B. Sc. (Honours) in Mathematics

Under the Framework of Honours School System

Semester I - VI

2018-19
OUTLINES OF TESTS

OBJECTIVE OF THE COURSE

To teach the fundamental concepts of Mathematics and their applications. The syllabus pertaining to B.Sc. (Honours) Mathematics (3 Year course & 6 Semesters) in the subject of Mathematics under Honours School Framework has been upgraded as per provision of the UGC module for CHOICE BASED CREDIT SYSTEM and demand of the academic environment. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to requisite intellectual skills according to UGC module for CHOICE BASED CREDIT SYSTEM pertaining to B.Sc. Honours (Mathematics).

Semester I

CORE COURSE (MATHEMATICS)

Theory Papers:
Core Course-1 (MAT -C1): Calculus 100 Marks (4 credits)
Core Course-2 (MAT-C2): Algebra 150 Marks (6 credits)

Practical:
Core Course-1 Practical (MAT-C1): Calculus 50 Marks (2 credits)

GENERIC ELECTIVE (MATHEMATICS)

Each student from other disciplines may opt any two of the generic electives offered by the Science Departments of Panjab University out of following:

GENERIC ELECTIVE SUBJECTS (Offered by Mathematics Department) for students of departments of Bio-Medical Sciences

Semester-I

1. MAT-GE1-BM: Algebra and Geometry 150 Marks (6 Credits)
GENERIC ELECTIVE SUBJECTS (Offered by Mathematics Department) for students of departments of Physical Sciences

Semester-I

1. MAT GE1-PS: Advanced Calculus and Geometry 150 Marks (6 Credits)

EVALUATION
1. There shall be one Mid Term Examination of 20% Marks in each semester.
2. End-semester examination will be of 80% of total marks.
3. Each practical examination shall be of 3 hours duration.
4. There shall be continuous internal assessment for practicals of 20% marks.
5. The final examination will be of 80% marks

Pattern of end-semester question paper

(i) Nine questions in all with equal weightage. The candidate will be asked to attempt five questions

(ii) One Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question.

(iii) The remaining eight questions will have Four Units comprising two questions from each Unit.

(iv) Students will attempt one question from each unit and the compulsory question.

ABILITY ENHANCEMENT COMPULSORY COURSE FOR MATHEMATICS STUDENTS

Each student of Mathematics Department has to opt one Ability Enhancement Compulsory Course of the following:

1. English Communication (2 credits)
2. Environmental Science (2 credits)
To teach the fundamental concepts of Mathematics and their applications. The syllabus pertaining to B.Sc. (Honours) Mathematics (3 Year course & 6 Semesters) in the subject of Mathematics under Honours School framework has been upgraded as per provision of the UGC module for CHOICE BASED CREDIT SYSTEM and demand of the academic environment. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to requisite intellectual skills according to UGC module for CHOICE BASED CREDIT SYSTEM pertaining to B.Sc. (Honours School) Mathematics.
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C: Core Courses; GE: General Elective; AECC: Ability Enhancement Compulsory Courses; SEC: Skill Enhancement Courses; DSE: Discipline Specific Elective

*: GE subjects are to be selected by the students from the pool of GE Subjects offered by various Departments of the University.
**SKILL ENHANCEMENT COURSES** (any one per semester in semesters 3-4)

1. MAT-SEC1: Logic and Sets
2. MAT-SEC2: LaTex and HTML
3. MAT-SEC3: Graph Theory
4. MAT-SEC4: Computer Algebra systems and Related Software

**DISCIPLINE SPECIFIC ELECTIVE COURSES** (any two per semester in semesters 5-6)

1. MAT-DSE1: Number Theory
2. MAT-DSE2: Probability and Statistics
3. MAT-DSE3: Discrete Mathematics
4. MAT-DSE4: Statics
5. MAT-DSE5: Linear Programming
6. MAT-DSE6: Dynamics
7. MAT-DSE7: Differential Geometry
8. MAT-DSE8: Mathematical Modeling

*Courses under these will be offered only if a minimum of 10 students opt for the same

**GENERIC ELECTIVE SUBJECTS** (any two per semester in semesters I-II and one per semester in Semester III-IV)

The Core courses MAT- C1, MAT- C2, MAT-C-3 and MAT-C4 of semester I-II may be the generic elective subjects of other departments.

**GENERIC ELECTIVE SUBJECTS** (Offered by Mathematics Department) for students of departments of Bio-Medical Sciences

**Semester-I**

1. MAT-GE1-BM: Algebra and Geometry
2. MAT-GE2-BM: Algebra and Geometry

**Semester-II**

1. MAT-GE3-BM: Calculus
2. MAT-GE4-BM: Calculus

**Semester-III**

1. MAT-GE5-BM: Matrices
## Semester-IV

1. MAT-GE6-BM: Vector Analysis, Differential Equations and Transform

**GENERIC ELECTIVE SUBJECTS (Offered by Mathematics Department) for students of departments of Physical Sciences**

## Semester-I

1. MAT-GE1-PS: Advanced Calculus and Geometry
2. MAT-GE2-PS: Advanced Calculus and Geometry

## Semester-II

1. MAT-GE3-PS: Linear Algebra
2. MAT-GE4-PS: Linear Algebra

## Semester-III

1. MAT-GE5-PS: Differential Equations and Fourier Series

## Semester-IV

1. MAT-GE6-PS: Integral Transforms and complex Analysis
Semester I

MAT-C1: Calculus

THEORY

4 hrs. per week
[Max. Marks: 100]
(Final-80+Internal Assessment-20)
Time: 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 40

Credits: 4

Objective: Calculus is one of the major branches of mathematics that finds application in almost all the fields of science. This course is an introduction to calculus. Students will be introduced to the hyperbolic functions, curve tracing, applications of integration and vector functions.

Unit I

Higher order derivatives, Leibniz rule and its applications, L’Hospital’s rule, Derivations and Applications of Reduction Formulae for the Integrals of Trigonometric Functions.


Unit II

Concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, Hyperbolic functions and their properties.

Unit III
Volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Scope as in [1] Sections 5.2 to 5.6

Unit IV
Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration.


List of Practicals (using any software)

(i)  Matrix operation (addition, multiplication, inverse, transpose).
(ii)  Plotting of graphs of function $e^{ax + b}$, log$(ax + b)$, $1/(ax + b)$, sin$(ax + b)$, cos$(ax + b)$, $lax + b$ to illustrate the effect of $a$ and $b$ on the graph.
(iii) Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
(iv)  Obtaining surface of revolution of curves.
(v)  Tracing of conics in Cartesian coordinates/ polar coordinates.
(vi) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.

Books Recommended

MAT-C1: Calculus

PRACTICAL

(Using any software)

(3 practicals per week )
In groups of 15 students
[Max. Marks: 50](Final-40+Internal Assessment-10)
Time : 3hrs.

Total Lectures : 20  
Credits: 2

List of Practicals (using any software)

(i) Plotting of graphs of function eax + b, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b), lax + bland to illustrate the effect of a and b on the graph.
(ii) Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
(iii) Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
(iv) Obtaining surface of revolution of curves.
(v) Tracing of conics in Cartesian coordinates/ polar coordinates.
(vi) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.
(vii) Matrix operation (addition, multiplication, inverse, transpose).

Books Recommended

MAT-C2: Algebra

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60
Credits: 6

Objective: The concepts and techniques from linear algebra are of fundamental importance in many scientific disciplines. The main objective is to introduce basic notions in linear algebra that are often used in mathematics and other sciences. The emphasis will be to combine the abstract concepts with examples in order to intensify the understanding of the subject.

UNIT I (15 hrs)
Polar representation of complex numbers, $n^{th}$ roots of unity, De Moivre’s theorem for rational indices and its applications. Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers.

UNIT II (15 hrs)
General properties of polynomials, Descarte’s rule of signs, positive and negative rule, Relation between the roots and the coefficients of equations, Algebraic solutions of the cubic and biquadratic, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

UNIT III (15 hrs)
Systems of linear equations, matrices, rank, Gaussian elimination, Determinants and their properties, Cramer's Rule, Vector spaces, subspaces, bases and dimension, the null space and the column space of a matrix and their dimension.

UNIT IV (15 hrs)
Linear transformations, representation of linear transformations by matrices, change of basis, rank-nullity theorem, Applications to difference equations and Markov chains, Eigenvalues and eigenvectors, characteristic polynomials, minimal polynomials, Cayley-Hamilton Theorem, triangulation
References:


Semester II

MAT-C3: Real Analysis

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60
Credits: 6

Objective: Introduction to the completeness property of real numbers, sequences and series of reals along with the cardinality of sets.

Unit I


Sequences, Subsequences, Bounded sequence, Convergence of a sequence, Divergence of a sequence, Limit Theorems.

Scope as in [1] Sections 3.1, 3.2.

Unit II


Scope as in [1] Sections 3.3, 3.4, 3.5.
Unit III
Scope as in [3] 2.1 to 2.16.

Unit IV
Convergence and Divergence of Infinite Series, Cauchy Criterion, Comparison Test, Limit Comparison Test, Ratio Test, Root Test, Generalized Root Test, Integral Test, Alternating series, Leibniz Test, Absolute and Conditional convergence, Addition and Multiplication of Series, Abel’s test and Dirichlet’s test, Rearrangement of a Series, Riemann’s Theorem on Rearrangement (statement only).

Books Recommended
MAT-C4: Differential Equations

THEORY

[4 hrs/per week]
[Max. Marks: 100]
(Final-80+Internal Assessment-20)
Time: 3hrs.

Note:
1. The question paper will have nine questions. Question No. 1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 40 Credits: 4

Objective: To exhibit the techniques for obtaining solutions to ordinary differential equations and the basic ideas and theory behind those techniques.

UNIT I (10 hrs)
Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. Clairaut equation. (Scope as in Chapter 2 of S.L. Ross)

UNIT II (10 hrs)
Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Orthogonal and oblique trajectories. Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting. (Scope as in Chapters 1, 3 of S.L. Ross)

UNIT III (10 hrs)
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, Reduction of order. (Scope as in Chapter 4 of S.L. Ross)

UNIT IV (10 hrs)
Power Series solution about an ordinary point, solutions about singular points, The method of Frobenius, Bessel equation, Legendre equation, Hermite equation, Bessel function and their recurrence relations. (Scope as in Chapter 6 of S.L. Ross)
References:


MAT-C4: Differential Equations
PRACTICAL

(3 practicals per week )
In groups of 15 students
[Max. Marks: 50](Final-40+Internal Assessment-10)
Time : 3hrs.

Total Lectures: 20
Credits: 2

List of Practicals (using any software)

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. Some other applications of the topics in the course.

References:


GENERIC ELECTIVE SUBJECTS

GE1 COURSES

MAT-GE1-BM: Algebra and Geometry

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150] (Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory.
2. Candidates will attempt five questions.
3. There will be two questions from each unit and the students will be required to answer one question from each unit.
4. All questions carry equal marks.

Total Lectures: 60 Credits: 6

Objective:
The objective of this course is to study the basics of various topics of Mathematics which is a foundation for further learning in Mathematics, Physics, Statistics etc.

UNIT I (15 hrs)
Review of trigonometric functions, sum and product formulae for trigonometric functions, Trigonometric Equations. [Scope as in Chapters 3 of a Textbook – ‘Mathematics’ for Class XI, NCERT.]
Complex Numbers and Quadratic Equations, Permutations and combinations, Binomial Theorem, sequences and series. Exponential and Logarithmic series.
[Scope as in Chapters 5, 7, 8, 9, Appendix 1 of a Textbook – ‘Mathematics’ for Class XI, NCERT.]

UNIT II (15 hrs)
Matrices, Operations on Matrices, Determinants, singular and non-singular matrices, Adjoint and inverse of a matrix [Scope as in Chapters 3, 4 of a Textbook – ‘Mathematics’ for Class XII, NCERT. Part I]

UNIT III (15 hrs)

UNIT IV (15 hrs)
Three dimensional space, Coordinates of a point in three dimensional space. Distance between two points. Section Formula [Scope as in Chapter 12 of a Textbook – ‘Mathematics’ for Class XI, NCERT.]

Suggested Readings
Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60
Credits: 6

Objective: The objective of the course is to equip the students with the knowledge of basic concepts and their applications in geometry.

UNIT I (15 hrs)

UNIT II (15 hrs)


UNIT III (15 hrs)
Transformation of axes, shifting of origin, reflection and rotation of axes, reduction of the equation S=Ax²+Bxy+Cy² +Dx+Ey+f=O into simpler forms by transformation of coordinate axes(without proof). Identification of curves represented by S=0. Invariance of discriminant and trace t. Condition that a second degree equation should represent a pair of straight lines. Polar coordinates, polar equation of a conic.
UNIT IV (15 hrs)
Sphere, Cone, Cylinder, Equation of paraboloid, ellipsoid and hyperboloid in standard forms. Simple properties of these surfaces. Equation of tangent planes to the above surfaces.

Suggested Readings
SEMESTER-II

MAT-GE3-BM: Calculus

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150](Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60  
Credits: 6

Objective: This course is designed to introduce the fundamental concepts of continuity, differentiation and integration of functions of one variable. Its objective is to acquaint students with various applications of these topics relating to extreme value problems, problems of finding areas and distance travelled, moreover to describe connection between integral and differential calculus through Fundamental Theorem of Calculus.

UNIT I (15 hrs)

UNIT II (15 hrs)

UNIT III (15 hrs)
Integral Calculus: Integral as antiderivative. Integration by substitution, by partial fractions and by parts. Definite integral and its properties. Areas of bounded regions. The definition of integral of a real valued function of real variable as limit of sum.
motivated by the determination of area. Fundamental theorem of integral calculus. [Scope as in Chapters 7 & 8 of a Text book- ‘Mathematics’ for Class XII, NCERT. Part II]

UNIT IV (15 hrs )


**Suggested Readings**

MAT –GE3-PS: Linear Algebra

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150](Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60 Credits: 6

Objective: This Course is a requirement for majors in other sciences because Linear Algebra provides a basis for advanced studies not only in Mathematics but also in other branches like engineering, physics and computers etc.

UNIT I (15 hrs)

UNIT II (15 hrs)
[Scope as in Chapters 3(Sections 3.1-3.6), 4(Sections 4.1-4.5), 5(Sections 5.1, 5.2, 5.7-5.9) of the book ‘Introduction to Linear Algebra’ by V. Krishnamurthy, V.P.Mainra and J. L. Arora, East-West Press Pvt. Ltd.]

UNIT III (15 hrs)

UNIT IV (15 hrs)
Similarity of matrices, similarity reduction to a diagonal form, diagonalizable matrix, orthogonal reduction of real symmetric matrices. Unitary reduction of a Hermitian
matrix (for these three reductions only the methods are expected to be taught. No proofs are expected to be taught).


References

GE2 COURSES

SEMESTER-I

MAT-GE2-BM: Algebra and Geometry

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60

Credits: 6

Objective: The objective of this course is to study the basics of various topics of Mathematics which is a foundation for further learning in Mathematics, Physics, Statistics etc.

UNIT I (15 hrs )

Review of trigonometric functions, sum and product formulae for trigonometric functions, Trigonometric Equations. [Scope as in Chapters 3 of a Textbook – ‘Mathematics’ for Class XI, NCERT.]
Complex Numbers and Quadratic Equations, Permutations and combinations, Binomial Theorem, sequences and series. Exponential and Logarithmic series.

[Scope as in Chapters 5,7,8, 9, Appendix 1 of a Textbook – ‘Mathematics’ for Class XI, NCERT.]

UNIT II (15 hrs )

Matrices, Operations on Matrices, Determinants, singular and non-singular matrices, Adjoint and inverse of a matrix [Scope as in Chapters 3, 4 of a Textbook- ‘Mathematics’ for Class XII, NCERT.Part I]

UNIT III (15 hrs )

Co-ordinate Geometry: Rectangular Coordinate system. Straight lines. Circles and family of circles. Parabola, Ellipse and Hyperbola-their equations in standard form. [Scope as in Chapters 10, 11 of a Textbook- ‘Mathematics’ for Class XI, NCERT.]
UNIT IV (15 hrs)
Three dimensional space, Coordinates of a point in three dimensional space. Distance between two points. Section Formula [Scope as in Chapter 12 of a Text book – ‘Mathematics’ for Class XI, NCERT.]

Suggested Readings
MAT-GE2-PS: Advanced Calculus and Geometry

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note :
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60 Credits: 6

Objective: The objective of the course is to equip the students with the knowledge of basic concepts and their applications in geometry.

UNIT I (15 hrs)

UNIT II (15 hrs)


UNIT III (15 hrs)
Transformation of axes, shifting of origin, reflection and rotation of axes, reduction of the equation $S=Ax^2+Bxy+Cy^2+Dx+Ey+f=0$ into simpler forms by transformation of coordinate axes(without proof). Identification of curves represented by $S=0$. Invariance of discriminant and trace t. Condition that a second degree equation should represent a pair of straight lines. Polar coordinates, polar equation of a conic.
UNIT IV (15 hrs)
Sphere, Cone, Cylinder, Equation of paraboloid, ellipsoid and hyperboloid in standard forms. Simple properties of these surfaces. Equation of tangent planes to the above surfaces.

Suggested Readings
SEMESTER-II

MAT-GE4-BM: Calculus

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60 Credits: 6

Objective: This course is designed to introduce the fundamental concepts of continuity, differentiation and integration of functions of one variable. Its objective is to acquaint students with various applications of these topics relating to extreme value problems, problems of finding areas and distance travelled, moreover to describe connection between integral and differential calculus through Fundamental Theorem of Calculus.

UNIT I (15 hrs)

UNIT II (15 hrs)

UNIT III (15 hrs)
Integral Calculus: Integral as antiderivative. Integration by substitution, by partial fractions and by parts. Definite integral and its properties. Areas of bounded regions. The definition of integral of a real valued function of real variable as limit of sum motivated by the determination of area. Fundamental theorem of integral
calculus.[Scope as in Chapters 7 & 8 of a Text book- ‘Mathematics’ for Class XII, NCERT Part II]

UNIT IV (15 hrs)


Suggested Readings

MAT –GE4-PS: Linear Algebra

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60

Credits: 6

Objective: This Course is a requirement for majors in other sciences because Linear Algebra provides a basis for advanced studies not only in Mathematics but also in other branches like engineering, physics and computers etc.

UNIT I (15 hrs)

UNIT II (15 hrs)

[Scope as in Chapters 3(Sections 3.1-3.6), 4(Sections 4.1-4.5), 5(Sections 5.1, 5.2, 5.7-5.9) of the book 'Introduction to Linear Algebra' by V. Krishnamurthy, V.P.Mainra and J. L. Arora, East-West Press Pvt. Ltd.]

UNIT III (15 hrs)

UNIT IV (15 hrs)
Similarity of matrices, similarity reduction to a diagonal form, diagonalizable matrix, orthogonal reduction of real symmetric matrices. Unitary reduction of a Hermitian matrix (for these three reductions only the methods are expected to be taught. No proofs are expected to be taught).


References
SEMESTER-III

MAT-C5: Theory of Real Functions

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time: 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60
Credites: 6

Objective: Introduction to the limit, continuity and derivatives real functions.

Unit I

Limit of a function (epsilon-delta approach), limit theorems, sequential criterion for limits, One-sided limits, Infinite limits, limits at infinity, Continuous functions, sequential criterion for continuity & discontinuity, Algebra of continuous functions, Composition of continuous functions.

Scope as in [1] Sections 4.1 to 4.3, 5.1, 5.2.

Unit II

Intermediate Value Theorem and its Applications, Extreme Value Theorem, Uniform Continuity, Continuity and Uniform Continuity.

Differentiability, Carathéodory’s theorem, Algebra of differentiable functions, Chain Rule, Lipschitz Functions and Uniform Continuity, Inverse of Strictly Monotone Functions.

Scope as in [1] Sections 5.3, 5.4.1 to 5.4.3, 6.1.

Unit III

Local Extrema, Interior Extremum Theorem, Rolle’s theorem, Mean Value Theorem and its Applications to inequalities & approximation of polynomials, Darboux’s Theorem, L’Hospital’s Rules.


Unit IV

Taylor’s theorem and its application to inequalities, Taylor’s theorem with Lagrange’s form of remainder, Taylor’s theorem with Cauchy’s form of remainder, application of Taylor’s theorem to Convex functions, Taylor’s series & Maclaurin’s series expansions of exponential & trigonometric functions.
Continuity of a Monotone function, functions of Bounded Variation, Total Variation of a function, the Total Variation Function, Rectifiable Curves.


Books Recommended
MAT-C6: Group Theory - I

[6 hrs/per week (including Tutorials)]

[Max. Marks: 150]

(Final-120+Internal Assessment-30)

Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60

Credits: 6

Objective: The course is an introduction to Group Theory which is one of the most important subjects of algebra.

UNIT-I
Symmetries of a square, Dihedral groups, binary operations, semigroups, groups, groups of integers modulo n, matrix groups, groups of quaternions, symmetric groups, cycle notation for permutations, even and odd permutations, property of permutations. Elementary properties of groups.

UNIT-II
Subgroups, examples of subgroups, order of group elements, centralizer, normalizer, center of a group, product of two subgroups, cyclic groups, classification of subgroups of cyclic groups, subgroups generated by a subset, generators and relations, generators of Sn and An.

UNIT-III
Cosets, Lagrange’s theorem and consequences including Fermat’s Little theorem. Conjugacy, Class Equation and its applications, Normal subgroups, Quotient groups, Homomorphisms, Isomorphism Theorems, Cayley’s Theorem.

UNIT-IV
External and internal direct products and their properties, the group of units modulo n as an external direct product. Cauchy’s theorem for finite abelian groups, Fundamental Theorem for finite Abelian groups and its applications. Elementary divisors and invariant factors of finite Abelian groups. Conjugacy in Sn, Simplicity of An.

Scope as in Chapters 1-11 and 25 of [1]

References
MAT-C7: PDE and System of ODE

THEORY

4 hrs. per week
[Max. Marks: 100]
(Final-80+Internal Assessment-20)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 40
Credites: 4

Objective: To study Ordinary differential equations in more than two variables, Partial differential equations of the first and second order and systems of linear equations.

Unit I
Ordinary differential equations in more than two variables-Surfaces and curves in three dimensions, Simultaneous differential equations of first order and the first degree in three variables, Methods of solutions of \( \frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R} \), Orthogonal trajectories of a system of curves on a surface, Pfaffian differential forms and equations, Solution of Pfaffian differential equations in three variables. (I N Sneddon, Chapter 1, section 1.1-1.6)

Unit II
Partial differential equations of the first order-Partial differential equations, Origins of first order partial differential equations, Cauchy’s problem for first order equations, linear equation of first order, Integral surface passing through a given curve, Surfaces orthogonal to a given system of surfaces, Non-linear partial differential equation of the first order, Cauchy method of characteristics, Compatible system of first order equations, Charpit’s method, Special types of first order equations, Solutions satisfying given conditions, Jacobi’s method, Applications of first order equations. (I N Sneddon, Chapter 2)

Unit III
PDEs of second order-The origin of second order equations, Linear pdes with constant coefficients, separation of variables. Solution of Laplace equation, Heat equation and Wave equation with separation of variables in two dimensions. (I N Sneddon, Chapter 3).

Unit IV
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. (S L Ross, Chapter 7, Section 7.1-7.4)

Books Recommended
MAT-C7: PDE and System of ODE

PRACTICAL
(Using any software)

(3 practicals per week)
In groups of 15 students
[Max. Marks: 50](Final 40+Internal Assessment-10)
Time: 3hrs.

Total Lectures: 20
Credits: 2

List of Practicals (using any software)
(i) Solution of Cauchy problem for first order PDE.
(ii) Finding and plotting the characteristics for the first order PDE.
(iii) Plot the integral surfaces of a given first order PDE with initial data.
(iv) Solution of one dimensional heat equation.
(v) Solution of wave equation with associated conditions.
(vi) Solving system of ODEs.

Books Recommended
GENERIC ELECTIVE COURSE
(For students with background in Mathematics)

MAT-GE5-PS: Differential Equations and Fourier Series
[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60 Credits: 6

Objective: The objective of the course is to enable the students to understand the basic concepts related to ordinary differential, partial differential equations and Fourier Series and their applications.

UNIT I

UNIT II
Solution in series of second order linear differential equations with variable coefficients (in particular, solutions of Legendre’s and Bessel’s equations.) Bessel functions, Legendre functions, their recurrence and orthogonal relations, Gamma and Beta functions.

UNIT III

UNIT IV
[Scope as in Sections 1.5.4, 4.6, 5.3.1, 5.3.2, 5.3.4, 5.4.1, 5.5, 6.1-6.4, 7.2, 7.4, 7.4.1, 7.5.1, 8.1, 8.2, 8.3, 8.5.4, 8.6 of Ref.1.]

Suggested Readings
MAT-GE5-BM: Matrices

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)

Time : 3hrs.

Note :
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
4. There will be two questions from each unit and the students will be required to answer one question from each unit.
5. All questions carry equal marks.

Total Lectures : 60
Credits: 6

Objective : This course familiarizes the students with the theory of matrices which are used in solving equations in mechanics and other streams used in Mathematics, Physics etc.

UNIT - I
Symmetric and Skew symmetric, Hermitian and Skew Hermitian, Orthogonal and Unitary matrices (Definitions and examples only).
Rank of a matrix, elementary transformations, reduction to normal form (methods only), elementary matrices, equivalence of matrices.
[Scope as in Chapter 1, 2, 4 of ‘A Text Book of Matrices’ by Shanti Narayan and P. K. Mittal, S. Chand & Co. Ltd., New Delhi, Reprint 2002].

UNIT - II
Vector as n-tuples. Linear dependence and independence of vectors. Rank of a matrix.
Row rank, Column Rank and Determinantal Rank of a matrix.
[Scope as in Chapter 5(Sections 5.1-5.8), Chapter 6(Sections 6.1-6.6) of ‘A Text Book of Matrices’ by Shanti Narayan and P. K. Mittal, S. Chand & Co. Ltd., New Delhi, Reprint 2002.]

UNIT - III
[Scope as in Chapters 11(Sections 11.1-11.4, 11.11) Chapter 12(Sections12.1, 12.2) of ‘A Text Book of Matrices’ by Shanti Narayan and P. K. Mittal, S. Chand & Co. Ltd., New Delhi, Reprint 2002.]

UNIT - IV
[Scope as in Chapter 12(Sections 12.3-12.5), Chapter 13(Sections 13.1-13.4) of ‘A Text Book of Matrices’ by Shanti Narayan and P. K. Mittal, S. Chand & Co. Ltd., New Delhi, Reprint 2002.]

Suggested Readings
MAT-SEC-1 Logic and Sets

[2 hrs/per week]
[Max. Marks: 50]
(Final-40+Internal Assessment-10)
Time : 3hrs.

Total Lectures : 20

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.


Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.

Books Recommended

MAT-SEC-2 LaTeX and HTML

(3 practicals per week) In groups of 15 students
[Max. Marks: 50] (Final 40+Internal Assessment-10)
Time : 3hrs.

(2 hrs/week)
Credits - 2
Total Lectures 20

Objective : The objective of this syllabus is to teach computer fundamentals and introduction to ‘C’ Language. This will help students to learn about functioning of computers and familiarity with computer Language ‘C’ and also learn about create a web pages through HTML.

LaTeX: This Will help Student to Typesetting of journal articles, technical reports, thesis, books, and slide presentations. Control over large documents containing sectioning, cross-references, tables and figures. Typesetting of complex mathematical formulae.

PART 1
Introduction to ‘C’ language: Data types, constants and literals. Operators: arithmetic, relational and logical. Statements for: decision control, loop control and case control.

PART 2
Elements of LaTeX; Hands-on-training of LaTeX; graphics in LaTeX; PSTricks; Beamer presentation;
HTML, creating simple web pages, images and links, design of web pages.
[1] Chapter 1-5,
[3] Chapter 9-11, 15

Practical
Six practical should be done by each student. The teacher can assign practical from the exercises from [1] and [3].

References:
SEMESTER-IV

MAT-C8: Numerical Methods

4 hrs. per week
[Max. Marks: 100]
(Final-80+Internal Assessment-20)

Time: 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.
4. Use of Scientific Calculator is allowed.

Total Lectures: 40

Credits: 4

Objective: To acquaint the students with Numerical approximations, convergence problems, Different rules of Numerical integrations and numerical differentiation.

Unit-I

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation.
Transcendental and Polynomial equations: Bisection method, Newton’s method, Secant method. Rate of convergence of these methods.

Unit-II


Unit-III

Numerical Integration: Trapezoidal rule, Simpson’s rule, Simpsons 3/8th rule, Boole’s Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson’s rule.

Unit-IV

Ordinary Differential Equations: Numerical differentiation, Taylor’s series method, Euler’s method, Modified Euler’s method, Runge-Kutta methods of orders two and four.

Books Recommended
MAT-C8: Numerical Methods

PRACTICAL

(Using any software)

(3 practicals per week )
In groups of 15 students
[Max. Marks: 50](Final
40+Internal Assessment-10)
Time : 3hrs.

Total Lectures : 20
Credits: 2

List of Practicals (using any software)
(i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ---------+ 1/ N.
(ii) To find the absolute value of an integer.
(iii) Enter 100 integers into an array and sort them in an ascending order.
(iv) Bisection Method.
(vii) Regulari Falsi Method.
(viii) LU decomposition Method. (ix) Gauss-Jacobi Method.
(x) SOR Method or Gauss-Siedel Method.
(xi) Lagrange Interpolation or Newton Interpolation. (xii) Simpson’s rule.

Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

Books Recommended
MAT-C9: Riemann Integration and Series of Functions

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60
Credits: 6

Objective: Introduction to Riemann Integration, Improper Integrals, Uniform Convergence and Power Series.

Unit I

Scope as in [1] Chapter 6 (Art. 32.1 to 32.9, 33.1, 33.2, 33.3, 33.4 to 33.8, 33.9, 34.1, 34.3)

Unit II
Improper Integrals, Tests for Convergence of Improper Integrals, Beta and Gamma functions.

Unit III
Pointwise and Uniform Convergence of Sequence of functions, Weierstrass M-Test, Uniform Convergence and Continuity, Uniform convergence and Integration, Uniform convergence and differentiation, A Continuous nowhere differentiable function, Weierstrass Approximation Theorem.

Scope as in [2] 7.1 to 7.12, 7.16, 7.17, 7.18.

Unit IV
Power series, Radius of convergence, Cauchy-Hadamard Theorem, Differentiation and integration of power series, Taylor Series Theorem, Abel’s Theorem, Multiplication of Two Series, Exponential, Logarithmic and Trigonometric functions.

Scope as in [2] 8.1 to 8.7.
Books Recommended

MAT-C10: Ring Theory and Linear Algebra-I

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 6
Credits: 6

Objective: The course is an introduction to Ring Theory and Linear Algebra which is one of the most important subjects of algebra.

UNIT-I
Definition and examples of rings, properties of rings, subrings and ideals, integral domains, Division rings and fields, characteristic of a ring, ideal generated by a subset of a ring, factor rings, algebra of ideals, prime and maximal ideals.

UNIT-II
Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients and Embedding Theorems. Polynomial Rings over commutative rings, division algorithm and consequences, Eisenstein’s irreducibility criterion

Scope as in Chapters 12-16 of [4]

UNIT-III

UNIT-IV
Bilinear Forms, Symmetric and Skew Symmetric Bilinear Forms, Groups preserving Bilinear Forms.

Scope as in Chapters 8, 9 and 10 of [8]

Books Recommended
MAT-SEC-3 Graph Theory

[2 hrs/per week]
[Max. Marks: 50]
(Final-40+Internal Assessment-10)
Time : 3hrs.

Total Lectures : 20
Credits: 2

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman’s problem, shortest path, Dijkstra’s algorithm, Floyd-Warshall algorithm.

Books Recommended


MAT-SEC-4  Computer Algebra Systems and Related Softwares

(3 practicals per week) In groups of 15 students
[Max. Marks: 50] (Final 40+Internal Assessment-10)
Time : 3hrs.

Total Lectures – 20

Credits-2

Objective : The objective of this course is to teach pointers, structures in ‘C’. This paper also introduces mathematical packages from programming point of view to help Mathematics students to solve their problems.

PART 1
Functions and storage classes in C. Arrays: declaring an array, initializing an array. one dimensional arrays: array manipulation, two dimensional arrays, addition/multiplication of two matrices. Pointers: concept of pointers, address operators, pointer type declaration, pointer assignment, pointer initialization pointer arithmetic.
Structures and Unions: basic of structures, structures variables, initialization, structure assignment.

PART 2
Use of Mathematica, Maple, and Maxima as calculator, in computing functions, in making graphs; MATLAB/Octave for exploring linear algebra and to plot curve and surfaces; the statistical software R: R as a calculator, explore data and relations, testing hypotheses, generate table values and simulate data, plotting.
[1] Chapter 5,8,10
[3] Chapter 12-14

Practical
Six practical should be done by each student. The teacher can assign practical from the exercises from [1] and [3]

References:
GENERIC ELECTIVE COURSES

MAT-GE6-PS: Integral Transforms and Complex Analysis

(For students with background in Mathematics)

[6 hrs/week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60
Credits: 6

Objective: To acquaint the students with the application of Laplace transforms to solve ordinary differential equations. Moreover, basics of Complex Analysis are also included in this course.

UNIT I

UNIT II
Complex numbers, absolute value, argument. Functions $e^z$, $\sin z$, $\cos z$, $\log z$ and hyperbolic functions. Analytic functions, Cauchy-Riemann equations. Harmonic functions and their conjugates.

UNIT III
Integration of complex functions, Cauchy’s theorem (statement only), Cauchy’s theorem for multiply connected domains (statement only). Cauchy’s integral formula (statement only) and simple consequences.

UNIT IV
Expansion into Laurent series, singularities, Residues, Cauchy residue theorem (statement only). Evaluation of definite integrals using contour integration. [Scope as in relevant sections of Chapter 1-6 of Ref. 4.]

Suggested Readings

(For students without background in Mathematics)

MAT-GE6-BM: Vector Analysis, Differential Equations and Transforms

[6 hrs/per week (including Tutorials)]

[Max. Marks: 150]

(Final-120+Internal Assessment-30)

Time : 3hrs.

Note :
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60

Credits: 6

Objective: The aim of this course is to make the students acquire facility and confidence in the use of vectors and vector calculus so that they may employ the same in an effective manner to various applications and to exhibit the techniques of solving ordinary and partial differential equations.

UNIT - I
Vector valued functions. Limit and continuity of vector functions. Differentiation of vector functions., Arc length., Line, Surface and Volume integrals. The gradient, divergence and curl. The del operator. Green’s, Gauss’ and Stokes’ theorems (statements only). Applications to physical problems.


UNIT - II
Homogeneous and nonhomogeneous ordinary differential equations of second order with constant co-efficients. Wronskian and Linear independence and dependence of solution, particular integral, D-operator method, method of variation of parameters.

[Scope as in Sections 4.5-4.7, 5.1, 5.2, 5.3.1, 5.3.2, 5.4.1, 5.5 of Ref.4.]

UNIT - III
The Laplace transforms, Shifting theorem. The Convolution theorem. Inverse transform, Applications to ordinary differential equations. Legendre polynomials. Their recurrence and orthogonal relations.

[Scope as in Sections 8.1-8.4, 8.5.4, 7.2 of Ref.4.]

UNIT - IV
Formation of first and second order partial differential equations, solutions of first order equation, classification of linear second order equations, separation of variables, solution of one dimensional wave and heat equations, solution of Laplace equation.

[Scope as in Sections 16.2, 16.3.1, 9.5.1, 9.5.2, 9.5.3, 9.5.4, 9.5.5 of Ref.4.]

Suggested Readings
SEMESTER - V

C11 Multivariate Calculus

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60
Credits: 6

Use of Scientific calculator is allowed.

Objective: To apprise the students with theory of functions of several variables, its derivatives double and triple integrals and change of order of integration.

Unit I
Functions of several variables, limit and continuity of functions of several variables, partial differentiation, directional derivatives, total differentiability, Jacobian matrix, Chain rule.

Mean value theorem for differentiable functions, sufficient condition for differentiability, symmetry of mixed partial derivatives, Taylor’s formula for real valued functions of several variables.

Unit II
The gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of several variables, method of Lagrange multipliers, constrained optimization problems.

Banach Contraction principle, Inverse function theorem and implicit function theorem.

Unit III
Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, cylindrical and spherical co-ordinates.


Unit IV
Definition of vector field, divergence and curl, Green’s theorem, surface integrals, integrals over parametrically defined surfaces. Stoke’s theorem, The Divergence theorem.

Scope:
Units I and II: Chapter 12-13 from [1].
Units III and IV: Chapters 15 and 16 from [2].
Scope as in
Books Recommended
MAT-C12 : Group Theory II

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60 Credits: 6

Objective: Group Theory is a mathematical concept which is used as a tool in almost all branches of science. This is an advanced course in group theory and MAT C6 is a prerequisite for this course.

Unit-I
Automorphism, Inner automorphism, automorphism group, automorphism group of finite and infinite cyclic groups, automorphism group of Klein's four group. Inner automorphism group as factor group of the group, Characteristic subgroups, Commutator subgroup and its properties.

Unit-II
Group actions, group acting on themselves by left multiplication and conjugation. Stabilizers and kernels, permutation representation associated with a given group action, Applications of group actions, Generalized Cayley's theorem, Index theorem. Class equation as a consequence.

Unit-III

Unit-IV
Normal and subnormal series, Derived series, composition series, solvable groups and nilpotent groups, Zassenhaus lemma, Schreier refinement theorem, Jordan Holder's theorem

Scope as in 3, 4, 5, 6 of [2]

Books Recommended
MAT DSE 1 : Number Theory

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note :
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60
Credtis: 6

Objective : The aim of this course is to teach the students about the basics of Elementary Number Theory starting with primes, congruences, quadratic residues, primitive roots, arithmetic functions. Apart from teaching the theory, stress will be on solving problems.

UNIT-I
Divisibility, Greatest common divisor, Euclidean algorithm, The Fundamental theorem of arithmetic, Congruences, Residue classes and reduced residue classes, Chinese remainder theorem, Fermat’s little theorem.

UNIT-II
Wilson’s theorem, Euler’s theorem and its application to a cryptography, Arithmetic functions \( \phi(n), d(n), \sigma(n), \mu(n) \), Mobius inversion formula, Greatest integer function.

UNIT-III
Primitive roots and indices. Quadratic residues, Legendre symbol, Euler’s criterion, Gauss’s lemma, Quadratic reciprocity law, Jacobi symbol.

UNIT-IV
Representation of an integer as a sum of two and four squares. Diophantine equations \( ax+by=c \), \( x^2+y^2=z^2 \), \( x^4+y^4=z^2 \). Binary quadratic forms and equivalence of quadratic Forms. Perfect numbers, Mersenne primes and Fermat numbers, Farey fractions.

References:
MAT DSE 3 : Discrete Mathematics

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60 Credits: 6

Objective: The objective of this course is to acquaint the students with the basic concepts in Discrete Mathematics and Graph Theory.

UNIT-I
Pigeonhole principle, Basic counting principles, permutations and combinations of sets and multisets, Binomial and multinomial theorems, Combinatorial identities, inclusion and exclusion principle, Recurrence relations.

UNIT-II
Generating functions solution of recurrence relations using difference equations and generating functions, Catalan numbers, Difference sequences and Sterling numbers. Partitions as associated to distribution identical objects in identical boxes.

UNIT-III
Elements of Graph Theory, Eulerian and Hamiltonian trails and cycles. Bipartite multigraphs, Trees, Planer graphs, Euler formula.

UNIT-IV
Spanning Trees, Algorithms for BFS and DFS trees weighted Graphs, Greedy algorithm and Prim’s Algorithm for generating minimum weight spanning graphs, Digraphs, and Chromatic numbers. (Scope as in Introductory Combinatorics, 5th Edition by R.A. Brualdi, Chapters 1-3,5-8,11 (except § 11.6), 12.1, 13.1,13.2)

Suggested Readings
MAT DSE 5 - Linear Programming

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60

Objective: To provide the knowledge of basic concepts of optimization problems, theoretical development and applications of various techniques to solve real world problems, which can be formulated as linear programs.

Unit I
Convex sets, half spaces and their properties, Convex polytopes and polyhedrons, Hyperplane, Caratheodory’s theorem, extreme points and their existence, Supporting hyperplanes, Separating Hyperplanes, their existence, Separation theorems. (Scope as in chapter 2 of Ref1, chapter 2 of Ref 2)

Unit II
Linear Programming problems, basic feasible solution, mathematical formulation of practical problems, graphical method for the solution of linear programming problems, Basic solutions and extreme points. Fundamental properties of Linear programs, 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. (Scope as in chapter 3, 4, 5 of Ref1)

Unit III
Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. Theorem of Weak duality, strong duality, Basic duality theorem, Weak complementary slackness theorem, Strong complementary slackness theorem, their applications, Application of Duality to Farkas’ lemma and solutions of linear inequalities. (Scope as in chapter 15 of Ref 3)

Unit IV
Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, Properties of coefficient matrix, triangular basis, UV algorithm for solving transportation problem, unbalanced transportation problems, time minimization transportation problem, Paradox in Transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving cost minimization assignment problem and its convergence, time minimization assignment problem. (Scope as in chapter 5 of Ref 2, Chapter 5 of Ref 4).

References
DSE-7: Differential Geometry

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)

Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60

Credits: 6

Objective: In this course the tools of calculus, differential equations and linear algebra acquired in courses C1, C3, C4, C5, C9, C11 will be used to study problems in geometry.

Unit I
Theory of Space Curves: Curves in the planes and in space, arc length, reparametrization, curvature, Serret-Frenet formulae. osculating circles, evolutes and involutes of curves, apace curves, torsion, Serret-Frenet formulae.

Unit II
Theory of Surfaces Surfaces, smooth surfaces, tangents, normals and orientability, quadric surfaces, the first and the second fundamental forms, Euler’s theorem. Rodrigue’s formula.

Unit III
Gaussian Curvature, Gauss map and Geodesics: The Gaussian and mean curvatures, the pseudosphere, flat surfaces, surfaces of constant mean curvature, Gaussian curvature of compact surfaces, the Gauss map, Geodesics, geodesic equations, geodesics of surfaces of revolution, geodesics as shortest paths, geodesic coordinates.

Unit IV
Minimal Surfaces and Gauss’s Remarkable Theorem: Plateau’s problem, examples of minimal surfaces, Gauss map of a minimal surface, minimal surfaces and holomorphic functions, Gauss’s Remarkable Theorem, isometries of surfaces, The Codazzi-Mainardi Equations, compact surface of constant Gaussian curvature

Books Recommended
SEMMESTER - VI

C13 Metric Spaces and Complex Analysis

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60

Objective: Introduction to metric spaces and the theory of analytic functions.

Unit I

Metric spaces: definition and examples, balls and bounded sets, sequences in metric spaces, convergent and Cauchy sequences, open sets, closed sets, limit points, subspace topology, limits and continuity, homeomorphisms, Complete Metric Spaces, Cantor intersection property, totally bounded sets.

Unit II

Compact sets, Heine Borel theorem, sequential compactness, Bozano Weierstrass property, finite intersection property, continuity and compactness, uniform continuity, Dense sets, separable sets, perfect sets, connectedness, connected subsets of reals, continuity and connectedness, connected components, path connectedness.

Unit III

Axiomatic approach to complex numbers, Stereographic projection, Simply Connected regions, Branches of multi-valued functions, Principle Logarithm, complex exponents, Derivative of a complex function, Cauchy-Riemann equations, sufficient conditions for differentiability, Differentiation of Elementary functions, Analytic functions, Harmonic functions and their Conjugates, Analyticity at Infinity.

Unit IV

Curves, Simply closed curves, Complex line integral, Path independence of a line integral, Cauchy’s theorem for Rectangles and Disks, the Cauchy Integral Formula and Applications, Liouville’s theorem and its consequences, Absolute and Uniform Convergence of Power Series, Introduction to Taylor and Laurent series and their examples.

Scope:

Units I and II: Chapter 4 from [1], Chapter 2 and 4 from [2] and Chapter 7 of [3].
Units III and IV: Sections 1.1, 1.6, 2.4 to 2.7, 3.2, 3.5, 3.6, 3.7, 4.1 to 4.8, 6.1, 6.2, 6.3, 6.5. from [4].
Books Recommended
MAT C14: Ring Theory and Linear Algebra-II

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60
Credits: 6

Objectives: This is an advanced course in ring theory and linear algebra. MAT C10 is a prerequisite for this course.

UNIT-I
Factorization and Divisibility in integral domains, Unique Factorizaion Domains (UFDs), Principal Ideal Domains (PID), Euclidean domains and relationships between them.

UNIT-II
Primitive Polynomials and Gauss Lemma, Eisenstein’s irreducibility criterion, Factorization of polynomials in one variable over a field, Unique Factorization in R[X], R a UFD.

Scope as in Chapters 8 and 9 of [9]

UNIT-III
Modules, definition and examples, Submodules, Quotient modules, Free modules, Comparison with vector spaces, Homomorphisms, Simple and Semisimple Modules.

UNIT-IV
Structure of finitely generated modules over a PID. Rational and Jordan Canonical forms.

Scope as in Chapters 10 and 12 of [9]

Books Recommended
MAT DSE 2 - Probability and Statistics
[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures: 60
Credits: 6

Objective: This course provides an introduction to probability theory, random variables, mathematical statistics, Central Limit theorem and Markov chains, learn commonly used probability distributions and their uses in real life. Probability theory is important because of its direct application in areas such as genetics, finance and telecommunications. It also forms the fundamental basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modelling.

Unit I
Sample Space, review of set theory, events, probability function, probability axioms, the concept of real random variables (discrete and continuous), cumulative distribution function, probability mass / density functions, conditional probability, mathematical expectation, moments, moment generating function, characteristic function.

Unit II

Unit III
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, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

Unit IV
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, Markov Chains, Chapman-Kolmogorov equations, classification of states.

Books Recommended
Objective: Mechanics is one of the important branches of mathematics that finds application in almost all real world problems. This course is an introduction to statics, that is, the bodies at rest under action of forces. Students will be introduced to the concept of force, their addition and resolution, moments, couples, friction and equilibrium conditions. In addition, the centre of mass, gravity and stability of body will be taught.

UNIT-I
Basic notions: Inertial and non-inertial frame of reference, Weight of body, Force, Force with contact and without contact, Force systems, Principle of transmissibility of forces, Basic concepts of mechanics.
Forces acting on a particle: Parallelogram law of forces, Triangle law of forces and its converse, Polygon of forces, $\lambda-\mu$ Theorem, Lami’s theorem and its converse, Components of a force in given directions, Resolution of forces, Theorem on resolved parts of two concurrent forces. Condition of equilibrium of any number of forces, Trignometric m-n theorem, equilibrium of a rigid body under the action of three forces.

UNIT-II
System of two Parallel forces: Resultant of two like parallel forces, unequal unlike parallel forces, Theorem of resolved parts of two parallel forces.
Moments and Couples: Moment of a force about a point, Moment of a force about a line; Couple, Moment of a couple, Varignon’s theorem on moments of two coplanar forces. Composition of coplanar couples, Composition of a number of couples, equilibrium of couples, equivalence of couples.

UNIT-III
Coplanar force system: Resultant of three concurrent coplanar forces, Theorem of resolved parts of three forces, Resultant of any number of coplanar concurrent forces, Condition of equilibrium of a system of coplanar forces, Reduction of two coplanar forces to a single force or a single couple, Resultant of three coplanar forces to two, Reduction of any number of coplanar forces to a single force or a single couple, Generalization theorem of resolved parts, generalisation of Varignon’s theorem of moments.
Resultant of a force and a couple, Resolution of a force into a force and a couple, Reduction of a system of coplanar forces to a force and a couple.

UNIT-IV
Friction: Definition and nature of friction, coefficient of friction, angle of friction, cone of friction, laws of friction, equilibrium of a particle on a rough plane, Problems on ladders, rods etc.
Virtual Work: Work done by a force, Principle of virtual work with Applications.
Stable and Unstable Equilibrium: Stable, unstable and neutral equilibrium, Criteria for stability of equilibrium, Examples.

Suggested Readings:
2. The Elements of Statics and Dynamics by S. L. Lony, Cambridge University Press.
3. Elements of Mechanics: Statics and Dynamics by K R Chaudhary and A C Aggarwal, S. Chand and Company Ltd, New Delhi
MAT DSE 6: Dynamics

[6 hrs/per week (including Tutorials)]
[Max. Marks: 150]
(Final-120+Internal Assessment-30)
Time : 3hrs.

Note:
1. The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
2. There will be two questions from each unit and the students will be required to answer one question from each unit.
3. All questions carry equal marks.

Total Lectures : 60
Credits: 6

Objective: Mechanics is one of the important branches of mathematics that finds application for bodies in motion. This course is to study the motion of moving body. Students will be introduced to the concept of motion along a straight line with constant and variable acceleration. In addition, motion in a plane, SHM, projectile, work, power energy, momentum and impulsive motion will be taught.

UNIT-I

Basic notions: Kinematics, kinetics, uniform motion, position, displacement, velocity, acceleration, uniform velocity, Linear momentum.

Motion of a particle in a straight line: Motion of a particle with constant acceleration, motion of a body let fall free from rest, motion of a body projected vertically upwards.

UNIT-II

Newton’s Laws of Motion: Newton’s Laws of Motion, Motion of two particles connected by a string, Motion along a smooth inclined plane, constrained motion along a smooth inclined plane.

Variable acceleration: Simple harmonic motion.

UNIT-III

Motion of a particle in a plane Composition and resolution of velocities and Acceleration in a plane, Projectiles, motion in a circle, Motion under constraint

Work, power and energy: Work, power, Conservative fields and the potential energy, work done against gravity, Potential energy of a gravitational field.

UNIT-IV

Relative motion: Relative displacement, velocity and acceleration, motion relative to a rotating frame of reference.

Momentum: Linear momentum, angular momentum, conservation of angular momentum, impulsive forces, principle of impulse and momentum, motion with respect to centre of mass of a system of particles,

Impulsive motion: Collisions of elastic bodies, loss of energy during impact.

Suggested Readings:
2. The Elements of Statics and Dynamics Part II : Dynamics by S L Loney, MTG Learning Media Ltd. (2004)
Objective: This course apprise basic concepts of mathematical modelling, some special functions and some basic models.

UNIT-1
Simple situations requiring Mathematical Modelling, The techniques of Mathematical modelling, Classifications and some characteristics of Mathematical Modelling, Limitations of Mathematical Modelling.

UNIT-2
Bessel’s and Legendre’s equations, orthogonal properties & recurrences relation, Generating Function. Laplace transform and inverse transform application to initial value problem up to second order.

UNIT-3
Monte Carlo Simulation Modelling: simulating deterministic behaviour (area under a curve, volume under a surface), Generating Random Numbers: middle square method, linear congruence.

UNIT-4
Queuing Models: harbor system, morning rush hour, Overview of optimization modelling, Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

Books Recommended
4. Partial Differential equations of Mathematical Physics: Tyn Myint-U.