

University of Kalyani



CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE

IN

Mathematics (HONOURS)

WITH EFFECT FROM THE ACADEMIC SESSION

2021-22

FOREWORD

The draft syllabus for B.A./ B.Sc. (Hons.) in Mathematics was prepared by the Undergraduate Board of Studies (UGBOS) in Mathematics, University of Kalyani by considering the proposals received through the “*Online Workshop on Curricular Modifications of Undergraduate Courses in Mathematics under CBCS pattern*” held on 11th July, 2021 and also by considering the suggestions received through an extended meeting of UGBOS held on 26th July, 2021.

In 5th meeting of UGBOS in Mathematics held on 29th July, 2021, the Chairman of the board placed before the members a draft syllabus by maintaining the guidelines ‘Instructional Template for Facilitating Implementation of Choice Based Credit System (CBCS)’ notified by University Grants Commission (UGC), New Delhi, which has been adopted by University of Kalyani, and also following the outline “Proposed Syllabus and Scheme of Examination for B.Sc. (Hons.) Mathematics” of UGC under the Choice Based Credit System dated May 2015.

After threadbare discussion, this Board unanimously resolved to recommend the Course curriculum for B.A./ B.Sc. (Hons.) program in Mathematics under Choice Based Credit System. The Board, after a thorough perusal of all details within prescribed units of each course, recommended the same and authorized the Chairman to forward the proposal in its totality to the appropriate section of the university administration so that it could be finalized and introduced from the new academic session of 2021-2022.

Existing Members of UGBOS in Mathematics, KU

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

Kalyani
29th July, 2021

--Chairman, UGBOS in Mathematics, KU

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN Mathematics (HONOURS)

INTRODUCTION:

The University Grants Commission (UGC) has taken various measures by means of formulating regulations and guidelines and updating them, in order to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions in India. The various steps that the UGC has initiated are all targeted towards bringing equity, efficiency and excellence in the Higher Education System of the country. These steps include introduction of innovation and improvements in curriculum structure and content, the teaching-learning process, the examination and evaluation systems, along with governance and other matters. The introduction of Choice Based Credit System is one such attempt towards improvement and bringing in uniformity of system with diversity of courses across all higher education institutes in the country. The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising of core, elective, skill enhancement or ability enhancement courses. The courses shall be evaluated following the grading system, is considered to be better than the conventional marks system. This will make it possible for the students to move across institutions within India to begin with and across countries for studying courses of their choice. The uniform grading system shall also prove to be helpful in assessment of the performance of the candidates in the context of employment.

Outline of the Choice Based Credit System being introduced:

1. **Core Course (CC):** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
2. **Elective Course:** Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the student's proficiency/skill is termed as an Elective Course.
 - 2.1 **Discipline Specific Elective Course (DSEC):** Elective courses that are offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
 - 2.2 **Generic Elective Course (GEC):** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
3. **Ability Enhancement Courses/ Skill Enhancement Courses:**
 - 3.1 **Ability Enhancement Compulsory Course (AECC):** Ability enhancement courses are the courses based upon the content that leads to Knowledge enhancement. They (i) Environmental Science, (ii) English Communication) are mandatory for all disciplines.
 - 3.2 **Skill Enhancement Course (SEC):** These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN Mathematics (HONOURS)

A. TOTAL Number of courses in UG-CBCS (B.A./B.Sc. Hons.):

Types of course	Core Course (CC)	Elective course		Ability enhancement course		TOTAL
		Discipline Specific Elective course (DSE)	Generic Elective course (GE)	Ability Enhancement Compulsory Course (AECC)	Skill Enhancement Course (SEC)	
No. of course	14	4	4	2	2	26
Credit/course	6	6	6	2	2	140

TABLE-1: DETAILS OF COURSES & CREDIT OF B.A./ B.SC. (HONOURS) UNDER CBCS

S. No.	Particulars of Course	Credit Point	
1.	Core Course: 14 Papers	Theory + Practical	Theory + Tutorial
1.A.	Core Course: Theory (14 papers)	14x4 = 56	14x5 = 70
1.B.	Core Course (Practical/Tutorial)* (14 papers)	14x2 = 28	14x1 = 14
2.	Elective Courses: (8 papers)		
2.A.	A. Discipline specific Elective (DSE) (4 papers)	4x4 = 16	4x5 = 20
2.B.	DSE (Practical / Tutorial)* (4 papers)	4x2 =8	4x1 =4
2C.	General Elective (GE) (Interdisciplinary) (4 papers)	4x4 = 16	4x5 = 20
2.D.	GE (Practical /Tutorial)* (4 papers)	4x2 =8	4x1 =4
#Optional Dissertation/ Project Work in place of one DSE paper (6 credits) in 6th semester			
3. Ability Enhancement Courses			
A.	AECC (2 papers of 2 credits each) ENVS, English Communication/ MIL	2x2 = 4	2x2 = 4
B.	Skill Enhancement Course (SEC) (2 papers of 2 credits each)	2x2 = 4	2x2 = 4
Total Credit:		140	140
## Wherever there is a practical, there will be no tutorial and vice-versa.			

TABLE-2: SEMESTERWISE DISTRIBUTION OF COURSE & CREDITS IN B.A./B.SC. (HONS)

Courses/ (Credits)	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-Vi	Total No. of Courses	Total credit
CC (6)	2	2	3	3	2	2	14	84
DSE (6)	--	--	--	--	2	2	04	24
GE (6)	1	1	1	1	--	--	04	24
AECC (2)	1	1			--	--	02	04
SEC (2)	--	--	1	1	--	--	02	04
Total No. of Course/ Sem.	4	4	5	5	4	4	26	--
Total Credit /Semester	20	20	26	26	24	24	-----	140

TABLE-3: SEMESTER & COURSEWISE CREDIT DISTRIBUTION IN IN B.A./B.COM/B.SC. (Hons.)
(6 Credit: 75 Marks)

SEMESTER-I			
Course Code	Course Title	Course wise Class (L+T+P)	Credit
MATH-H-CC-T-01	Calculus & Analytical Geometry	5:1:0	6
MATH-H-CC-T-02	Algebra	5:1:0	6
MATH-H-GE-T-01*	Algebra & Analytical Geometry	5:1:0	6
AECC-T-01	Environmental Studies	2:0:0	2
Total	4 courses	Total	20
SEMESTER-II			
Course Code	Course Title	Course Nature	Credit
MATH-H-CC-T-03	Real Analysis	5:1:0	6
MATH-H-CC-T-04	Differential Equations	5:1:0	6
MATH-H-GE-T-02*	Calculus & Differential Equations	5:1:0	6
AECC-T-02	English/Modern Indian Language	2:0:0	2
Total	4 courses	Total	20
SEMESTER-III			
Course Code	Course Title	Course Nature	Credit
MATH-H-CC-T-05	Theory of Real & Vector Functions	5:1:0	6
MATH-H-CC-T-06	Group Theory-I	5:1:0	6
MATH-H-CC-T-07	Numerical Methods (Theory) & Numerical Methods Lab	4:0:2	6
MATH-H-GE-T-03*	Algebra & Analytical Geometry	5:1:0	6
MATH-H-SEC-T-01	A. Programming in 'C' B. Programming in Python (Choose any one)	2:0:0	2
Total	5 courses	Total	26
SEMESTER-IV			
Course Code	Course Title	Course Nature	Credit
MATH-H-CC-T-08	Ring Theory & Linear Algebra	5:1:0	6
MATH-H-CC-T-09	Multivariate Calculus & Tensor Analysis	5:1:0	6
MATH-H-CC-T-10	Linear Programming Problems & Game Theory	5:1:0	6
MATH-H-GE-T-04*	Calculus & Differential Equations	5:1:0	6
MATH-H-SEC-T-02	A. Logic & Boolean Algebra B. Graph Theory (Choose any one)	2:0:0	2
Total	5 courses	Total	26
SEMESTER-V			
Course Code	Course Title	Course Nature	Credit
MATH-H-CC-T-11	Riemann Integration & Series of Functions	5:1:0	6
MATH-H-CC-T-12	Mechanics-I	5:1:0	6
MATH-H-DSE-T-01	A. Group Theory-II B. Partial Differential Equations & Laplace Transforms (Choose any one)	5:1:0	6
MATH-H-DSE-T-02	A. Number Theory B. Differential Geometry (Choose any one)	5:1:0	6
Total	4 courses	Total	24
SEMESTER-VI			
Course Code	Course Title	Course Nature	Credit
MATH-H-CC-T-13	Metric Spaces & Complex Analysis	5:1:0	6
MATH-H-CC-T-14	Probability & Statistics	5:1:0	6
MATH-H-DSE-T-03	A. Fuzzy Set Theory B. Bio-Mathematics (Choose any one)	5:1:0	6
MATH-H-DSE-T-04	A. Point Set Topology B. Mechanics-II (Choose any one)	5:1:0	6
Total	4 courses	Total	24
Total (All semesters)	26 courses	Total	140

*These courses are to be taken by the students of other disciplines.

Detail Course & Contents of Mathematics (Honours) syllabus

B.A./B.Sc. Mathematics (Honours)

SEMESTER-I

Course: MATH-H-CC-T-01

Course title: Calculus & Analytical Geometry

Core 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.
- 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 lines, reflection properties of conics, canonical form 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} , $\log(ax+b)$, $\frac{1}{(ax+b)}$, $\sin(ax+b)$, $\cos(ax+b)$, $|ax+b|$ 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 (e.g., 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, Pearson Education, Delhi.
3. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, Dorling Kindersley (India) P. Ltd. (Pearson Education).
4. H. Anton, I. Bivens and S. Davis, Calculus, 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.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-I
Course: MATH-H-CC-T-02
Course title: Algebra
Core 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).
- 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.

Unit 3.

[20L]

- Orthogonal matrix and its properties. 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, 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 Text Book 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.A./B.Sc. Other than Mathematics (Honours)
SEMESTER-I
Course: MATH-H-GE-T-01
Course title: Algebra & Analytical Geometry
General Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.

[40L]

- 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 with 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.**[35L]**

- 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, polar equation of chord joining two points, polar equations of tangents and normals.

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, Pearson Education Asia, Indian Reprint.
6. P. K. Saikai, Linear Algebra, Pearson.
7. K. Hoffman, R. Kunze, Linear Algebra, Pearson.
8. John B. Fraleigh, A First Course in Abstract Algebra, Pearson.
9. P. R. Vittal, Analytical Geometry 2D and 3D, Pearson.
10. S. L. Loney, Co-ordinate Geometry, Arihant Publications.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-II
Course: MATH-H-CC-T-03
Course title: Real Analysis
Core Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.

[17L]

- The natural numbers: Peano's axioms.
- Review of algebraic and order properties of \mathbb{R} .
- Bounded above sets, bounded below sets, bounded sets, unbounded sets. L.U.B. (supremum) and G.L.B. (infimum) of a set and its properties. L.U.B. axiom or order completeness of \mathbb{R} .
- Idea of countable sets, uncountable sets and uncountability of \mathbb{R} . Countability of \mathbb{Q} .
- The Archimedean property, density of rational (and irrational) numbers in \mathbb{R} .

Unit 2.

[18L]

- Intervals, ε -neighbourhood of a point in \mathbb{R} , interior points and open sets, limit points and closed sets, union and intersection of open and closed sets, isolated points, adherent point, derived set, closure of a set, interior of a set.
- Illustrations of Bolzano-Weierstrass theorem for sets. Upper and lower limits of a subset of \mathbb{R} .
- Compact set in \mathbb{R} , basic properties of compact sets. Lindelöf covering theorem (statement only). Heine-Borel theorem and its application. Converse of Heine-Borel theorem.

Unit 3.

[20L]

- Sequences, bounded sequence, convergent sequence, limit of a sequence, $\lim inf x_n$, $\lim sup x_n$.
- 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 theorems.

Unit 4.

[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 (Statement only), integral test, Cauchy's condensation test with examples.
- Alternating series, Leibnitz test. Absolute and conditional convergence.

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 n^{th} and $(n+1)^{\text{th}}$ term.

SUGGESTED READINGS/REFERENCES:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
2. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, An Introduction to Analysis, 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.A./B.Sc. Mathematics (Honours)
SEMESTER-II
Course: MATH-H-CC-T-04
Course title: Differential Equations
Core 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 for homogeneous equation.
- 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, 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, 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, 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.A./B.Sc. Other than Mathematics (Honours)

SEMESTER-II

Course: MATH-H-GE-T-02

Course title: Calculus & Differential Equations
General Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.

[35L]

- 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.
- 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.

[15L]

- 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.

[25L]

- 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.

SUGGESTED READINGS/REFERENCES:

1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 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. G. B. Thomas and R.L. Finney, Calculus, Pearson Education.
5. Santi Narayan, Integral Calculus, S. Chand.
6. S. L. Ross, Differential Equations, John Wiley and Sons, India.
7. E. L. Ince, Ordinary Differential Equations, Dover Publications.
8. E. Rukmangadachari, Differential Equations, Pearson.
9. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.
10. G. F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-III
Course: MATH-H-CC-T-05
Course title: Theory of Real & Vector Functions
Core Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1: **[25L]**

- Limits of functions ($\epsilon - \delta$ approach). Sequential criterion for limits. Divergence criteria. Limit theorems, one sided limits. 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.

Unit 2. **[20L]**

- Differentiability of a function at a point and in an interval.
- Caratheodory's theorem.
- Algebra of differentiable functions.
- Darboux's theorem.

Unit 3. **[20L]**

- 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.

Unit 4. **[10L]**

- Vector products.
- Introduction to vector functions, operations with vector-valued functions.
- Limits and continuity of vector functions.
- Differentiation and integration of vector functions of one variable ($\int_a^b \vec{f}(t) dt$).
- Gradient, divergence, curl of vector functions.

SUGGESTED READINGS/REFERENCES:

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons.
2. K. A. Ross, Elementary Analysis: The Theory of Calculus, Springer.

3. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House.
6. A. Mattuck, Introduction to Analysis, Prentice Hall.
7. S. R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer.
8. V. Karunakaran, Real Analysis, Pearson.
9. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer.
10. Terence Tao, Analysis II, Hindustan Book Agency.
11. S. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing.
12. M. S. Speizel, Vector Analysis, McGraw Hill Education.
13. Barry Spain, Vector Analysis, Von Nostrand.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-III
Course: MATH-H-CC-T-06
Course title: Group Theory-I
Core Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.

[30L]

- Subgroups, examples and properties of subgroups.
- Product of two subgroups.
- Cyclic group, examples and properties of cyclic group.
- Classification of subgroups of cyclic groups.
- Cosets and their properties.
- Lagrange's theorem and consequences including Fermat's little theorem.

Unit 2.

[25L]

- External direct product of a finite number of groups.
- Centre of a group, centralizer, normalizer.
- Normal subgroups.
- Factor groups.
- Cauchy's theorem for finite abelian groups.

Unit 3.

[20L]

- Group homomorphisms, basic properties of homomorphisms.
- Cayley's theorem.
- Properties of isomorphisms.
- First, second and third isomorphism theorems.

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, Pearson.
3. M. Artin, Abstract Algebra, Pearson.
4. Joseph A. Gallian, Contemporary Abstract Algebra, Narosa Publishing House, New Delhi.
5. Joseph J. Rotman, An Introduction to the Theory of Groups, 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.A./B.Sc. Mathematics (Honours)
SEMESTER-III****Course: MATH-H-CC-T-07****Course title: Numerical Methods (Theory) & Numerical Methods Lab
Core Course; Credit-6; Full Marks-75****Numerical Methods (Theory)****COURSE CONTENT:**

6 Credits (4+2) (Theory + Practical)

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' or Python programming)

[25L]

[Two experiments are to be performed in the presence of External Examiner(s) (Marks: 7.5x2) and Viva (Marks: 5)]

(A practical note book must be maintained as a part of Internal Assessment)

- (i) Calculate the sum of infinite convergent series.
- (ii) Find the absolute value of an integer.
- (iii) Enter 100 integers into an array and sort them in an ascending order.
- (iv) Bisection Method.
- (v) Newton Raphson Method.
- (vi) Secant Method.
- (vii) Regula-Falsi Method.
- (viii) LU decomposition Method.
- (ix) Gauss-Jacobi Method.
- (x) SOR Method or Gauss-Seidel Method.
- (xi) Lagrange's Interpolation
- (xii) Trapezoidal Rule.
- (xiii) Simpson's rule.

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.A./B.Sc. Other than Mathematics (Honours)
SEMESTER-III
Course: MATH-H-GE-T-03
Course title: Algebra & Analytical Geometry
General Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.

[40L]

- 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 with 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.

[35L]

- 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 polar equation of chord joining two points polar equations of tangents and normals.

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, Pearson Education Asia, Indian Reprint.
6. P. K. Saikai, Linear Algebra, Pearson.

7. K. Hoffman, R. Kunze, Linear Algebra, Pearson.
8. John B. Fraleigh, A First Course in Abstract Algebra, Pearson.
9. P. R. Vittal, Analytical Geometry 2D and 3D, Pearson.
10. S. L. Loney, Co-ordinate Geometry, Arihant Publications.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-III
Course: MATH-H-SEC-T-1A
Course title: Programming in 'C'
Skill Enhancement Course; Credit-2; Full Marks-50

COURSE CONTENT:

2 Credits (Theory)

Unit 1.

[7L]

- 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.

[18L]

- 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.

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.A./B.Sc. Mathematics (Honours)
SEMESTER-III
Course: MATH-H-SEC-T-1B
Course title: Programming in Python
Skill Enhancement Course; Credit-2; Full Marks-50

COURSE CONTENT:

2 Credits (Theory)

Unit 1.

[7L]

- 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.

[18L]

- Overview of programming: Structure of a Python Program, elements of Python.
- Introduction to Python: Python Interpreter, Using Python as calculator, Python shell, Indentation. Atoms, identifiers and keywords, literals, strings, operators (Arithmetic operator, relational operator, logical or Boolean operator, assignment, operator, ternary operator, bit wise operator, increment or decrement operator).
- Creating Python Programs: Input and Output statements, control statements (branching, looping, conditional statement, exit function, difference between break, continue and pass), defining functions, default arguments.

SUGGESTED READINGS/REFERENCES:

1. T. Budd, Exploring Python, McGraw Hill Education.
2. Kenneth A. Lambert, Fundamentals of Python, Cengage Learning, Inc.
3. Mark Lutz, Learning Python, O'Reilly Media, Inc.
4. Tony Gaddis, Starting Out with Python, Pearson.
5. T. Sheetal, K. Naveen, Python Programming: A modular approach, Pearson.
6. R. N. Rao, Core Python Programming, Dreamtech Press.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-IV
Course: MATH-H-CC-T-08
Course title: Ring Theory & Linear Algebra
Core Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1. **[20L]**

- 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.

Unit-2: **[20L]**

- Ring homomorphisms, properties of ring homomorphisms.
- Isomorphism theorems I, II and III.
- Field of quotients.

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

- 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 4. **[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 Education.
2. John B. Fraleigh, A First Course in Abstract Algebra, Pearson.
3. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
4. Joseph J. Rotman, An Introduction to the Theory of Groups, Springer Verlag.
5. R. K. Sharma, S. K. Shah and A. G. Shankar, Algebra-I, Pearson.
6. U. M. Swamy, A.R.S.N. Murthy, Algebra, Pearson.

7. M. Artin, Abstract Algebra, Pearson.
8. Joseph A Gallian, Contemporary Abstract Algebra, Narosa.
9. S. Lang, Introduction to Linear Algebra, Springer.
10. Gilbert Strang, Linear Algebra and its Applications, Thomson.
11. M. K. Sen, S. Ghosh and P. Mukhopadhyay, Topics in Abstract Algebra, University Press.
12. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India.
13. A. R. Rao, P. Bhimasankaram, Linear Algebra, Hindustan book Agency.
14. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, Prentice-Hall of India Pvt. Ltd.
15. S. H. Friedberg, A.L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-IV
Course: MATH-H-CC-T-09
Course title: Multivariate Calculus & Tensor Analysis
Core 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 Theorems, Young's Theorems.
- 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]

- Directional derivatives. The gradient, maximal and normal property of the gradient.
- 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^2 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, 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. B. Spain, Tensor Calculus: A Concise Course, Dover Publications.
13. I. S. Sokolnikoff, Tensor Analysis and Applications, John Wiley & Sons.
14. D. C. Kay, Tensor Calculus, McGraw Hill Education.
15. A. I. Borisenko, Vector and Tensor Analysis with Applications, Dover Publications.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-IV
Course: MATH-H-CC-T-10
Course title: Linear Programming Problems & Game Theory
Core 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, two-phase method. Big-M method and their comparison.
- 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 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 problems.
- Travelling Salesman Problems.

Unit 4. **[20L]**

- Game theory: Formulation of two-person zero sum games.
- Solving two persons 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.A./B.Sc. Other than Mathematics (Honours)
SEMESTER-IV
Course: MATH-H-GE-T-04
Course title: Calculus & Differential Equations
General Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.

[35L]

- 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.
- 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.

[15L]

- 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.

[25L]

- 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.

SUGGESTED READINGS/REFERENCES:

1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 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, 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.A./B.Sc. Mathematics (Honours)
SEMESTER-IV
Course: MATH-H-SEC-T-2A
Course title: Logic & Boolean Algebra
Skill Enhancement Course; Credit-2; Full Marks-50

COURSE CONTENT:

2 Credits (Theory)

Unit 1. **[10L]**

- 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. **[5L]**

- 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 **[10L]**

- 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 and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, Pearson Education (Singapore) P.Ltd., Indian Reprint.
6. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-IV
Course: MATH-H-SEC-T-2B
Course title: Graph Theory
Skill Enhancement Course; Credit-2; Full Marks-50

COURSE CONTENT:

2 Credits (Theory)

Unit 1.

[8L]

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

Unit 2

[10L]

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

Unit 3.

[7L]

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

SUGGESTED READINGS/REFERENCES:

1. B. A. Davey and 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, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
4. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, Pearson Education (Singapore) P. Ltd., Indian Reprint.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-V
Course: MATH-H-CC-T-11
Course title: Riemann Integration and Series of Functions
Core Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1. **[23L]**

- 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. **[22L]**

- 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.A./B.Sc. Mathematics (Honours)
SEMESTER-V
Course: MATH-H-CC-T-12
Course title: Mechanics-I
Core 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: [10L]

- 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: [30L]

- 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. Equi-momental 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.A./B.Sc. Mathematics (Honours)
SEMESTER-V
Course: MATH-H-DSE-T-1A
Course title: Group Theory-II
Discipline Specific Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

- Unit 1.** **[25L]**
- 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 basic properties, relationship with solvability of groups.
- Unit 2.** **[17L]**
- 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.
- Unit 4.** **[15L]**
- Group actions, stabilizers and kernels, permutation representation associated with a given group action.
 - Applications of group actions: Generalized Cayley's theorem, Index theorem.
- Unit 4.** **[18L]**
- Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n , p -groups,
 - Sylow's theorems and consequences.
 - Cauchy's theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests.

SUGGESTED READINGS/REFERENCES:

1. D. S. Malik, John M. Mordeson and M. K. Sen, Fundamentals of Abstract Algebra. McGraw-Hill.
2. M. K. Sen, S. Ghosh and P. Mukhopadhyay, Topics in Abstract Algebra, University Press.
3. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
4. John B. Fraleigh, A First Course in Abstract Algebra, Pearson.
5. M. Artin, Abstract Algebra Pearson.
6. Joseph A. Gallian, Contemporary Abstract Algebra, Narosa Publishing House.
7. David S. Dummit and Richard M. Foote, Abstract Algebra, John Wiley and Sons (Asia) Pvt. Ltd.
8. R. K. Sharma, S. K. Shah and A. G. Shankar, Algebra-I, Pearson.
9. U. M. Swamy, A.R.S.N. Murthy, Algebra, Pearson.
10. J. R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc.
11. D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd.

B.A./B.Sc. Mathematics (Honours) SEMESTER-V

Course: MATH-H-DSE-T-1B

Course title: Partial Differential Equations & Laplace Transforms Discipline Specific Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.

[20L]

- Derivation of heat equation, wave equation and Laplace equation.
- Classification of second order linear equations.
- Reduction of second order linear equations to canonical forms.

Unit 2.

[30L]

- The Cauchy problem, Cauchy-Kovalevskaya theorem (Statement only), Cauchy problem of an infinite string.
- Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end.
- 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.

Unit 3.

[15L]

- Laplace Transform (LT) of Elementary functions. Properties of LTs: change of scale theorem, shifting theorem. LTs of derivatives and integrals of functions, derivatives and integrals of LTs. LT of Dirac Delta function, periodic functions.
- Convolution Theorem. Inverse LT. Application of Laplace transforms to solve ordinary and partial differential equations.

Graphical Demonstration (Teaching aid)**[10L]**

1. Solution of Cauchy problem for first order PDE.
2. Finding the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:
 - (a) $u(x,0) = \phi(x), u_t(x,0) = \psi(x), x \in R, t > 0.$
 - (b) $u(x,0) = \phi(x), u_t(x,0) = \psi(x), u(0,t) = 0, x \in (0, \infty), t > 0$
5. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:
 - (a) $u(x,0) = \phi(x), u(0,t) = a, u(l,t) = b, 0 < x < l, t > 0.$
 - (b) $u(x,0) = \phi(x), x \in R, 0 < t < T.$

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 and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, Springer.
5. S. L. Ross, Differential Equations, John Wiley and Sons.
6. M. L. Abell, J. P. Braselton, Differential Equations with MATHEMATICA, Elsevier Academic Press.
7. F. H. Miller, Partial Differential Equations, John Wiley and Sons.
8. G. B. Folland, Introduction to Partial Differential Equations, Princeton University Press.
9. J. L. Schiff, The Laplace Transform: Theory and Applications, Springer.
10. D. V. Widder, The Laplace Transform, Dover Publications Inc.
11. M. Spiegel, Schaum's Outline of Laplace Transforms, McGraw-Hill Education.

B.A./B.Sc. Mathematics (Honours)**SEMESTER-V****Course: MATH-H-DSE-T-2A****Course title: Number Theory****Discipline Specific Elective Course; Credit-6; Full Marks-75****COURSE CONTENT:**

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

Unit 1.**[20L]**

- Linear diophantine equation, prime counting function, statement of prime number theorem.
- Goldbach conjecture, linear congruences, complete set of residues.
- Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, Statement of Fermat's Last theorem and their applications.

Unit 2.**[25L]**

- Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function.
- Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Unit 3.**[30L]**

- Order of an integer modulo n , primitive roots for primes, composite numbers having primitive roots.
- Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli.
- Prime number and its properties.
- The arithmetic of Z_p , p a prime, pseudo prime and Carmichael Numbers, Fermat Numbers, perfect numbers, Mersenne numbers.
- Public key encryption, RSA encryption and decryption, the equation $y^2 + x^2 = z^2$.

SUGGESTED READINGS/REFERENCES:

1. David M. Burton, Elementary Number Theory, Tata McGraw-Hill.
2. Neville Robinns, Beginning Number Theory, Narosa Publishing House Pvt. Ltd.
3. G. H. Hardy, E. M. Wright, An Introduction to the Theory of Numbers, Oxford University Press.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-V
Course: MATH-H-DSE-T-2B
Course title: Differential Geometry
Discipline Specific Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1.**[25L]**

- Space curves. Parametrised curves, arc length, regular curves, reparametrisation of space curves, curvature and torsion, planer curves, signed curvature of planer curves, curvature, torsion and Serret-Frenet formula.
- Osculating circles, osculating circles and spheres. Existence of space curves.
- Evolutes and involutes of curves. Simple closed curves, isoperimetric inequality, four vertex theorem.

Unit 2.**[15L]**

- Theory of surfaces: Definition of smooth surfaces, tangents normal and orientability, parametric curves on surfaces.
- Lengths of curves on surfaces, direction coefficients. First fundamental forms on surfaces.

Unit 3.**[15L]**

- Curvature of surfaces: Second fundamental forms. Curvature of curves on surfaces, Principal and Gaussian curvatures. Normal curvature, lines of curvature, Meusnier's theorem, Euler's theorem.

Unit 4.

[20L]

- Developable surfaces: Developable surfaces, surfaces of constant mean curvature, minimal surfaces.
- Geodesics, equation of geodesics. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem.

SUGGESTED READINGS/REFERENCES:

1. Andrew Pressly, Elementary Differential Geometry, Springer-Verlag.
2. T. J. Willmore, An Introduction to Differential Geometry, Dover Publications.
3. B. O'Neill, Elementary Differential Geometry, Academic Press.
4. C. E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press.
5. D. J. Struik, Lectures on Classical Differential Geometry, Dover Publications.
6. S. Lang, Fundamentals of Differential Geometry, Springer.
7. M. P. Do Carmo, Differential Geometry of Curves and Surfaces, Dover Publications.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-VI
Course: MATH-H-CC-T-13
Course title: Metric Spaces and Complex Analysis
Core Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1. [20L]

- 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. Subspaces, dense sets, separable spaces.

Unit 2. [15L]

- 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, continuous functions on compact sets.

Unit 3. [20L]

- Regions in the complex plane, stereographic projection, 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. [20L]

- Complex integration: Curves in the complex plane, properties of complex line integrals, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals.
- Cauchy- Goursat theorem (statement only), Cauchy integral formula, problems relating to Cauchy's integral formula and its applications.
- Absolute and uniform convergence of power series, Taylor series and its examples. Laurent series and its examples.

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. Shiral, 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.A./B.Sc. Mathematics (Honours)
SEMESTER-VI
Course: MATH-H-CC-T-14
Course title: Probability & Statistics
Core 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, Beta, Gamma.
- 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. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson.
5. Irwin Miller and 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.A./B.Sc. Mathematics (Honours)
SEMESTER-VI
Course: MATH-H-DSE-T-3A
Course title: Fuzzy Set Theory
Discipline Specific Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit 1. **[5L]**

- Interval numbers, arithmetic operations on interval numbers, distance between intervals, two level interval numbers.

Unit 2. **[20L]**

- Fuzzy versus crisp sets, different types of fuzzy sets, α -cuts and its properties.
- Representations of fuzzy sets, decomposition theorems.
- Support, convexity, normality, cardinality of fuzzy sets.
- Standard set-theoretic operations on fuzzy sets.
- Zadeh's extension principle.

Unit 3. **[30L]**

- Types of fuzzy operations.
- Fuzzy complements, fuzzy intersections, fuzzy unions and their properties.
- Combinations of fuzzy operations.

Unit 4. **[10L]**

- Crisp versus fuzzy relations.
- Fuzzy matrices and fuzzy graphs.
- Composition of fuzzy relations, relational joins.
- Fuzzy binary relations.

Unit 5. **[10L]**

- Fuzzy numbers.
- Arithmetic operations on fuzzy numbers (multiplication and division on \mathbb{R}^+ only).
- Fuzzy equations.

SUGGESTED READINGS/REFERENCES:

1. H. J. Zimmermann, Fuzzy Set Theory and Its Applications, Springer.
2. G. J. Klir, B. Yuan, Fuzzy Sets & Fuzzy Logic, Theory and Applications, Pearson.
3. A. Kaufmann, M.M. Gupta, Introduction to Fuzzy Arithmetic Theory and Applications, Van Nostrand Reinhold.
4. R. Lowen, Fuzzy Set Theory, Springer.
5. G. Bojadziev and M. Bojadziev, Fuzzy Set, Fuzzy Logic, Applications, World Scientific.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-VI
Course: MATH-H-DSE-T-3B
Course title: Bio-Mathematics
Discipline Specific Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit-1

[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).
- Activator-inhibitor system, Insect outbreak model.

Unit-2

[25L]

- Qualitative analysis of continuous models: Linearization, equilibrium points, hyperbolic and non-hyperbolic equilibrium, Routh-Hurwitz criteria for stability.
- 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 one-dimensional diffusion. Two species model with one-dimensional diffusion.
- Conditions for diffusive instability, spreading colonies of microorganisms.

Unit-3

[25L]

- 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.

Graphical Demonstration (Teaching Aid) [using any software]

[5L]

Numerical solution of the models and its graphical representation:

- Growth model (exponential, logistic, Gompertz).
- Limited growth of population (with and without harvesting).
- Predator-prey model (Lotka-Volterra model, with density dependence, two prey one predator).
- Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
- Spruce Budworm outbreak model.

SUGGESTED READINGS/REFERENCES:

1. L. E. Keshet, Mathematical Models in Biology, SIAM.
2. M. Kot, Elements of Mathematical Ecology, Cambridge University Press.
3. J. D. Murray, Mathematical Biology-I: An Introduction, Springer.
4. J. D. Murray, Mathematical Biology-II: Spatial Models and Biomedical Applications, Springer.
5. Suzanne Lenhart, Mathematics for the Life Sciences, Princeton University Press.
6. Y. C. Fung, Biomechanics, Springer-Verlag.
7. F. Brauer, P. V. D. Driessche and J. Wu, Mathematical Epidemiology, Springer.
8. Hal L. Smith, P. Waltman, The Theory of the Chemostat, Cambridge University Press.
9. F. Verhulst, Nonlinear Differential Equations and Dynamical Systems, Springer.

B.A./B.Sc. Mathematics (Honours)
SEMESTER-VI
Course: MATH-H-DSE-T-4A
Course title: Point Set Topology
Discipline Specific Elective Course; Credit-6; Full Marks-75

COURSE CONTENT:

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

Unit-1. **[20L]**

- Topological spaces, discrete and indiscrete topology, co-finite topology, co-countable topology.
- Basis and sub-basis for a topology, topology on a set generated by a family of subsets, metric topology, lower limit topology in \mathbb{R} .
- Neighbourhood of a point, interior points, limit points, derived set, boundary of a set, closed sets, closure and interior of set, dense subsets.

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

- Subspace topology, finite product topology.
- Continuous functions, open maps, closed maps, homeomorphisms.
- Net in a topological space and its convergence.

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

- First, second countable and separable spaces with examples and basic properties.
- Separation axioms, T_0 , T_1 and T_2 spaces, regular topological spaces with examples, basic characterizations.

Unit-4. **[25L]**

- Connected spaces, basic properties and characterizations, components, connected sets in.
- Compact spaces, finite intersection property (FIP), compact sets in a topological space, characterization of compactness via net and FIP, preservation of compactness under continuity and finite product.
- Properties of real valued continuous function on connected and compact spaces.

SUGGESTED READINGS/REFERENCES:

1. J. Dugundji, Topology, Allyn and Bacon.
2. J. R. Munkres, Topology, A First Course, Prentice Hall of India Pvt.Ltd.
3. M. A. Armstrong, Basic Topology, Springer.
4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill.
5. J. L. Kelley, General Topology, Van Nostrand Reinhold Co., New York.
6. J. Hocking, G. Young, Topology, Addison-Wesley Reading.
7. L. Steen, J. Seebach, Counter Examples in Topology, Holt, Reinhart and Winston, New York.
8. A. Dasgupta, Set Theory, Birkhäuser.

B.A./B.Sc. Mathematics (Honours)**SEMESTER-VI****Course: MATH-H-DSE-T-4B****Course title: Mechanics-II****Discipline Specific Elective 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 and its converse.
- Forces in three dimensions: Moment of a force about a line. Reduction of a system of forces in space. Poinsot'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 and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley (India) Pvt. Ltd.
3. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, Dorling Kindersley (India) 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.

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