B. Sc. (Honours) Mathematics

Under the Framework of Honours School System
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-GEBM1: 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-GEPS1: 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)
PREAMBLE

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.
### COURSE STRUCTURE

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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
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-GEBM1: Algebra and Geometry

**Semester-II**

2. MAT-GEBM3: Calculus

**Semester-III**

3. MAT-GEBM5: Matrices
Semester-IV

4. MAT-GBM6: Vector Analysis, Differential Equations and Transform

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

Semester-I

1. MAT-GEPS1: Advanced Calculus and Geometry

Semester-II

2. MAT-GEPS3: Linear Algebra

Semester-III

3. MAT-GEPS5: Differential Equations and Fourier Series

Semester-IV

4. MAT-GEPS6: Integral Transforms and complex Analysis
B. Sc. (Honours) in Mathematics

Under the Framework of Honours School System

I Year

Semester I and II
Semester I

MAT-C1: Calculus

THEORY

5 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: 60

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 and applications of integration.

UNIT I (15 hrs)

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L’Hospital’s rule, applications in business, economics and life sciences.

UNIT II (15 hrs)

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx \, dx$, $\int \cos nx \, dx$, $\int \tan nx \, dx$, $\int \sec nx \, dx$, $\int (\log x)^n \, dx$, $\int \sin^n x \sin^m x \, dx$, 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.
UNIT III (15 hrs)
Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

UNIT IV (15 hrs)
Vectors, 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, modeling ballistics and planetary motion, Kepler’s second law.

MAT-C1: Calculus
PRACTICAL
(Using any software)

(3 practical per week )
In groups of 15 students

[Max. Marks: 50]
(Final-40+Internal Assessment-10)

Time : 3hrs.

Total Lectures : 60
Credits: 2

(i) Plotting of graphs of function $e^{ax + b}$, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b), lax + bl and 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, \( n^{\text{th}} \) 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:
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 learn about the completeness property of R, sequences and series of real terms and various tests of convergence.

UNIT I (15 hrs)

UNIT II (15 hrs)
Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Cauchy sequence, Cauchy’s Convergence Criterion, Limit Theorems, Monotone Sequences,
Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences.

UNIT III (15 hrs)

UNIT IV (15 hrs)
Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy’s n\text{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

References:

5. N. L. Carothers, Real Analysis, Cambridge University Press.
MAT-C4: Differential Equations

THEORY

[5 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: 60 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 (15 hrs)
Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. 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.

UNIT II (15 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.
UNIT III (15 hrs)
General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients.

UNIT IV (15 hrs)

MAT-C4: Differential Equations

PRACTICAL

(3 practical per week)
In groups of 15 students

[Max. Marks: 50]

(Final-40+Internal Assessment-10)

Time : 3hrs.

Total Lectures: 60
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. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
10. Battle model (basic battle model, jungle warfare, long range weapons).

References:

GENERIC ELECTIVE SUBJECTS

MAT-GEBM1: 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 Text book-‘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-GEPS1: 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 )

Line integrals vector fields. Path independence and surface integrals. Divergence and Stoke’s theorem (Applications only). [Scope as in Sections 14.1, 14.3, 14.4, 14.5, 14.7 of Chapter 14

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 $\Delta$ and trace $t$. Condition that a second degree equation should represent a pair of straight lines. Polar coordinates, polar equation of a conic.
[Scope as in Chapters 1, 6(Sections 6.1-6.4), 7(Sections 7.1-7.8, 7.11-7.15) from Plane Geometry of “New Pattern Vector Algebra and Geometry” by J. P. Mohindru, Mrs. Usha Gupta and A. S. Dogra, International Publishers, Edition 2004.]

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.
[Scope as in Chapters 1(Sections 1.1-1.6, 1.11-1.14), 2(Sections 2.1-2.5, 2.12. 2.13), 3(Sections 3.1-3.3), 4(Sections 4.6, 4.7, 4.10, 4.11) from Solid Geometry of “New Pattern Vector Algebra and Geometry” by J. P. Mohindru, Mrs. Usha Gupta and A. S. Dogra, International Publishers, Edition 2004.]

Suggested Readings
MAT-GEBM2: 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)

Application of derivative: increasing and decreasing functions. Maxima and Minima. Rolle’s Theorem (without proof). Mean Value Theorem. Tangents and Normals. [Scope as in Chapters 6 of a Text book –‘Mathematics’ for Class XII, NCERT.]

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 – GEPS2: 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)
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