid of equilibrium under gravity. Fluid in relative equilibrium. Rotating fluid.

Unit-4: [15L]

- Centre of pressure: Definition, position of the centre of pressure (C.P.) of a plane area. C.P. of a plane area immersed in a heavy liquid under gravity. Positions of centres of pressure of some simple areas, e.g. triangular area, parallelogram, circular area, composite plane area. C.P. of a plane area immersed in a number of liquids with different densities. Locus of the C.P. C.P. of a plane area referred to the axes through its centroid.
- Thrusts on curved surfaces: Resultant thrust on a curved surface of a heavy homogeneous fluid at rest. Resultant thrust on a solid body wholly or partially immersed in a heavy fluid at rest. Resultant vertical

thrust on a surface exposed to the pressure of a heavy fluid at rest. Resultant horizontal thrust in a given direction on a given surface. Resultant thrust on any surface of a liquid at rest under given forces. Resultant thrust on the curved surface of a solid bounded by a plane curve.

Unit-5: [15L]

- Equilibrium of floating bodies: Conditions of equilibrium. Bodies floating under constraint. Potential energy of a liquid.
- Stability of floating bodies: Plane and surface of floatation. Buoyancy. Metacentre and metacentric height. Conditions of stability of equilibrium. Properties of surface of buoyancy. Equilibrium of a vessel containing liquid. Some elementary curves of buoyancy, e.g., triangle, rectangle. Oscillation of floating bodies.

SUGGESTED READINGS/REFERENCES:

1. Verma, R. S., A Textbook on Statics, Pothishala.
2. I.H. Shames, G.K.M. Rao, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley Pvt. Ltd.
3. R.C. Hibbeler, A. Gupta, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley Pvt. Ltd.
4. A.S. Ramsey, Hydrostatics, Cambridge University Press.
5. W. H. Besant, A.S. Ramsey, A Treatise on Hydromechanics: Part 1, CBS Publishers.

B.Sc. Mathematics (Major)
SEMESTER-VII
Course Code: MATH-M-T-13
Course title: Metric Spaces & Complex Analysis
Major Course; Credit-4; Full Marks-75

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

Unit 1. [15L]

- Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set.
- Sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's intersection theorem (statement only), subspaces, dense sets, separable spaces.

Unit 2. [20L]

- Continuous mappings, sequential criterion, and other characterizations of continuity. Uniform continuity. Connectedness in metric space and its basic properties, connected subsets of \mathbb{R} .
- Compactness, sequential compactness, Heine-Borel property, countable compactness, totally bounded spaces, finite intersection property, and continuous functions on compact sets.

Unit 3. [10L]

- Complex plane, functions of complex variables, limits, limits involving the point at infinity, continuity.
- Derivatives of functions, analytic functions, examples of analytic functions, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

Unit 4. [15L]

- Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.

- Complex line integral. Cauchy- Goursat theorem (statement only). Cauchy integral formula. Liouville's theorem. Fundamental theorem of classical algebra.

Unit 4. **[15L]**

- Zeros of an analytic function. Singularities and their classifications. Riemann's Theorem, Rouche's Theorem. Argument Principle (statement only).
- Bilinear transformation. Conformal mapping. Contour integration.

SUGGESTED READINGS/REFERENCES:

1. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House.
2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill.
3. S. Shirali, H. L. Vasudeva, Metric Spaces, Springer Verlag, London.
4. B. K. Lahiri, Elements of Functional Analysis, World Press.
5. L. Ahlfors, Complex Analysis, McGraw Hill Education.
6. J. W. Brown, R. V. Churchill, Complex Variables and Applications, McGraw-Hill.
7. R. Roopkumar, Complex Analysis, Pearson.
8. J. Bak and D. J. Newman, Complex Analysis, Undergraduate Texts in Mathematics, Springer-Verlag.
9. S. Ponnusamy, Foundations of Complex Analysis.
10. E. M. Stein and R. Shakrachi, Complex Analysis, Princeton University Press.

B.Sc. Other than Mathematics (Minor)
SEMESTER-VII
Course: MATH-MI-T-04
Course title: Dynamics of a Particle
Minor Course; Credit-4; Full Marks-50

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

Unit-1: **[15L]**

- Motion in a straight line, motion under attractive and repulsive forces, motion under acceleration due to gravity.
- Simple Harmonic Motion, Horizontal Oscillation, Composition of two S.H.M.'s, damped harmonic motion, forced oscillation, damped forced oscillation.
- Motion in a resisting medium: Vertical and curvilinear motion in a resisting medium.
- Motion of varying mass: Equations of motion.

Unit-2: **[15L]**

- Work, Power and Energy: Definitions. Work done in stretching an elastic string.
- Conservative forces. Conservation of energy.
- Impulse and impulsive forces: Impulse of a force. Impulsive forces. Conservation of linear momentum.
- Collision of elastic bodies: Elasticity. Impact of smooth bodies. Impact on a fixed plane. Direct and oblique impact of two smooth spheres. Loss of kinetic energy. Angle of deflection

Unit-3: **[20L]**

- Motion in a Plane: Velocity and acceleration of a particle moving on a plane in Cartesian and polar coordinates. Motion of a particle moving on a plane refers to a set of rotating rectangular axes. Angular velocity and acceleration. Circular motion. Tangential and normal accelerations.

- Central orbit: Characteristics of central orbits. Areal velocity. Law of force for elliptic, parabolic and hyperbolic orbits. Velocity under central forces. Orbit under radial and transverse accelerations. Stability of nearly circular orbits.
- Planetary motion: Newtonian law. Orbit under inverse square law. Kepler's laws of planetary motion. Time of description of an arc of an elliptic, Parabolic and hyperbolic orbit. Effect of disturbing forces on the orbit. Artificial satellites: Orbit round the earth. Parking orbits. Escape velocity.

SUGGESTED READINGS/REFERENCES:

1. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw Hill Book Company, New York.
2. I. H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. F. Chorlton, Textbook of Dynamics, John Wiley & Sons.
5. S. L. Loney, An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, New Age International Private Limited.
6. S. L. Loney, Elements of Statics and Dynamics I and II, AITBS.
7. A. S. Ramsey, Dynamics (Part I), CBS Publishers & Distributors.

B.Sc. Mathematics (Major)
SEMESTER-VIII
Course Code: MATH-M-T-14
Course title: Ordinary and Partial Differential Equations
Major Course; Credit-4; Full Marks-50

COURSE CONTENT:

4 Credits (3+1) (Theory + Tutorial)

- Unit 1.** **[20]**
- Existence and uniqueness of Initial Value Problems: Picard's Theorem, Gronwall's lemma.
 - Boundary Value Problems: Regular Sturm-Liouville problems, Sturm Separation theorem, Sturm Comparison theorem.
 - Green's functions.
 - Series solution of second order linear equations: ordinary points, regular singular points: Fuchs' theorem and Frobenius theorem (statement only).
 - Legendre polynomials and properties, Bessel functions and properties.
- Unit 2.** **[10L]**
- Derivation of heat equation, wave equation and Laplace equation.
 - Classification of second order linear equations as hyperbolic, parabolic or elliptic.
 - Reduction of second order linear equations to canonical forms.
- Unit 3.** **[20L]**
- The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string.
 - Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end.
 - Equations with non-homogeneous boundary conditions. Non-homogeneous wave equation.

- Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem.
- One dimensional diffusion equation and parabolic differential equations. Method of separation of variables. Solving the vibrating string problem and the heat conduction problem.
- Wave equation. Travelling Waves.

SUGGESTED READINGS/REFERENCES:

1. I. N. Sneddon, Elements of Partial Differential Equations, McGraw Hill.
2. L. C. Evans, Partial Differential Equations, American Mathematical Society Press.
3. P. J. Oliver, Introduction to Partial Differential Equations, Springer.
4. Tyn Myint-U, L. Debnath, Linear Partial Differential Equations for Scientists and Engineers, Springer.
5. S. L. Ross, Differential Equations, John Wiley and Sons.
6. F. H. Miller, Partial Differential Equations, John Wiley and Sons.
7. G. B. Folland, Introduction to Partial Differential Equations, Princeton University Press.

B.Sc. Mathematics (Major)
SEMESTER-VIII
Course Code: MATH-M-T-15
Course title: Classical Mechanics
Major Course; Credit-4; Full Marks-50

COURSE CONTENT:

4 Credits (3+1) (Theory + Tutorial)

Unit 1.

[20]

- Generalized coordinates. Generalized forces. Constraints. Virtual work. Holonomic and non-holonomic systems.
- Lagrange's equations of first kind and second kind. Lagrange's equations using D' Alembert's Principle for a holonomic conservative system.
- Hamilton's Principle. Derivation of Hamilton's principle from D'Alembert's principle. Derivation of Lagrange equations from Hamilton's principle.
- Extension of principle to nonholonomic systems. Conservation theorems and symmetry properties.

Unit 2.

[15]

- Physical significance of Hamiltonian.
- Hamilton equations of motion.
- Derivation of Hamilton's equations from variational principle.
- Cyclic coordinates and Routhian procedure.
- The principle of least action. Small oscillations of conservative system.
- Orthogonal transformations. Properties of transformation matrix, infinitesimal rotations.

Unit 3.

[15]

- Canonical transformations, Hamilton-Jacobi equation. Method of Separation of variables.
- Hamilton's equations in Poisson bracket.
- Canonical character of transformation through Poisson bracket.

SUGGESTED READINGS/REFERENCES:

1. H. Goldstein, Classical Mechanics, 2nd Edition, Narosa publishing house, New Delhi.
2. Donald T. Greenwood, Classical Dynamics, 3rd Edition, Prentice-Hall Private Limited, New Delhi.
3. N.C. Rane, P.S.C. Joag, Classical Mechanics, New Delhi: Tata McGraw Hill.
4. S. Chandra, Classical Mechanics: A Textbook, UK: Alpha Science International.
5. John R. Taylor, Classical Mechanics, 2nd Edition, California: University Science Books, Sausalito.
6. J.E. Marsden, Lectures on Mechanics, Cambridge University Press.

B.Sc. Mathematics (Major)
SEMESTER-VIII
Course Code: MATH-M-T-16
Course title: Operations Research
Major Course; Credit-4; Full Marks-50

COURSE CONTENT:

4 Credits (3+1) (Theory + Tutorial)

Unit 1. [10L]

Extension of Linear Programming Methods: Theory of Revised Simplex Method and algorithmic solution approaches to linear programs, Dual-Simplex Method.

Unit 2. [10L]

Sensitivity Analysis: Changes in price vector of objective function, changes in resource requirement vector, addition of decision variable, addition of a constraint.

Unit 3. [5L]

Parametric Programming: Variation in price vector, Variation in requirement vector.

Unit 4. [10L]

Integer Programming (IP): The concept of cutting plane for linear integer programs, Gomory's cutting plane method, Gomory's All-Integer Programming Method, Mixed integer programming method, Branch-and-Bound Algorithm for general integer programs.

Unit 5. [5L]

Sequencing Models: The mathematical aspects of Job sequencing and processing problems, Processing n jobs through Two machines, processing n jobs through m machines.

Unit 6. [10L]

Nonlinear Programming (NLP): Convex analysis, Necessary and Sufficient optimality conditions, General Non-linear programming problem, Graphical solution method.

SUGGESTED READINGS/REFERENCES:

1. Linear Programming – G. Hadley.
2. Mathematical Programming Techniques – N. S.Kambo.
3. Nonlinear and Dynamic Programming – G. Hadley.
4. Operations Research – K. Swarup, P. K. Gupta and Man Mohan.
5. Operations Research – H. A. Taha.
6. Operations Research – S. D. Sharma.
7. Introduction to Operations Research – A. Frederick, F. S. Hillier and G. J. Lieberman.
8. Optimization: Theory and Applications – S. S. Rao.
9. Nonlinear and Mixed-Integer Optimization – Christodoulos A. Floudas.

B.Sc. Mathematics (Major)
SEMESTER-VIII
Course Code: MATH-M-T-17
Course title: Real Analysis-II & Functional Analysis
Major Course; Credit-6; Full Marks-75

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

Unit 1. [15L]

- Functions of bounded variation, Definition and basic properties, Lipschitz condition.
- Absolutely continuous functions, Definition and basic properties.
- Characterization of an absolutely continuous function in terms of its derivative vanishing almost everywhere.
- Riemann-Stieltjes integral, Basic properties and conditions for existence, integration by parts, change of variable.

Unit 2. [20L]

- The Lebesgue measure, Definition of the Lebesgue outer measure on the power set of \mathbb{R} .
- Countable subadditivity, Measurability of an interval, Countable additivity.
- Characterizations of measurable sets by open sets.
- G_δ sets, closed sets and F_σ sets, Measurability of Borel sets.
- Measurable functions, Definition on a measurable set in \mathbb{R} and basic properties.
- Simple functions, Sequences of measurable functions.
- Measurable functions as the limits of sequences of simple functions.

Unit 3. [15L]

- Hölder's and Minkowski's inequalities (statement only), Baire's category theorem. The spaces \mathbb{R}^k , \mathbb{C}^k , $\mathbb{C}[a, b]$, ℓ_p .
- Contraction, Banach's fixed point theorem, simple applications
- Normed-linear spaces, Banach spaces, Riesz's lemma (statement only). Finite dimensional normed linear spaces and subspaces, completeness, compactness criteria, Equivalent norms.

Unit 4. [25L]

- Linear operators, Linear operators on normed linear spaces, continuity, bounded linear operators, norm of an operator, Inverse of an operator.
- Linear functionals. Hahn-Banach theorem (statement only), simple applications, Uniform boundedness principle (statement only), simple applications.
- Inner product spaces, Cauchy Schwarz's inequality, polarization identity, parallelogram law.
- Orthogonality, Pythagorean theorem, orthonormality, Bessel's inequality.

SUGGESTED READINGS/REFERENCES:

1. W. Rudin: Principles of Mathematical Analysis.
2. H. L. Royden: Real Analysis.
3. B. K. Lahiri and K. C. Ray: Real Analysis.

4. W. Sierpinsky: Cardinal Number and Ordinal Number.
5. I. P. Natanson: Theory of Integrals of a Real Variable (Vol. I and II).
6. Malik and Arora: Mathematical Analysis.
7. G. de BARRA: Measure theory and integration.
8. B. K. Lahiri and K. C. Ray: Real Analysis.
9. P. K. Jain, V. P. Gupta and P. Jain: Lebesgue measure and integration
10. E. Kreyszig: Introductory Functional Analysis with Applications.
11. W. Rudin: Functional Analysis.
12. N. Dunford and L. Schwartz : Linear Operators (Part I).
13. A. E. Taylor: Introduction to Functional Analysis.
14. B. V. Limaye: Functional Analysis.
15. K. Yoshida: Functional Analysis.
16. B. K. Lahiri: Elements of Functional Analysis.

B.Sc. Mathematics (Major)
SEMESTER-VIII
Course Code: MATH-M-T-18
Course title: Nonlinear Dynamics & Biomathematics
Major Course; Credit-6; Full Marks-75

COURSE CONTENT:

6 Credits (5+1) (Theory + Tutorial)

Unit 1.

[20L]

- Linear autonomous systems: Linear autonomous systems, existence, uniqueness and continuity of solutions, diagonalization of linear systems, fundamental theorem of linear systems, the phase paths of linear autonomous plane systems, complex eigen values, multiple eigen values.
- Qualitative analysis of continuous models: Linearization, equilibrium points, hyperbolic and non-hyperbolic equilibrium, Routh-Hurwitz criteria for stability.
- Global stability (Liapunov's method). Limit set, attractors, periodic orbits, limit cycles. Bendixon criterion, Dulac criterion, Poincare-Bendixon Theorem.
- Bifurcations: Saddle-Node, transcritical, pitchfork, and Hopf bifurcations.

Unit-2

[20L]

- Mathematical biology and the modeling process: an overview.
- Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth.
- Bacterial growth in a chemostat, harvesting a single natural population.
- Prey-predator systems and Lotka-Volterra equations, populations in competitions, epidemic models (SI, SIR, SIRS).

Unit-3

[20L]

- Interpretation of the phase plane. Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenarios.
- Spatial models: One species model with diffusion. Two species model with diffusion.
- Conditions for diffusive instability, spreading colonies of microorganisms.

Unit-4**[15]**

- Introduction to discrete models, Overview of difference equations, steady state solution and linear stability analysis.
- Linear models, growth models, decay models, drug delivery problem, discrete prey-predator models, density dependent growth models with harvesting, host-parasitoid systems (Nicholson-Bailey model),
- Optimal exploitation models, models in genetics, stage-structure models, age-structure models.

SUGGESTED READINGS/REFERENCES:

1. D. W. Jordan and P. Smith (1998): Nonlinear Ordinary Equations- An Introduction to Dynamical Systems (Third Edition), Oxford Univ. Press.
2. L. Perko (1991): Differential Equations and Dynamical Systems, Springer Verlag.
3. F. Verhulst (1996): Nonlinear Differential Equations and Dynamical Systems, Springer Verlag.
4. H. I. Freedman - Deterministic Mathematical Models in Population Ecology.
5. Mark Kot (2001): Elements of Mathematical Ecology, Cambridge Univ. Press.
6. W. G. Kelley, A. C. Peterson, Difference Equations- An Introduction with Applications, Academic Press.
7. S. Elaydi. An Introduction of Difference Equation, Springer.
8. L. E. Keshet, Mathematical Models in Biology, SIAM.
9. J. D. Murray, Mathematical Biology-I: An Introduction, Springer.
10. J. D. Murray, Mathematical Biology-II: Spatial Models and Biomedical Applications, Springer.
11. Suzanne Lenhart, Mathematics for the Life Sciences, Princeton University Press.
12. F. Brauer, P. V. D. Driessche and J. Wu, Mathematical Epidemiology, Springer.
13. Hal L. Smith, P. Waltman, The Theory of the Chemostat, Cambridge University Press.