RAMAKRISHNA MISSION VIDYAMANDIRA

BELURMATH, HOWRAH, WEST BENGAL

DEPARTMENT OF MATHEMATICS

PROGRAMME OFFERED : B.Sc. MATHEMATICS HONOURS

PROGRAMME CODE : MTMA

DURATION : 6 SEMESTERS

TOTAL CREDIT : 148

FULL SYLLABUS WITH COURSE OUTCOME

VALID & ONGOING AS ON 30TH JUNE, 2019

Following is the credit distribution for B.Sc. Mathematics Hons. Programme:

	CR SEM 1	CR SEM 2	CR SEM 3	CR SEM 4	CR SEM 5	CR SEM 6	Total Credit
Core Course / Hons.	14	14	14	14	26	26	**108**
Generic Elective	6	6	6	6	--	--	**24**
AECC-Lang.	2	2	2	2	--	--	**4**
AECC-ENVS	--	--	--	--	--	--	**4**
SEC- ICSH	1	1	1	1	2	2	**8**
	23	**23**	**23**	**23**	**28**	**28**	**148**

Following is the Grade Point distribution:

% of Marks	Descriptor	Grade	Grade Point
85 - 100	OUTSTANDING	**O**	**10**
70 - 84.99	EXCELLENT	**A+**	**9**
60 - 69.99	VERY GOOD	**A**	**8**
55 - 59.99	GOOD	**B+**	**7**
50 - 54.99	ABOVE AVERAGE	**B**	**6**
40 - 49.99	AVERAGE	**C**	**5**
35 - 39.99	PASS (HONOURS)	**P**	**4**
30 - 34.99	PASS (OTHERS)	**P**	**4**
LESS THAN 35	FAILED (HONOURS)	**F**	**0**
LESS THAN 30	FAILED (OTHERS)	**F**	**0**

Name of the Core Course	Credit for the Core Course	Generic Elective Course and the Credit
Mathematics Hons	108	Total Credit : 24 Guidelines to make Choice : While Generic Elective subject Course ‘a’ is to be taken by all students, any one from Generic Elective subject Course ‘b’ may be chosen by the students a) Computer Science & b) Physics/ Statistics

B.Sc. Mathematics Hons. Programme has introduced Discipline Specific Elective Course (DSE) and/or Project in 5th and/or 6th semester:

Sl. No.	Name of the Programme	Discipline Specific Elective / Project
9	Mathematics Hons	DSE (Topology / Differential Geometry / Measure Theory / Graph Theory / Tensor Calculus)

Students of B.Sc. Mathematics Hons. Programme must take following courses :

- Ability Enhancement Compulsory Courses (AECC):
  - Environmental Science : 4 Credit
  - English Language and MIL (Bengali Language/ Alternative English) : 4 Credit
- Value-Oriented Course (Indian Cultural and Spiritual Heritage) : 8 Credit

Total Credit to be earned by a student to complete B.Sc. Mathematics Hons. Programme: 148 Credit
Mark sheet after each semester will be given both with SGPA and detailed marks obtained by the examinee.

Similarly Mark sheet after the final semester will be given with CGPA and detailed marks obtained by the examinee.

Calculation of SGPA = (Total Credit X Total Grade Point = Total Credit Point);
Total Credit Points / Total Credits

Calculation of CGPA = (Total SGPA X Total Credits in each Sem.) / Total Credits earned in all the semesters

B.Sc. Mathematics Honours

6 Semester Course

Course Structure

Sl No	Name of the Course	Semester	Course Code	Credit	Marks in the Course	Course outcome
1	Algebra IA, Analysis IA, Analytical Geometry I & Vector Algebra, Differential Equations I	1	MTMA-P1	14	100	Algebra IA: To learn the concept of relation, function, group, subgroup, permutation group, cyclic group, Lagrange's theorem and its application. It is required for next algebra and analysis courses. Analysis IA: To learn the concept of well ordering principal for N, mathematical induction, countability of sets with various examples, topology in R, sequence, functions and limit of a function. It is required for next analysis, topology courses. Analytical Geometry I & Vector Algebra: To learn the concept of orthogonal transformation, classification of conics, pair of straight lines, pole, polar, conjugate points and conjugate lines, conjugate diameters, vectors, vectors products and solution of vector equations. It is required for differential equation and mechanics course Differential Equations I: To learn the classification of ODE, solution techniques of first order ODE, higher order ODE with constant coefficients , concept of trajectories. It is required for next differential and mechanics courses.
2	Algebra IB, Analysis IB, Linear Algebra I and Optimization Techniques	2	MTMA-P2	14	100	Algebra IB: To learn the concept and applications of inequalities, complex numbers, theory of equations. This will help students for courses on number theory and analysis. Analysis IB: To learn the concept of series (in R), compact sets,

						continuous function, differentiation of function. This will help the student to take up advanced courses on analysis. Linear Algebra I: To learn the concept of matrix, determinant and vector space. This is required for next course on linear algebra, applications in LPP, multivariable calculus. Optimization Techniques: To learn the concept of basic feasible solution in L.P.P, simplex method, duality theory, transportation and assignment problem. This is the basic requirement for the courses on operation research.
3	Linear Algebra II A, Analysis IIA, Analytical Geometry II and Mechanics I	3	MTMA-P3	14	100	Linear Algebra II A: To learn the concept of quotient space, linear transformation and its applications, congruence of matrices. This is required for next course on linear algebra, multivariable calculus, numerical analysis. Analysis IIA : To learn the concept of sequence and series of functions and power series. This is required for the advanced courses on differential equations and numerical analysis. Analytical Geometry II: To learn the concept of planes, straight line, sphere, conics, tangent plane, generating lines, transformation of rectangular axes by translation, rotation and their combinations, general equation of second degree in x, y, z ; nature of quadrics. This is required for courses on mechanics, differential equation and differential geometry. Mechanics I: To learn the concept of S. H. M., motion of a particle in a plane, tangent and normal accelerations, circular motion, motion of a particle in a plane under different laws of resistance, central forces and central orbits. This is the basic requirement for the advanced mechanics course.

4	Analysis II B, Linear Algebra II B, Differential Equations II, and Applications of Calculus	4	MTMA-P4	14	100	Analysis II B: To learn the concept of metric space. This is useful for the topology and analysis courses. Linear Algebra II B : To learn the concept of eigen-value, eigen function, Cayley Hamilton theorem, inner-product space, operators. This is required for the multivariable analysis, differential geometry, numerical analysis courses and quantum mechanics. Differential Equations II : To learn the solution methods for P.D.E., Sturm-Liouville problem, Simultaneous linear differential equations, Series solution, Laplace transform. This is required for mechanics and advanced differential equation courses in post graduate level. Applications of Calculus: To learn the concept of tangents and normals, rectilinear asymptotes, curvature, envelopes, concavity, convexity, singular points, nodes, cusps, points of inflexion, surface and volume of revolution. This is required for the differential geometry courses.
5	Algebra III, Multivariable Calculus , Analysis IIIA	5	MTMA-P5	13	100	Algebra III : To learn the concept of normal subgroups, isomorphism, class equation, group action, Sylow theorems and ring theory. This course is helpful for advance study of abstract algebra. Multivariable Calculus : To learn the concept of limit, continuity, differentiation of the functions from R^m to R^n and their applications. This paper is useful in further analysis studies and various applied papers. Analysis IIIA : To learn the concept of Riemann integration and function of bounded variation. This paper is useful in post-graduate analysis and it is useful in various applied topics in post graduate level.

6	Numerical Analysis, Vector Calculus, Mechanics II,	5	MTMA-P6	13	100	Numerical Analysis: To learn the solution techniques of interpolation, differentiation, integration, ODE, finding roots of algebraic and transcendental equations, and system of linear equation by numerical methods. It is useful in advanced numerical analysis in postgraduate level. Vector Calculus: To learn the concept of gradient, divergence, curl, vector integration. It is useful in further study of mechanics, analysis. Mechanics II: To learn the concept of moment of inertia, D'Alembert's principle, equation of motion of a rigid body about a fixed axis, equations of motion of a rigid body moving in two dimensions, equations of motion under impulsive forces, planetary motion and Kepler's laws, motion on a smooth curve under resistance, slightly disturbed orbits, equation of motion of a particle of varying mass. It is required for advance course in mechanics in postgraduate level
7	Analysis IIIB, Number Theory, Probability Theory, Complex Analysis	6	MTMA-P7	13	100	Analysis IIIB : To learn the concept of multiple integration, improper integration and Fourier series. It is required for advance study in analysis. Number Theory: Familiarize the students with different properties of integers. It is required for advance study in number theory. Probability Theory : To learn the concept of random variables, different probability distributions and inequalities. This course is required in various courses in pure and applied mathematics courses. Complex Analysis: To learn the concept of analytic function, elementary functions, sequence and series of complex valued functions. This course is required for further analysis course and advanced course in complex analysis.

8	Mechanics III, Computer fundamentals and Programming in C, Numerical Practical using Computer and Optional paper	6	MTMA-P8	13	100	Mechanics III: To learn the concept of friction, virtual work, astatic equilibrium, stable and unstable equilibrium, equilibrium of flexible strings, forces in the three dimensions. It is required in advanced mechanics courses in post graduate level. Computer fundamentals and Programming in C: To learn C language and the concept of Boolean algebra. It is required for Numerical practical. Numerical Practical using Computer: To learn the solution techniques of numerical problems by C programme. It is required to use numerical computation in various courses in applied mathematics. Optional Paper: Tensor Calculus: To learn the concept of tensor algebra, Christoffel symbols, Covariant differentiation. It is required for further study in differential geometry in postgraduate level. Differential geometry: To learn the geometry of curves and surfaces. It is the basic course in differential geometry which helps students in advance differential geometry course. Measure theory: To learn the basic concept of Lebesgue measure. It helps students in advance probability theory and measure theory in post graduate level. Graph theory: To learn the concept of Euler graph, planner graph and tree. It helps students to study graph theory in post graduate level. Topology: To learn the basic concept of set theoretic topology. It helps students to study topology course in post graduate level.

B.Sc. Mathematics Honours

6 Semester Course

Mapping of Employability etc.

Sl No	Name of the Course	Semester	Course Code	**Activities with direct bearing on Employability/ Entrepreneurship/ Skill development**
1	Algebra IA, Analysis IA, Analytical Geometry I & Vector Algebra, Differential Equations I	1	MTMA-P1	Skill develpoment : Analytical and reasoning skills are developed by group discussion or free participation of students related to nontrivial problems in class. Employabality :Group discussions and problem solving sessions in this course will help a student to develop analytical and reasoning skills required for teaching jobs at High School Level. Further, the students will develop mathematical reasoning skills required for various professional examinations like IAS, IPS, IFS, WBCS, clerical and officer level jobs in banking sectors.
2	Algebra IB, Analysis IB, Linear Algebra I and Optimization Techniques	2	MTMA-P2	Skill develpoment : Analytical reasoning and business analytic skills are developed by group discussion or free participation of students related to nontrivial problems in class. Employabality : Group discussions and problem solving sessions in this course will help a student to develop analytical and reasoning skills required for teaching jobs at High School Level, Indian forest services, clerical and officer level jobs in commercial sectors such as banking, insurance, share market, etc.
3	Linear Algebra II A, Analysis IIA, Analytical Geometry II and Mechanics I	3	MTMA-P3	Skill develpoment : Analytical and reasoning skills are developed by group discussion or free participation of students related to nontrivial problems in class.

4	Analysis II B, Linear Algebra II B, Differential Equations II, and Applications of Calculus	4	MTMA-P4	Skill develpoment : Analytical and reasoning skills are developed by group discussion or free participation of students related to nontrivial problems in class. They will also learn to apply various analytical methods to solve real life problems as applications of differential equations. Employabality :Group discussions and problem solving sessions in this course will help a student to develop analytical and reasoning skills required for teaching jobs at High School Level, Indian forest services, clerical and officer level jobs in commercial sectors such as banking, insurance, share market, etc.; Industrial research areas involving machine designing.
5	Algebra III, Multivariable Calculus , Analysis IIIA	5	MTMA-P5	Skill develpoment : Analytical and reasoning skills are developed by group discussion or free participation of students related to nontrivial problems in class. They will also learn to apply various analytical methods to solve real life problems using integration.

6	Numerical Analysis, Vector Calculus, Mechanics II,	5	MTMA-P6	Employabality : Group discussions and problem solving sessions in this course will help a student to develop analytical and reasoning skills required for teaching job in high school level, Indian forest service, banking examinations, jobs that require numerical modeling like software development etc. Skill develpoment : Analytical and reasoning skills are developed by group discussion or free participation of students related to nontrivial problems in class. They will also learn to apply various analytical methods to solve real life problems using numerical methods.
7	Analysis IIIB, Number Theory, Probability Theory, Complex Analysis	6	MTMA-P7	Skill develpoment : Analytical and reasoning skills are developed by group discussion or free participation of students related to nontrivial problems in class. Employabality :Group discussions and problem solving sessions in this course will help a student to develop analytical and reasoning skills required for teaching jobs at High School Level, Indian forest services, clerical and officer level jobs in banking sectors

8	Mechanics III, Computer fundamentals and Programming in C, Numerical Practical using Computer and Optional paper	6	MTMA-P8	Employabality : Group discussions and problem solving sessions in this course will help a student to appear for school service commission, Indian forest service, banking examinations, jobs that require numerical modeling like software development etc. Skill develpoment : Analytical and reasoning skills are developed by group discussion or free participation of students related to nontrivial problems in class. They will also learn to apply various analytical methods to solve real life problems using numerical applications and programming techniques.
9	Classical Algebra, Modern Algebra and Differential Calculus	1	MTMG-P1	Skill develpoment : Algebraic and analytic skills are developed by group discussion or free participation of students related to nontrivial problems in class.
10	Analytical Geometry of 2 Dimensions, Vector Algebra, Differential Calculus II, Integral Calculus, Ordinary Differential Equations I	2	MTMG-P2	Skill develpoment : Algebraic and analytic skills are developed by group discussion or free participation of students related to nontrivial problems in class.
11	Geometry 3D, L.P.P., Numerical Analysis	3	MTMG-P3	Skill develpoment : Algebraic and analytic skills are developed by group discussion or free participation of students related to nontrivial problems in class.
12	Integral Calculus II, Ordinary Differential Equation II, Probability and Statistics	4	MTMG-P4	Skill develpoment : Algebraic and analytic skills are developed by group discussion or free participation of students related to nontrivial problems in class.

Course-structure for B. Sc. (Mathematics (Hons.))

Sem I:

Paper I:

M 1: Algebra IA (25)
Analysis IA (25)
M 2: Analytical Geometry I
& Vector Algebra (25)
Differential Equations I (25)

Sem II:

Paper II:

M 1: Algebra IB (25)
Analysis IB (25)
M 2: Linear Algebra I (20)
Optimization Techniques (30)

Sem III:

Paper III:

Sem IV:

Paper IV:

M 1: Linear Algebra II A (35)
Analysis IIA (15)

M 2: Analytical Geometry II (20)
Mechanics I (30)

M 1: Analysis II B (35)
Linear Algebra II B(15)

M 2: Differential Equations II (30)
Applications of Calculus (20)

Sem V:

Paper V:

M 1: Algebra III (50)

M 2: Multivariable Calculus (30)
Analysis IIIA (20)

Paper VI:

M 1: Numerical Analysis (30)
Vector Calculus (20)
M 2: Mechanics II (50)

Sem VI:

Paper VII:

M 1: Analysis III (30)
Number Theory (20)
M 2: Probability Theory (30)
Complex Analysis (20)

Paper VIII:

M 1: Mechanics III (30)
Computer fundamentals and Programming in C (20)
Tensor Calculus / Differential Geometry/Measure Theory/ Graph Theory /Topology (20)

M 2: Numerical Practical using Computer (30)

UG SEM 1

Course Code: MTMA-P1 (Credit-14, Full Marks-100)

Name of the Course: Algebra IA, Analysis IA, Analytical Geometry I & Vector Algebra, Differential Equations I

Course outcome:

Algebra IA: To learn the concept of relation, function, group, subgroup, permutation group, cyclic group, Lagrange's theorem and its application. It is required for next algebra and analysis courses.

Analysis IA: To learn the concept of well ordering principal for $\mathbb{N}$, mathematical induction, countability of sets with various examples, topology in $\mathbb{R}$, sequence, functions and limit of a function. It is required for next analysis, topology courses.

Analytical Geometry I & Vector Algebra: To learn the concept of orthogonal transformation, classification of conics, pair of straight lines, pole, polar, conjugate points and conjugate lines, conjugate diameters, vectors, vectors products and solution of vector equations. It is required for differential equation and mechanics course

Differential Equations I: To learn the classification of ODE, solution techniques of first order ODE, higher order ODE with constant coefficients , concept of trajectories. It is required for next differential and mechanics courses.

Module - I (50)
Algebra IA (25)

1. Set, subset and superset. Operation on set, properties including De Morgan's laws.Cartesian product of sets. Mapping: Bijective mapping, Identity mapping, inverse mapping, Composition of mappings, related theorems. Restriction and Extension of mapping, Binary relation, Equivalence relation and Partial order relation, Equivalence class, partition of set, Fundamental theorem on Equivalence relation and partition.

2. Binary composition, Group, Abelian group, Examples of groups, Elementary properties of groups. Semigroup with examples and related theorems.Subgroups with examples and related theorems. Centre of a group. Permutation, Product of permutations, Inverse of a permutation, Order of a permutation, Cycles and transposition with related theorems, Even and odd permutations, Symmetric group and alternating group, Integral power (multiple) of an element of a group, Order of an element of a group and related theorems, Order of a group, Cyclic group with examples and related theorems, Coset and related theorems. Lagrange's theorem and its applications.

References
[1] Higher Algebra (Abstract and Linear) - S. K. Mapa.
[2] Abstract Algebra - M. Artin.
[3] Topics in Algebra - I. N. Herstein.
[4] Topics in Abstract Algebra - Sen, Ghosh &Mukhopadhyay.
[5] First Course in Abstract Algebra – Fraleigh.

Analysis IA (25)

1. Natural numbers, Well ordering principle for N, Mathematical induction - simple applications. Rational numbers – examples, Algebraic property, order property and density property of rational numbers. Real Numbers - Algebraic property and order property, Point set in one dimension, Bounded set, Least upper bound axiom or completeness axiom, Archimedean property and density property of real numbers. Absolute value, Symbols $+\infty$ and $-\infty$.

2. Point set in one dimension: (a) Neighbourhood of a point, interior point, accumulation point and isolated point of linear point set. Bolzano Weierstrass theorem on accumulation point. Derived set and closed set. Union, intersection, complement of open and closed sets in R. Closure of a set. Deduction of basic properties of interior of a set and closure of a set.
(b) Denumerable, countable and uncountable sets.

3. Sequence of points in one dimension: Bounds, limits, convergence and non convergence of a sequence, operations on limits. Sandwich rule. Monotone sequences and their convergence. Theorem on nested intervals.Cauchys general principle of convergence, Cauchy sequence.Cauchys first and second limit theorems. Subsequence, Bolzano – Weierstrass theorem for sequence, Subsequential limits.Upper limit and lower limit of a sequence.Inequalities and equalities with upper and lower limits.

4. Real valued functions defined on intervals: Bounded functions, Step functions, Monotone functions, composite functions. Limit of functions: Algebra of limits, Sandwich rule, Cauchy criterion for existence of finite limits. Limits of monotone functions.

References

[1] Principles of Mathematical Analysis – Walter Rudin.
[2] Mathematical Analysis - T. M. Apostol.
[3] Real analysis – Goldberg.
[3] Real Analysis - S. K. Mapa.

Module - II (50)

Analytical Geometry I and Vector Algebra (25)

Analytical Geometry I (Two Dimensional Geometry)

1(a) Orthogonal transformation of co-ordinate axes: Translation, Rotation and their combinations. Invariance.
(b) General equation of second degree in two variables. Reduction to canonical form.
Classification of conics.Position of axes, their lengths.

2. Pair of straight lines: Condition that the equation $ax^2 + 2hxy + by^2 = 0$ may represent a pair of straight lines through the origin. Angle and angle bisectors of the pair of lines $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$. Condition that $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$ may represent a pair of straight lines. Angle and angle bisectors, point of intersection of the pair of lines $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$. Equation of the pair of straight lines joining the origin to the points in which a line meets a conic.
3. Polar equations of straight line, circle and conic. Equations of chord, tangent, normal and chord of contact of a conic.

4. Pole, polar, conjugate points and conjugate lines.

5. Conjugate diameters of different conics and their properties.

Vector Algebra

1. Definition, Difference between scalar and vector, Types of vectors - Free / geometric vector, line vector, constant vector, variable vector. Collinearity of two or more vectors, like, unlike and equality of two vectors.Addition of vectors, Multiplication of a vector by a scalar.Position vector, section ratio, collinearity of three points, coplanarity of four points.Linear combination of a set of vectors, their dependence and independence.Coordinates of a vector in two dimensions and three dimensions.
2. Product of vectors - Scalar product, Vector product, scalar triple product, vector triple product, product of four vectors.

3. Applications of vector algebra in (i) geometrical and trigonometrical problems (ii) work done by a force, moment of a force about a point and about a line.Vector equations of straight lines and planes, signed distance of a point from a plane, Volume of a tetrahedron.Shortest distance between two skew lines.Vector equations and their solutions.

References

[1] Co-ordinate Geometry – S. L. Loney.
[2] Co-ordinate Geometry of Three Dimensions – Robert J. T. Bell.
[3] Analytic Geometry , M. C. Chaki.
[4] Vector Analysis – Barry Spain.
[5] Vector Analysis – Louis Brand.

[6] Vector Analysis – Barry Spain.
[7] Vector & Tensor Analysis – Spiegel (Schaum).
[8] Elementary Vector Analysis – C. E. Weatherburn (Vol. I & II).
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Differential Equations I (25)

1. Significance of ordinary differential equation. Geometrical and physical consideration.Formation of differential equation by elimination of arbitrary constant.Meaning of the solution of ordinary differential equation.Concept of linear and non-linear differential equations.

2**.** Equations of first order and first degree: Statement of existence theorem. Separable, Homogeneous and Exact equation. Condition of exactness, Integrating factor. Rules of finding integrating factor, (statement of relevant results only).

3**.** First order linear equations : Integrating factor (Statement of relevant results only). Equations reducible to first order linear equations (Bernoulli's Equation). Method of variation of parameters.

4**.** Equations of first order but not of first degree. Clairaut's equation.Singular solution.

5**.** Applications : Geometric applications, ω-trajectories, Orthogonal trajectories.

6**.** Higher order linear equations with constant co-efficients : Complementary function, Particular Integral. Method of undetermined co-efficients, Symbolic operator D. Method of variation of parameters.Exact Equation.Euler's homogeneous equation and Reduction to an equation of constant coefficients.

References

[1] An Introductory Course on Ordinary Differential Equation – D. A. Murray.
[2] Differential Equations – S. L. Ross.
[3] Differential Equations – H. T. H. Piaggio.
[4] A Text Book of Ordinary Differential Equations – Kiseleyev, Makarenko&Krasnov.
[5] Differential Equations with Application & Programs – S. BalachandaRao, H. R. Anuradha.
[6] Text Book of Ordinary Differential Equations (2nd Ed.) – S. G. Deo, V. Lakshmikantham& V. Raghavendra (Tata McGraw Hill).
[7] An Introduction to Differential Equations - Ghosh&Maity.
[8] Differential Equations - Chakraborty& Ghosh.

UG SEM 2

Course Code: MTMA-P2 (Credit-14, Full Marks-100)

Name of the Course: Algebra IB, Analysis IB, Linear Algebra I and Optimization Techniques

Course outcome:

Algebra IB: To learn the concept and applications of inequalities, complex numbers, theory of equations. This will help students for courses on number theory and analysis.

Analysis IB: To learn the concept of series (in ℝ), compact sets, continuous function, differentiation of function.This will help the student to take up advanced courses on analysis.

Linear Algebra I: To learn the concept of matrix, determinant and vector space. This is required for next course on linear algebra, applications in LPP, multivariable calculus.

Optimization Techniques: To learn the concept of basic feasible solution in L.P.P, simplex method, duality theory, transportation and assignment problem.This is the basic requirement for the courses on operation research.

Module I (50 Marks)

Algebra IB (25)

[Classical Algebra]

1. Weierstrass' inequality, Cauchy - Schwarz inequality, Arithmetic, geometric, harmonic means and weighted means and related theorems.
2. Complex numbers - Definition and field structure, Conjugate of a complex number, modulus of a complex number, Triangle inequality, Amplitude of a complex number, De Moivre's theorem, roots of a complex number, nth roots of unity, exponential and logarithm of a complex number. Definition of $a^z\left(a\neq 0\right)$
3. Polynomials and polynomial equations, Addition and multiplication of polynomials, Division algorithm, Remainder theorem and factor theorem, Fundamental theorem of classical algebra (statement only) and its consequences. Polynomials with real co-efficient and related theorems, Rolles theorem (statement only) and its consequences, Multiple roots

and related theorems, Descartes rule of signs (statement only) and its consequences, relation between roots and coefficients, Transformation of equation, Reciprocal equation, Binomial equation, Special roots and related theorems, Cardan's method for solving cubic equations, Ferrari's method for solving biquadratic equations.

References

[1] Higher Algebra (Classical) – S. K. Mapa.
[2] Higher Algebra – Barnard & Child.

Analysis IB (25)

1**.** Infinite Series of real numbers:
a)Convergence, Cauchy's criterion of convergence.
b)Series of non-negative real numbers: Tests of convergence – Cauchy's condensation test. Comparison test, Kummer's test. Statements and applications of : Abel – Pringsheim's Test, Ratio Test , Root test, Raabe's test, Bertrand's test, Logarithmic test and Gauss's test.
c)Series of arbitrary terms : Absolute and conditional convergence
d)Alternating series : Leibnitz test.
e)Non-absolute convergence : Abel's and Dirichlet's test (statements and applicatins). Riemann's rearrangement theorem and rearrangement of absolutely convergent series.

2. Point set in one dimension: Open cover of a set. Compact set in R, Heine- Borel Theorem.

3. Continuity of a function at a point. Continuity of a function on an interval and at an isolated point.Algebra of continuous functions.Continuity of composite functions.Continuous function on a closed and bounded interval and its properties.Discontinuity of function, type of discontinuity. Step function. Piecewise continuity.Continuity of monotone function.Uniform continuity, Lipschitz condition and uniform continuity. Related theorems on uniform continuity.

4. Derivatives of real valued functions of a real variable: Darboux theorem, Rolle'stheorem, Mean value theorems of Lagrange and Cauchy. Taylor's theorem on closed and bounded interval with Lagrange's and Cauchy's form of remainder.Maclaurin's theorem as a consequence of Taylor's theorem.Statement of Maclaurin's Theorem on infinite series expansion. Expansion of e^x, log(1+x), $(1+x)^m$, sin x, cos x with their range of validity. Statement of L Hospital's rule and its consequences.Point of local extremum of a function in an interval.Sufficient condition for the existence of a local extremum of a function at a point.Problems on local maxima - minima.

References

[1] Principles of Mathematical Analysis – Walter Rudin.
[2] Mathematical Analysis - T. M. Apostol.
[3] Real analysis – Goldberg.
[3] Real Analysis - S. K. Mapa.

<u>Module II (50)</u>

Linear Algebra I (20)

1. Matrices of real and complex numbers : Algebra of matrices. Symmetric and skew-symmetric matrices.Hermitian and skew-Hermitian matrices.Orthogonal matrices.

2. Determinants: Definition, Basic properties of determinants, Minors and cofactors. Laplaces method. Vandermonde's determinant.Symmetric and skewsymmetric determinants. (No

proof of theorems). Adjoint of a square matrix.Invertible matrix, Non-singular matrix.Inverse of an orthogonal Matrix.

3. Elementary operations on matrices. Echelon matrix. Rank of a matrix. Determination of rank of a matrix (relevant results are to be state only). Normal forms.Elementary matrices.Statements and application of results on elementary matrices. Systems of linear equations.

4. Vector space: Definitions and examples, Subspace, Union and intersection of subspaces. Linear sum of two subspaces.Linear combination, independence and dependence.Linear span.Generators of vector space. Dimension of a vector space. Finite dimensional vector space.Examples of infinite dimensional vector spaces.Replacement Theorem, Extension theorem.Extraction of basis.

References

[1] Linear Algebra – Hoffman and Kunze.
[2] Linear Algebra – Bhimasankaram and Rao.
[3] Linear Algebra A Geometrical Approach – S. Kumaresan.
[4] University Algebra – N. S. Gopalakrishnan.
[5] Higher Algebra – S. K. Mapa.
[6] Linear Algebra – Friedberg, Insel and Spence

Optimization Technique (30)

1**.** Definition of L.P.P. Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and Basic Feasible Solution (BFS) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.

2**.** Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separatinghyperplane. The collection of all feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions.
(the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

3**.** Slack and surplus variables. Standard from of L.P.P. theory of simplex method.Feasibility and optimality conditions.

4**.** The algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

5**.** Duality theory: The dual of the dual is the primal. Relation between the objective values of dual and the primal problems.Relation between their optimal values.Complementary slackness, Duality and simplex method and their applications.

6**.** Transportation and Assignment problems. Mathematical justification for optimality criterion.Hungarian method.Traveling Salesman problem.

References

[1] Linear Programming : Method and Application – S. I. Gass.
[2] Linear Programming – G. Hadley.
[3] An Introduction to Linear Programming & Theory of Games – S. Vajda.
[4] An Introduction to L. P. P. and Game – Ghosh and Chakravarty.
[5] Linear Programming- P. M. Karak.

UG SEM 3

Course Code: MTMA-P3 (Credit-14, Full Marks-100)

Name of the Course: Linear Algebra II A, Analysis IIA, Analytical Geometry II and Mechanics I

Course outcome:

Linear Algebra II A: To learn the concept of quotient space, linear transformation and its applications, congruence of matrices. This is required for next course on linear algebra, multivariable calculus, numerical analysis.

Analysis IIA: To learn the concept of sequence and series of functions and power series. This is required for the advanced courses on differential equations and numerical analysis.

Analytical Geometry II: To learn the concept of planes, straight line, sphere, conics, tangent plane, generating lines, transformation of rectangular axes by translation, rotation and their combinations, general equation of second degree in x, y, z ; nature of quadrics. This is required for courses on mechanics, differential equation and differential geometry.

Mechanics I: To learn the concept of S. H. M., motion of a particle in a plane, tangent and normal accelerations, circular motion, motion of a particle in a plane under different laws of resistance, central forces and central orbits. This is the basic requirement for the advanced mechanics course.

Module – I (50)

Linear Algebra II A

1. Quotient spaces, examples.
2. Linear Transformation on Vector Spaces : Definition of Linear Transformation, Null space, range space of an Linear Transformation, Rank and Nullity, Rank-Nullity Theorem and related problems. Non-singular Linear Transformation.Inverse of Linear Transformation.
3. Linear Transformation and Matrices : Matrix of a linear transformation relative to ordered bases of finite-dimensional vector spaces. Correspondence between Linear Transformations and Matrices. Linear Transformation is non-singular iff its representative matrix is non-singular. Rank of L.T. = Rank of the corresponding matrix.
4. Row space and column space of a matrix. Row rank and column rank of a matrix. Equality of row rank, column rank and rank of a matrix. Linear homogeneous system of equations : Solution space. Necessary and sufficient condition for consistency of a linear non-homogeneous system of equations.Solution of system of equations (Matrix method).
5. Congruence of matrices : Statement of applications of relevant results, Normal form of a matrix under congruence, Real Quadratic Form involving three variables. Reduction to Normal Form (Statements of relevant theorems and applications).

References

[1] Linear Algebra A Geometrical Approach – S. Kumaresan.
[2] Linear Algebra – Hoffman and Kunze.
[3] Linear Algebra – Bhimasankaram and Rao.
[4] University Algebra – N. S. Gopalakrishnan.
[5] Higher Algebra – S. K. Mapa.
[6] Linear Algebra – Friedberg, Insel and Spence

Analysis II A

Sequence and series of functions, Power series.

(i) Pointwise and uniform convergence of a sequence of functions, Cauchy criterion, consequences of uniform convergence (excluding integrability).

(ii) Pointwise and uniform convergence of a series of functions, Cauchy's principle, Weierstrass' M-test, consequences of uniform convergence (excluding integrability) .

(iii) Power series, radius of convergence, Ratio test, Cauchy-Hadamard theorem.

(iv) Weierstrass' approximation theorem.

References

[1] Mathematical Analysis - T. M. Apostol.
[2] Real Analysis - H. L. Royden.
[3] An Introduction to Modern Analysis and Topology - Simmons.
[4] Real Analysis - S. K. Mapa

Module – II (50)

Mechanics I (30)
(Analytical Dynamics of A Particle)

1. Recapitulations of Newton's laws. Applications of Newton's laws to elementary problems of simple harmonic motion, Composition of two simple harmonic motions. Motion of a particle tied to one end of an elastic string. Disturbed simple harmonic motion. Basic kinematic quantities : momentum, angular momentum and kinetic energy. Principle of energy and momentum.Work and power.Impulse and impulsive forces.Simple examples on their applications. Motion in a straight line under variable acceleration, Motion under inverse square law , Motion under gravity with resistance proportional to some integral power of velocity. Terminal velocity.

2. Expressions for velocity and acceleration of a particle moving on a plane in Cartesian and polar co-ordinates, Components of velocity and acceleration referred to a set of rotating rectangular axes. Motion of a particle in a plane.

3. Tangent and normal accelerations. Circular motion.Simple cases of a constrained motion of a particle.

4. Motion of a particle in a plane under different laws of resistance. Motion of a projectile in a resisting medium in which the resistance varies as the velocity.Trajectories in a resisting medium where resistance varies as some integral power of the velocity.

5. Central forces and central orbits. Typical features of central orbits. Areal velocity.Apse on a central orbit.Apsidal distance.Apsidal angle.Central orbit in a resisting medium.Stability of nearly circular orbits.

References

[1] An Elementary Treatise on the Dynamics of a Particle & of Rigid bodies – S. L. Loney.
[2] Dynamics (Part-I & II)- A. S. Ramsey.
[3] Analytical Dynamics of a particle- Ganguly&Saha.
[4] Dynamics of a particle- Datta& Jana.
[5] A text book on Dynamics- M. Ray.
[6] Advanced analytical Dynamics- Chakraborty& Ghosh.

Analytical Geometry II (20)
[Three Dimensional Geometry]

1. Rectangular Cartesian co-ordinates in space. Halves and Octants. Concept of a geometric vector (directed line segment). Projection of a vector on a coordinate axis.Inclination of a vector with an axis.Co-ordinates of a vector.Direction cosines of a vector. Distance between two points. Division of a directed line segment in a given ratio.

2. Equation of Plane: General form, Intercept and Normal form. The sides of a plane.Signed distance of a point from a plane.Equation of a plane passing through the intersection of two planes.
Angle between two intersecting planes.Bisectors of angles between two intersecting planes.Parallelism and perpendicularity of two planes.

3. Straight lines in space: Equation (Symmetric & Parametric form). Direction ratio and Direction cosines.Canonical equation of the line of intersection of two intersecting planes.Angle between two lines.Distance of a point from a line.Condition of coplanarity of two lines.Equations of skew-lines.Shortest distance between two skew lines.

4. (a) Sphere : General Equation. Circle, Sphere through the intersection of two spheres. Radical Plane, Tangent, Normal.
(b) Cone : General homogeneous second degree equation, Section of cone by a plane as a conic and as a pair of lines, Condition for three perpendicular generators, Reciprocal cone, Right circular cone.
(c) Ellipsoid, Hyperboloid, Paraboloid : Canonical equations only.

5. Tangent plane and normal of Ellipsoid, Hyperboloid, Paraboloid.
6. Generating lines.
7. Transformation of rectangular axes by translation, rotation and their combinations.
8. General equation of second degree in x, y, z ; nature of quadrics.

References:
1] Co-ordinate Geometry – S. L. Loney.
[2] Co-ordinate Geometry of Three Dimensions – Robert J. T. Bell.
[3] Analytic Geometry , M. C. Chaki.

UG SEM 4

Course Code: MTMA-P4 (Credit-14, Full Marks-100)

Name of the Course: Analysis II B, Linear Algebra II B, Differential Equations II, and Applications of Calculus

Course outcome:

Analysis II B: To learn the concept of metric space. This is useful for the topology and analysis courses.

Linear Algebra II B : To learn the concept of eigen-value, eigen function, Cayley Hamilton theorem, inner-product space, operators. This is required for the multivariable analysis, differential geometry, numerical analysis courses and quantum mechanics.

Differential Equations II : To learn the solution methods for P.D.E., Sturm-Liouville problem, Simultaneous linear differential equations, Series solution, Laplace transform. This is required for mechanics and advanced differential equation courses in post graduate level.

Applications of Calculus: To learn the concept of tangents and normals, rectilinear asymptotes, curvature, envelopes, concavity, convexity, singular points, nodes, cusps, points of inflexion, surface and volume of revolution.This is required for the differential geometry courses.

<u>Module – I (50)</u>
Analysis – II B (35 Marks)

Elements of metric spaces:

(i) Metric space – definition and examples including discrete metric space, R^n and C^n, l^p and l^∞ spaces, the space $C[a,b]$.

(ii) Diameter of a set, boundedness of a set, bounded metric, distance between two sets.

(iii) Open ball, open set, closed set, metric topology, limit point and isolated point of a set, subspace of a metric space, Equivalent metrics.

(iv) First countability of a metric space; second countability, separability and Lindeloff property and their equivalence.

(v) Sequence in a metric space, Cauchy sequence and complete metric space, completion, Cantor's intersection theorem, Baire's category theorem.

(vi) Continuous functions, Uniform continuity.

(vii) Compactness, Total boundedness, sequential compactness, B.W.compactness, Equivalence of different notions of compactness, Lebesgue number. Compactness and continuity.

(viii) Connectedness, Continuity and connectedness, path-connected spaces, and applications.

<u>References</u>

[1] Topology of Metric spaces – Kumaresan
[2] Elements of metric spaces – M.N. Mukherjee.
[3] Principles of Mathematical Analysis – Walter Rudin.
[4] Mathematical Analysis - T. M. Apostol.
[5] Real Analysis - H. L. Royden.
[6] An Introduction to Modern Analysis and Topology - Simmons.
[7] Real Analysis - S. K. Mapa.

Linear Algebra II B (15 Marks)

1. Inner Product Spaces: The Euclidean plane and dot product, Real and complex inner product spaces, Orthogonality, Orthogonal projection onto line, Orthonormal basis, Orthogonal complements and projections, Linear functionals and hyperplanes, Orthogonal transformations, Reflections and orthogonal maps of the plane and examples.

2. Diagonalization: Eigenvalues and eigenvectors, Cayley–Hamilton theorem, Diagonalization of symmetric matrices.

3. Normal, unitary and self adjoint operators. Spectral Theorem for normal operators (statement only), examples.

References

[1] Linear Algebra A Geometrical Approach – S. Kumaresan.
[2] Linear Algebra – Hoffman and Kunze.
[3] Linear Algebra – Bhimasankaram and Rao.
[4] University Algebra – N. S. Gopalakrishnan.
[5] Linear Algebra – Friedberg, Insel and Spence

Module – II (50)

Differential Equation II (30)

1. Second order linear equations with variable co-efficients : Reduction of order when one solution of the homogeneous part is known. Complete solution. Method of variation of parameters.Reduction to Normal form. Change of independent variable. Operational Factors.

2. Simple eigenvalue problems. Eigen-functions and Eigen-values, Regular Sturm-Liouville problem, Conversion to Sturm-Liouville form, Reduction to Cauchy Euler form.

3. Simultaneous linear differential equations. Total differential equation: Condition of integrability.

4. Partial differential equation (PDE): Introduction. Formation of P.D.E.,
Solution of PDE by Lagrange's method .Integral surfaces through a given curve, Surfaces orthogonal to a given system of surfaces, Non-linear PDE of order one, Solution by Charpit's method.

5. Laplace Transformation and its application in ordinary differential equations : Laplace Transform and Inverse Laplace Transform. Statement of Existence theorem.Elementary properties of Laplace Transform and its Inverse. Laplace Transform of derivatives. Laplace transform of integrals. Convolution theorem (Statement only).Application to the solution of ordinary differential equations of second order with constant coefficients.

6. Series solution at an ordinary point: Power Series solution of ordinary differential equations. Simple problems only.

References

[1] An Elementary Course in Partial Differential Equation – T. Amarnath.
[2] An introduction to differential equations, Ghosh &Maity.
[3] Differential equations, Chakraborty& Ghosh.
[4] Ordinary and Partial Differential Equations, Mukherjee &Bej.
[5] Differential equations - G.F. Simmons

Application of Calculus (20)

1. Tangents and normals : Sub-tangent and sub-normals. Angle of intersection of curves. Pedal equation of a curve, pedal of a curve.

2. Rectilinear asymptotes of a curve (Cartesian and parametric).
3. Curvature-Radius of curvature, centre of curvature, chord of curvature, evolute of a curve.
4. Envelopes of families of straight lines and curves (Cartesian and parametric equations only).

5. Concavity, convexity, singular points, nodes, cusps, points of inflexion, simple problems on species of cusps of a curve (Cartesian curves only).

6. Familiarity with the figure of following curves: Periodic curves with suitable scaling, Cycloid, Catenary, Lemniscate of Bernoulli, Astroid, Cardiode, Folium of Descartes, equiangular spiral.

7. Area enclosed by a curve, determination of C.G, Surface and volume of revolution, Pappus Theorem.

8. Reduction formulae – simple problems.

References:

1. An Introduction to Analysis and Differential Calculus – Maity and Ghosh.
2. Differential Calculus – Shantinarayan.
3. Differential Calculus – Edwards.

UG SEM 5

Course Code: MTMA-P5 (Credit-13, Full Marks-100)

Revision Vide BoS dated : 03.01.2015

Name of the Course: Algebra III, Multivariable Calculus , Analysis IIIA

Course outcome:

Algebra III: To learn the concept of normal subgroups, isomorphism, class equation, group action, Sylow theorems and ring theory. This course is helpful for advance study of abstract algebra.

Multivariable Calculus: To learn the concept of limit, continuity, differentiation of the functions from $\mathbb{R}^m$to$\mathbb{R}^n$ and their applications. This paper is useful in further analysis studies and various applied papers.

Analysis IIIA: To learn the concept of Riemann integration and function of bounded variation. This paper is useful in post-graduate analysis and it is useful in various applied topics in post graduate level.

<u>Module – I (50)</u>
Algebra - III

1. Normal subgroup, Quotient group, Homomorphism and its properties, Isomorphism, Kernel of a homomorphism, First Isomorphism Theorem, Cayley's Theorem, Automorphism, Inner Automorphism.
2. External and internal direct product of two groups and applications.
3. Class equation, Cauchy's Theorem on finite groups, Converse of Lagrange's Theorem for finite commutative group,Group Action, p-group, Sylow's Theorems and their applications.

4. Rings - examples and elementary properties, Units, Characteristic of a ring, Subring.
Integral domains, Skew fields, Fields, Subfields – Examples and properties,
Every finite integral domain is a field, Wedderburn's theorem (statement only).

5. Ideals of a commutative ring, Quotient ring, Ring homomorphism and its properties, First Isomorphism Theorem, Ring embedding – Every integral domain can be embedded in a field.
6. Maximal and prime ideals and the corresponding quotient rings.

7. Associates, Prime and irreducible elements in a ring, Principal ideal domain (PID) and Unique factorization domain (UFD), Every prime element is irreducible in an integral domain, Every irreducible element is prime in a principal ideal ring and in a Unique factorization domain, Problems related to prime and irreducible elements.

8. Polynomial ring and its properties **:** if R is an integral domain then so is R[x], Division algorithm (statement only), Remainder theorem and factor theorem. If R is an integral domain and if f(x) is a nonzero polynomial of degree n then f(x) has at most n roots in R. K[x] is a PID if and only if K is a field,Simple problems.

<u>References:</u>
[1] Abstract Algebra – Malik, Mordeson, Sen.
[2]University Algebra – N.S. Gopalakrishnan.
[3] Abstract Algebra – Dummit and Foote.
[4] Algebra (Vol. 1): Groups – Luthar and Passi.
[5] Algebra (Vol. 2): Rings – Luthar and Passi.
[6] Topics in Algebra - I. N. Herstein.
[7] Topics in Abstract Algebra - Sen, Ghosh &Mukhopadhyay.
[8] First Course in Abstract Algebra – Fraleigh.

<u>Module – II (50)</u>
Multivariable Calculus (30)

1. Concept of a function $f : R^n \rightarrow R^m$.
2. Limit and continuity.
(a) $f: R^2 \rightarrow R$. Partial derivatives. Sufficient condition for continuity. Relevant results regarding repeated limits and double limits. Neighborhood properties of continuous functions.
(b) Continuity of $f: R^n \rightarrow R^m$ given by $f(v) = (f_1(v), f_2(v),\ldots,f_m(v))$. Locally bounded function and relation with continuity.Composites of continuous functions.Directional Derivatives (Gradients) and Continuity.

3. Differentiability and Differential.

a) f: $R^n \to R^m$. Total derivative as a linear map. Differentiability, continuity and existence of partial derivatives.Chain rule.Sufficient condition for continuous differentiability. Sufficient condition for commutativity of the second order mixed partial derivatives.
b) f: $R^2 \to R$. Sufficient condition for differentiability. Change of dependent varibles. Higher order derivatives. Commutativity of the second order mixed partial derivatives: Theorems of Young and Schwarz.
c) Euler's theorem, its converse and generalization.

4. Inverse function theorem.

5. a) Implicit function f: $R^2 \to R$ and f: $R^3 \to R$. Theorems on the existence and uniqueness of Implicit function f: $R^2 \to R$. Derivative of implicit function.
b) Jacobian for f: $R^2 \to R$ and f: $R^3 \to R$. Chain rules. Jacobian for Implicit function , simple properties including functional dependence.
c) Implicit function re-visited for f: $R^n \to R^m$. Statement of Implicit function Theorem.

6. Mean Value Theorem and Taylor's theorem for function of two variables. Mean Value Theorem for f: $S \to R^m$, where S is open in R^n.

7. Maxima and minima of functions f: $R^2 \to R$ and f: $R^3 \to R$ (both free and with constraints). Lagrange's method of undetermined multipliers (stress on problems).

References:
[1] Principles of Mathematical Analysis – Walter Rudin.
[2] Mathematical Analysis - T. M. Apostol
[3] Multivariate Calculus and Geometry –Dineen.
[4] Calculus on manifolds – Spivak

Analysis - IIIA (20)

1. Function of bounded variation (BV): Definition and examples. Monotone function is of BV. If f is on BV on [a,b] then f is bounded on [a,b]. Examples of functions of BV which are not continuous and continuous functions not of BV.Definition of variation function. Necessary and sufficient condition for a function f to be of BV on [a,b]. Definition of rectifiable curve. A plane curve $\gamma = (f, g)$ is rectifiable if f and g both are of bounded variation (statement only). Length of a curve (simple problems only).

2. Riemann integration : (a) Partition and refinement of partition of a closed and bounded interval. Upper Darboux sum U(P,f) and lower Darboux sum L(P,f) and associated results. Upper integral and lower integral.Darboux's theorem.Darbouxs definition of integration over a closed and bounded interval.Riemanns definition of integrability. Equivalence with Darboux definition of integrability (statement only).Necessary and sufficient condition for Riemann intergrability.
(b) Examples of Riemann integrable functions. Sets of measure zero. Concept of oscillation of a function at a point and continuity. Lebesgue's theorem on Riemann integrable function. Problems on Riemann integrability of functions with sets of points of discontinuity having measure zero.
(c) Integrability of sum, scalar multiple, product, quotient, modulus of Riemann integrable functions. Properties of Riemann integrable functions arising from the above results.
(d) Function defined by definite integral $\int_a^x f(t)\,dt$ and its properties. Antiderivative (primitive or indefinite integral).

(e) Fundamental theorem of integral calculus. First mean value theorem of integral calculus. Statement and applications of second mean value theorems of integrals calculus (both Bonnets and Weierstrass' form).

(f) Integrability of the limit function of sequence of integrable functions and integrability of the sum function of a series of integrable functions, in case of uniform convergence.

References:

[1] Principles of Mathematical Analysis – Walter Rudin.
[2] Mathematical Analysis - T. M. Apostol.
[3] Real analysis – Goldberg.
[4] Real Analysis - S. K. Mapa.
[5] A first course in Real Analysis – Porter and Morrey.

UG SEM 5

Course Code: MTMA-P6 (Credit-13, Full Marks-100)

Name of the Course: Numerical Analysis, Vector Calculus, Mechanics II,

Revision Vide BoS dated : 03.01.2015

Course outcome:

Numerical Analysis: To learn the solution techniques of interpolation, differentiation, integration, ODE, finding roots of algebraic and transcendental equations, and system of linear equation by numerical methods. It is useful in advanced numerical analysis in postgraduate level.

Vector Calculus: To learn the concept of gradient, divergence, curl, vector integration.It is useful in further study of mechanics, analysis.

Mechanics II: To learn the concept of moment of inertia, D'Alembert's principle, equation of motion of a rigid body about a fixed axis, equations of motion of a rigid body moving in two dimensions, equations of motion under impulsive forces, planetary motion and Kepler's laws, motion on a smooth curve under resistance, slightly disturbed orbits, equation of motion of a particle of varying mass. It is required for advance course in mechanics in postgraduate level.

Module – I (50)

Numerical Analysis (30)

1. What is Numerical Analysis ?
Errors in Numerical computation : Gross error, Round off error, Truncation error. Approximate numbers.Significant figures.Absolute, relative and percentage error.

2. Interpolation: Problems of interpolation, Weierstrass' approximation theorem (Statement only). Polynomial interpolation and its uniqueness. Error terms in interpolation formulae.
General interpolation formulae: Deduction of Lagrange's interpolation formula..Newton's General Interpolation formula and Divided difference formula Inverse interpolation.
Equispaced arguments: Difference table. Operators:– Δ, ∇, E, μ, δ (Definitions and simple relations among them).Deduction of Newton's forward and backward interpolation formulae. Gauss interpolation formula and deduction of Stirling's and Bessel's interpolation formulae.Idea of Hermite interpolation formula (basic concepts).

3. Numerical Differentiation based on Newton's forward & backward and Lagrange's formulae.

4. Numerical Integration**:** Newton-Cote's formula.. Basic Trapezoidal , Simpson's ⅓rd. rule and Weddle's rule and their composite forms, and the error terms associated with these formulae. Gauss' Quadrature formula. Degree of precision

5. Numerical solution of non-linear equations **:** Location of a real root by tabular method. Bisection method, Regula-Falsi method. Fixed point iteration technique. Newton-Raphson methods, Secant method and their geometrical significance.

6. Numerical solution of a system of linear equations: Gauss elimination method, Gauss-Seidal iterative method. Matrix inversion by Gauss elimination method.

7. Numerical solution or Ordinary Differential Equation**:** Basic ideas, nature of the problem. Euler and Runge-Kutta (3rd order) methods and outline the proof of 4^{th} order Runge-Kutta method.

8. Eigenvalue Problems: Power method for numerically extreme eigenvalues.

References:
[1] Introduction to Numerical Analysis – F. B. Hilderbrand.
[2] Numerical Analysis – J. Scarborough.
[3] Introduction to Numerical Analysis – Carl Erik Froberg.
[4] Numerical methods for Science and Engineering – R. G. Stanton.

Vector Calculus (20)
1. Vector differentiation with respect to a scalar variable, Vector functions of one scalar variable. Derivative of a vector.Second derivative of a vector.Derivatives of sums and products, Velocity and Acceleration as derivative.

2. Concepts of scalar and vector fields. Directional derivative.Gradient, Divergence and curl, Laplacian and their physical significance.

3. Line integrals as integrals of vectors, circulation, irrotational vector, work done, conservative force, potential orientation. Statements and verification of Green's theorem, Stokes' theorem and Divergence theorem.

References:

[1] Multivariate Calculus and Geometry -Dineen.
[2] Mathematical Analysis – Malik and Arora.
[3] Vector Calculus – C. E. Weatherburn

Module – II (50)
Mechanics-II (50)
Rigid Dynamics (30)

1. Moment of inertia and Product of inertia of a rigid body about any two perpendicular lines through origin (d.c.'s of the lines are given) in terms of A, B, C, D,E, F. Momental ellipsoid, Equimomental system. Principal axis.D'Alembert's principle.D'Alembert's equations of motion.Principles of moments.Independence of the motion of centre of inertia and the motion relative to the centre of inertia.Principles of conservations of linear and angular momentum.Principle of energy.Principle of conservation of energy.

2**.** Equation of motion of a rigid body about a fixed axis. Expression for kinetic energy , moment of effective forces and moment of momentum of a rigid body moving about a fixed axis. Compound pendulum.Interchangeability of the centres of suspension and oscillation.Minimum time of oscillation.Reaction of axis of rotation.

3**.** Equations of motion of a rigid body moving in two dimensions. Expression for kinetic energy and angular momentum about the origin of rigid body moving in two dimensions.Two dimensional motion of a solid of revolution down a rough inclined plane.Necessary and sufficient condition for pure rolling.Two dimensional motion of a solid of revolution moving on a rough horizontal plane.

4. Equations of motion under impulsive forces. Equation of motion about a fixed axis under impulsive forces. To show that (i) of there is a definite straight line such that the sum of the moments of the external impulses acting on a system of particles about it vanishes, then the total angular momentum of the system about that line remains unaltered, (ii) the change of K.E. of a system of particles moving in any manner under the application of impulsive forces is equal to the work done by the impulsive forces. Impulsive forces applied to a rigid body moving in two dimensions.

Analytical Dynamics of a Particle (20)

1. Planetary motion and Kepler's laws. Time of describing an arc of the parabolic, elliptic, hyperbolic orbits.Orbital energy.Relationship between period and semi-major axis.Motion of an artificial satellite.

2. Motion on a smooth curve under resistance. Conservative field of force and principle of conservation of energy. Motion on a smooth curve and on a rough curve under gravity e.g., circle, parabola, ellipse, cycloid etc

3. Slightly disturbed orbits: Effect of some tangential disturbing force. Effect of an instantaneous change in μ.

4. Equation of motion of a particle of varying mass. Simple problems of motion of varying mass such as those of falling raindrops and projected rockets.

References:

[1] An Elementary Treatise on the Dynamics of a Particle & of Rigid bodies – S. L. Loney.
[2] Advanced analytical Dynamics- Chakraborty& Ghosh.
[3] Mechanics- T. K. Chadha.

UG SEM 6

Course Code:MTMA-P7 (Credit-13, Full Marks-100)

Name of the Course: Analysis IIIB, Number Theory, Probability Theory, Complex Analysis

Revision Vide BoS dated : 19.06.2014

Course outcome:

Analysis IIIB: To learn the concept of multiple integration, improper integration and Fourier series. It is required for advance study in analysis.

Number Theory: Familiarize the students with different properties of integers. It is required for advance study in number theory.

Probability Theory: To learn the concept of random variables, different probability distributions and inequalities. This course is required in various courses in pure and applied mathematics courses.

Complex Analysis: To learn the concept of analytic function, elementary functions, sequence and series of complex valued functions. This course is required for further analysis course and advanced course in complex analysis.

Module – I (50)
Analysis IIIB (30)

1. Improper Integral : (a) Range of integration, finite or infinite. Necessary and sufficient condition for convergence of improper integral in both cases.

(b) Tests of convergence : Comparison and μ -test. Absolute and non-absolute convergence and interrelations.Abel's and Dirichlet's test for convergence of the integral of a product (statement only).

(c) Convergence and working knowledge of Beta and Gamma function and their interrelation $(\Gamma(n)\Gamma(1-n)=\frac{\pi}{\sin\pi}, 0<n<1,$ to be assumed). Computation of the integrals $\int_0^{\pi/2}\sin^n x\,dx$, $\int_0^{\pi/2}\cos^n x\,dx$, $\int_0^{\pi/2}\tan^n x\,dx$ when they exist (using Beta and Gamma functions).

2. Fourier series: Trigonometric series. Statement of sufficient condition for a trigonometric series to be a Fourier series. Fourier co-efficients for periodic functions defined on [-p,p]. Statement of Dirichlet's conditions convergence. Statement of theorem on sum of Fourier series.

3. Multiple integral: Concept of upper sum, lower sum, upper integral, lower integral and double integral (no rigorous treatment is needed). Statement of existence theorem for continuous functions. Change of order of integration. Triple integral. Transformation of double and triple integrals (Problem only).Determination of volume and surface area by multiple integrals (Problem only).

References:

[1] Principles of Mathematical Analysis – Walter Rudin.
[2] Mathematical Analysis - T. M. Apostol.
[3] Real analysis – Goldberg.
[4] Real Analysis - S. K. Mapa.
[5] A first course in Real Analysis – Porter and Morrey.
[6] Introduction to the Theory of Fourier's series and integrals – H. S. Carslaw.

Number Theory (20)

1. Well ordering principle for N, Division algorithm, Principle of mathematical induction and its applications.

2. Greatest common divisor, relatively prime numbers, least common multiple.
3. Prime numbers, Euclid's Theorem.

4. Euler's ϕ function, multiplicative functions, properties of ϕ-function.

5. Congruence, Theorems of Fermat, Wilson, Euler-Fermat; Chinese remainder Theorem, applications.

6. Divisibility tests – statements and applications.

7. Diophantine equations and solutions.

8. Mobius μ-function, Mobius' inversion law, relation between ϕ and μ functions.

9. Number of positive divisors and their sum of a given positive integer, simple applications.

References:

[1] An Introduction to the Theory of Numbers – Niven, Zuckerman and Montogomery.
[2] Elementary Number Theory – David M. Burton.
[3] Elementary Number Theory – Jones and Jones.

Module - II (50)

Probability Theory (30)

1. Axioms of Probability. Statistical regularity.Multiplication rule of probabilities.Bayes' theorem.Independent events.Independent random experiments.Independent trials.Bernouli trials and binomial law.Poisson trials.

2. Random variables. Probability distribution.distribution function. Discrete and continuous distributions.Binomial, Poisson, Gamma, Uniform and Normal distribution.Mathematical expectation. Mean, variance, covariance, moments, central moments. Measures of location, dispersion, skewness and kurtosis.Median, mode, quartiles.Moment-generating function.Characteristic function.Transformation of random variables.Two dimensional probability distributions.Discrete and continuous distributions in two dimensions. Uniform distribution and two dimensional normal distribution. Conditional distributions.transformation of random variables in two dimensions.

3. Expectation of a function of two or more random variables. Covariance, Correlation co-efficient, Joint characteristic function. Multiplication rule for expectations.Conditional expectation. Regression curves, least square regression lines and parabolas. Chi-square and t-distributions and their important properties (Statements only).Tchebycheff's inequality.Convergence in probability. Statements of : Bernoulli's limit theorem. Law of large numbers.Poisson's approximation to binomial distribution and normal approximation to binomial distribution. Statement of central limit theorem in the case of equal components and of limit theorem for characteristic functions (Stress should be more on the distribution function theory than on combinatorial problems).

References:

[1] Mathematical Probability and Statistics - A. Gupta.
[2] Mathematical Probability – Banerjee, De and Sen.
[3] Elements of Probability and Statistics – Baisnav and Jas.
[4] Introduction to Probability Theory - K. Mukherjee.
[5] An Introduction to probability theory and its applications (Vol. 1) – W. Feller.

Complex Analysis (20)

1. Field structure of Complex numbers: field of complex numbers cannot be totally ordered. Geometric interpretation of complex numbers.
2. Open connected set and path connected set in C.
3. Extended Complex plane: Stereographic projection.

4. (i) Functions of a complex variable: concepts of limit and continuity. Sequential approach and $\varepsilon-\delta$ definition: their equivalence. Related theorems on limit. (iii) Concepts of $\lim_{|z|\to\infty} f(z)=A$ and $\lim_{z\to z_0} f(z)=\infty$ ..
5. Differentiability: definition, to show that differentiability implies continuity, differentiability of sum, difference, product, quotients and composition of differentiable functions, Cauchy- Riemann equations, sufficient condition for differentiability at a point. Definition of analytic function and entire functions; If f is analytic in a region G, it is infinitely differentiable in G.

6. Exponential, Logarithmic, Trigonometric functions, direct and Inverse circular and Hyperbolic functions-their algebraic properties & analytic properties.

7. Harmonic function and Harmonic conjugate; to show that a function $f(z)=u(x,y)+iv(x,y)$ is analytic on a region Giff$v$ is harmonic conjugate of u on G.

8. Sequence of functions and series of functions in C: concept of uniform convergence. (i) Cauchy's condition for uniform convergence of sequence of functions (statement only), statement of the theorems on continuity and analyticity of the limit function of uniformly convergent sequence of functions with illustration. (ii) Cauchy condition and M-test for uniform convergence of series of functions-statement only, statement of the theorems on continuity and analyticity of the sum function of uniformly convergent series of functions with illustration.

9. Power series in C: Determination of radius of convergence and circle of convergence. Absolute and uniform convergene of power series strictly within the circle of convergence. Examples to illustrate the behaviourof power series on the boundary points of the circle of convergence. A power series and its derived power series have same radius of convergenvce

(using Cauchy-Hadamard formula). A power series represents an analytic function strictly within its circle of convergence and conversely if f is analytic in a domain *D*, then *f* can be represented by a power series locally about each point in *D*.

10. Power series representation of e^z, sinz, cosz, $(1\pm z)^{-1}$, sinhz, coshz. mentioning their regions of convergence; deduction of their analytic properties from the series representations.

References:

[1] Functions of one Complex Variable – J. B. Conway.
[2] Complex Analysis – Ahlfors.
[3] Foundations of Complex Analysis – Ponnusamy.
[4] Theory and Applications of Complex Analysis – H. S. Kasana.

UG SEM 6

Course Code: MTMA-P8 (Credit-13, Full Marks-100)

Name of the Course: Mechanics III, Computer fundamentals and Programming in C, Numerical Practical using Computer and Optional paper

New course Vide BoS dated : 27.11.2017

Course outcome:

Mechanics III: To learn the concept of friction, virtual work, astatic equilibrium, stable and unstable equilibrium, equilibrium of flexible strings, forces in the three dimensions. It is required in advanced mechanics courses in post graduate level.

Computer fundamentals and Programming in C: To learn C language and the concept of Boolean algebra. It is required for Numerical practical.

Numerical Practical using Computer: To learn the solution techniques of numerical problems by C programme. It is required to use numerical computation in various courses in applied mathematics.

Optional Paper:

Tensor Calculus: To learn the concept of tensor algebra, Christoffel symbols, Covariant differentiation. It is required for further study in differential geometry in postgraduate level.

Differential geometry: To learn the geometry of curves and surfaces. It is the basic course in differential geometry which helps students in advance differential geometry course.

Measure theory: To learn the basic concept of Lebesgue measure. It helps students in advance probability theory and measure theory in post graduate level.

Graph theory: To learn the concept of Euler graph, planner graph and tree. It helps students to study graph theory in post graduate level.

Topology: To learn the basic concept of set theoretic topology. It helps students to study topology course in post graduate level.

Module - I (70)

Mechanics-III (30)

[Analytical Statics]

1. Friction: Law of Friction, Angle of friction, Cone of friction, To find the positions of equilibrium of a particle lying on a (i) rough plane curve, (ii) rough surface under the action of any given forces.

2. Astatic Equilibrium, Astatic Centre, Positions of equilibrium of a particle lying on a smooth plane curve under action of given force. Action at a joint in a frame work.

3. Virtual work: Principle of virtual work for a single particle. Deduction of the conditions of equilibrium of a particle under coplanar forces from the principle of virtual work.The principle of virtual work for a rigid body.Forces which do not appear in the equation of virtual work.Forces which appear in the equation of virtual work.The principle of virtual work for any system of coplanar forces acting on a rigid body.Converse of the principle of virtual work.

4. Stable and unstable equilibrium. Coordinates of a body and of a system of bodies.Field of forces.Conservative field.Potential energy of a system.The energy test of stability. Condition of stability of equilibrium of a perfectly rough heavy body lying on fixed body. Rocking stones.

5. Equilibrium of Flexible Strings: Common catenary, Parabolic chain, Catenary of uniform strength, General cartesian equations of equilibrium of a string under coplanar forces, Heavy string on rough surface, Central forces.

6. Forces in the three dimensions. Moment of a force about a line.Axis of a couple.Resultant of any two couples acting on a body.Resultant of any number of couples acting on a rigid body.Reduction of a system of forces acting on a rigid body. Resultant force is an invariant of the system but the resultant couple is not an invariant. Conditions of equilibrium of a system of forces acting on a body.Deductions of the conditions of equilibrium of a system of forces acting on a rigid body from the principle of virtual work.Poisnot's central axis. A given system of forces can have only one central axis. Wrench, Pitch, Intensity and Screw.Condition that a given system of forces may have a single resultant.Invariants of a given system of forces.Equation of the central axis of a given system of forces.

References:

[1] Analytical Statics - M. C. Ghosh.
[2] Analytical Statics – S. L. Loney.
[3] Analytical Statics- Pradhan&Sinha.

Computer fundamentals and Programming in C (20)

1. Programming languages : General concepts, Machine language, Assembly Language, High Level Languages, Compiler and Interpreter. Object and Source Program.Ideas about some major HLL. .

2. Concept of algorithm and data structure, character set, constants, variables, operators, control structure, loop structure, header file, arrays, functions, concept of pointers, library functions, concept of data file, input/output operations. To solve numerical problems using C-programme.

3. Boolean Algebra : Huntington Postulates for Boolean Algebra. Algebra of sets and Switching Algebra as examples of Boolean Algebra. Statement of principle of duality.Disjunctive normal and Conjunctive normal forms of Boolean Expressions. Design of simple switching circuits

OPTIONAL COURSES

OPTIONAL I - Tensor Calculus (20)

1. Tensor as generalization of the idea of a vector in an Euclidean space E^3. To generalize the idea in an n-dimensional space. Definition of E^n. Transformation of co-ordinates in E^n(n = 2, 3 as example). Summation convention.
2. Contravariant and covariant vectors. Invariants.Contravariant, covariant and mixed tensors.The Kronecker delta.Algebra of tensors Symmetric and skew-symmetric tensors.Addition and scalar multiplication.Contraction.Outer and Inner products of tensors.Quotient law.Reciprocal Tensor.
3. Riemannian space. Line element and metric tensor.Reciprocal metric tensor. Raising and lowering of indices with the help of metric tensor. Associated tensor.Magnitude of a vector.Inclination of two vectors.Orthogonal vectors.
4. Christoffel symbols and their laws of transformations. Covariant differentiation of vectors and tensors.

References:

[1] Vector & Tensor Analysis – Spiegel (Schaum).
[2] Tensor Calculus- M. C. Chaki

OPTIONAL II - Differential Geometry (20)

Curves in two and three dimensions, Curvature and torsion for space curves, Existence theorem for space curves, Serret-Frenet formula for space curves, Ideas of Inverse and implicit function theorems, Jacobian theorem, Surfaces in R^3 as two dimensional manifolds, Tangent space and derivative of maps between manifolds, First fundamental form, Orientation of a surface, Second fundamental form and the Gauss map, Mean curvature and scalar curvature.

References:

[1] Differential Geometry of curves and surfaces – M. P. do Carmo.
[2] Elementary Differential Geometry - A. Pressley.
[3] Curved spaces – P.M.H. Wilson

OPTIONAL III - MEASURE THEORY (20)

Lebesgue outer measure on **R** – related theorems, Lebesgue measurable sets in **R** – related theorems, σ-algebra, The class **M** of all Lebesgue measurable sets in **R** is a σ-algebra, Borel sets in **R,** Cantor set – its properties, Lebesgue measurable functions – related theorems, Existence of a non-Lebesgue measurable set in **R.**

References

1. Measure Theory and Integration – G. de Barra
2. Lebesgue and Integration – P.K. Jain, V.P. Gupta and P. Jain

OPTIONAL IV - GRAPH THEORY (20)

1. Graphs :Konigsberg Bridge Problem, Undirected graphs, directed graphs, basic properties, isomorphism, sub-graphs, walk, path, cycles, circuits, Hamiltonian paths and circuits, connected graphs, components of a graph, complete graph, complement of a graph, bipartite graphs. Necessary and sufficient condition for a bipartite graph.
2. Euler graphs : necessary and sufficient condition for a Euler graph.
3. Planar graphs : Euler's formula for a planar graph, To show the graphs – K_5 and $K_{3,3}$ are non-planar.
4. Tree : Basic properties, Spanning tree, minimal spanning tree, Kruskal's algorithm, Prim's algorithm, Rooted tree, Binary tree.

References

1. Graph Theory with Applications to engineering and Computer Science – DeoNarsingh
2. Graph Theory – Harary Frank
3. Graph Theory and its Applications – J. Gross and J. Yellen

OPTIONAL V - Topology (20)

1. Topological spaces – Open and closed sets, Interior and closure of a set, Limit point and derived set of a set, Boundary point and boundary of a set, G_δ-sets and F_σ- sets, Base and subbase of a topological space, Subspace of a topological space, Hereditary properties, Finite product of toplogical spaces. Metrizable spaces.

2. 1^{st}countability, 2^{nd}countability, separability andLindeloff property of a topological space – related theorems and examples, Sequence and its convergence in a topological space.

3. Continuous map, Open and closed map on a topological space – examples. Heine's continuity criteria, Pasting lemma, Homeomorphism and homeomorphic spaces – examples. Topological properties – examples.

References:
1. Topology – J. Munkresh
2. Topology – Willard

Module – II (30)

Numerical Analysis: Practical (30)

The following problems should be done on computer using C language :
1. Interpolation: Newton's Forward Interpolation, Lagrange's Interpolation, Inverse Interpolation.
2. Numerical Integration: Trapezoidal Rule, Simpson's ⅓ Formula.
3. Solution of Equations: Bisection Method, Regula-Falsi Method, Newton-Raphson formula.
4. Solution of System of Linear Equations: Gauss' Elimination Method with partial pivoting, Gauss-Seidel Method.
5. Numerical Solution of first order ordinary Differential Equation (given the initial condition) Euler Method, 4th order Runge-Kutta Method.
6. Dominant eigen value and eigenfunction of a (4×4) real symmetric matrix by Power Method.
7. Problems of Curve Fitting: To fit curves of the form $y=a+bx$, $y=a+bx+cx^2$ by Least Square Method.

References:
[1] Numerical methods – E. Balagurusamy.
[2] Let us C – Y. Kanetkar.
[3] Programming in C – V. Krishnamoorthy and K. R. Radhakrishnan..
[4] C by example - Noel Kalicharan.
[5] Programming in ANSI C – E. Balagurusamy

B.Sc. Mathematics Generic Elective

Course Structure

Sl No	Name of the Course	Semester	Course Code	Credit	Marks in the Course	Course outcome
1	Classical Algebra, Modern Algebra and Differential Calculus	1	MTMG-P1	3	75	Classical Algebra : Familiarize the students with the basic concept of complex numbers, theory of equations, determinants and matrices. Modern Algebra: Familiarize the students with the basic concept of group theory , ing theory, vector space, eigen value and eigen vetor. Differential Calculus: To learn the basic concept of number system, basic properties of real valued functions, functions of two and three variables.

2	Analytical Geometry of 2 Dimensions, Vector Algebra, Differential Calculus II, Integral Calculus, Ordinary Differential Equations I	2	MTMG-P2	3	75	Analytical Geometry of 2 Dimensions: To learn the basic concepts of orthogonal transformation, pair of straight lines, equation of tangent, polar equations. Vector Algebra : To learn the concept of vector products and to familiarize application of vectors in geometry and mechanics. Differential Calculus II : To learn the basic concept of sequence, series, real valued functions on an interval, application of calculus. Integral Calculus: To learn the basic concept of integral calculus. Ordinary Differential Equations I: To know the solution of first order linear differential equation.
3	Geometry 3D, L.P.P., Numerical Analysis	3	MTMG-P3	3	75	Geometry 3D : To familiarize the equation of plane, straight line, sphere, tangents and cone. L.P.P. : To know the basic concept of linear programming problem, simplex method, duality, transportation and assignment problem. Numerical Analysis: To know the concept of operators, interpolation, integration and numerical equations.
4	Integral Calculus II, Ordinary Differential Equation II, Probability and Statistics	4	MTMG-P4	3	75	Integral Calculus II: To know the concept of improper integration, double integration , application of integral calculus. Ordinary Differential Equation II: To know the solution techniques of 2nd order ODE and orthogonal trajectories. Probability and Statistics: To learn the basics of elementary statistics, probability theory, sampling theory.

B. SC Mathematics (General)

First Semester

Group – A : Classical Algebra (25 Marks)
Group –B : Modern Algebra (25 Marks)
Group – C :Differential Calculus (25 Marks)

Second Semester

Group –A :Analytical Geometry of 2 Dimensions (15 marks)
Group–B :Vector Algebra (15 marks)
Group–C :Differential Calculus II (25 marks)
Group – D : Integral Calculus (10 marks)
Group –E :Ordinary Differential Equations I (10 marks)

Third Semester

Group–A: Geometry 3D (20 Marks)
Group –B: L.P.P (40 Marks)
Group –C: Numerical Analysis (15 Marks)

Fourth Semester

Group–A: Integral Calculus II (20 Marks)
Group –B: Ordinary Differential Equation II (10 Marks)
Group –C : Probability and Statistics (45 Marks)

UG GEN SEM 1

Course Code: MTMG-P1 (Credit-3, Full Marks-75)

Name of the Course: Classical Algebra, Modern Algebra and Differential Calculus

Course outcome:

Classical Algebra: Familiarize the students with the basic concept of complex numbers, theory of equations, determinants and matrices.

Modern Algebra: Familiarize the students with the basic concept of group theory, ring theory, vector space, Eigen value and Eigenvector.

Differential Calculus: To learn the basic concept of number system, basic properties of real valued functions, functions of two and three variables.

Group - A [Classical Algebra (25 Marks)]

01. Complex Numbers: De-Moivre's Theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of $a^z (a \neq 0)$. Inverse circular and Hyperbolic functions.

02. Polynomials: Fundamental Theorem of Classical Algebra (Statement only).Polynomials with real co-efficient. The n-th degree polynomial equation has exactlyn roots. Nature of roots of an equation (Surd or Complex roots occur in pairs).Statement of Descarte's Rule of signs and its applications.Statements of:

(i) If the polynomial f(x) has opposite signs for two real values of x, e.g. aand b, the equation f(x) = 0 has an odd number of real roots between a and b, Iff(a) and f(b) are of same sign, either no real root or an even number of roots liesbetween a and b.

(ii) Rolle's Theorem and its direct applications.Relation between roots and co-efficients, Symmetric functions of roots, Transformationsof equations.Cardan's method of solution of a cubic.

03. Determinants up to third order: Properties, Cofactor and Minor, Productof two determinants. Adjoint, Symmetric and Skew-symmetric determinants.Solution of linear equations with not more than three variables by Cramer's Rule.

04. Matrices of Real Numbers: Equality of matrices. Addition of matrices.Multiplication of a matrix by a scalar.Multiplication of matrices - Associative properties. Transpose of matrix - its propertiesInverse of a non-singular square matrix. Symmetric and Skew-symmetricmatrices.Scalar matrix.Orthogonal matrix.Elementary operations on matrices.Rank of a matrix: Determination of rank either by considering minors or bysweep-out process. Consistency and solution of a system of linear equations withnot more than three variables by matrix method.

Group - B [Modern Algebra (25 Marks)]

01. Set, subset and super set. Operation on set, properties including De Morgan'slaws.Cartesian product of sets.Mapping: Bijective mapping, Identity mapping, inverse mapping, Compositionof mappings, related theorems.

02. Binary composition, Group, Abelian group, Examples of groups, Elementaryproperties of groups. Subgroups with examples and related theorems.

03. Ring, Commutative ring, Ring with identity, Ring with divisor of zero andwithout divisor of zero, Examples of rings, Elementary properties of rings, Subringwith examples, field and Subfield with examples.

04. Vector space with examples, Elementary properties of vector spaces, Linear dependenceand independence of a finite set of vectors, Subspace with examples, Basisof a finite dimensional vector space, Formation of basis of a vector space (problemsonly).

05. Real quadratic form involving not more than three variables (Problems only).

06. Characteristic equation of a square matrix of order not more than three, Determinationof eigen values and eigen vectors (problems only), Statement and illustrationof Caley- Hamilton theorem.

Group - C [Differential Calculus (25 Marks)]

01. Rationalnumbers, Geometrical representation, Irrational number, Real numberrepresented as point on a line - linear continuum, Acquaintance with basic propertiesof real numbers (No deduction or proof is needed).

02. Real valued functions defined on an interval; Limit of a function, Algebra oflimits. Continuity of a function at a point and in an interval.Acquaintance (noproof) with the important properties of continuous functions on closed intervals.Statement of existence of inverse function of a strictly monotone function and itscontinuity.

03. Derivative - its geometrical and physical interpretation. Sign of derivative,Monotonic increasing and decreasing functions. Relation between continuity andderivability. Differential - application in finding approximation.

04. Successive derivatives - Leibnitz' s theorem and its application.

05. Functions of two and three variables: Their geometrical representations. Limitand continuity of functions of two variables (Definition and simple problems). Partialderivatives, Knowledge and use of chain rule. Exact differentials (emphasis onsolving problems only).Functions of two variables - Successive partial derivatives, statement of Schwartz'stheorem on commutative property of mixed derivatives. Euler theorem on homogeneousfunctions of two and three variables.

06. Application of differential calculus: Tangents and normal, Pedal equation andPedal of a curve. Curvature of plane curves.

UG GEN SEM 2

Course Code: MTMG-P2 (Credit-3, Full Marks-75)

Name of the Course: Analytical Geometry of 2 Dimensions, Vector Algebra, Differential Calculus II, Integral Calculus, Ordinary Differential Equations I

Course outcome:

Analytical Geometry of 2 Dimensions: To learn the basic concepts of orthogonal transformation, pair of straight lines, equation of tangent, polar equations.

Vector Algebra: To learn the concept of vector products and to familiarize application of vectors in geometry and mechanics.

Differential Calculus II: To learn the basic concept of sequence, series, real valued functions on an interval, application of calculus.

Integral Calculus: Tolearn the basic concept of integral calculus.

Ordinary Differential Equations I: To know the solution of first order linear differential equation.

Group A (Analytical Geometry of 2 Dimensions) (15 marks)

01. Transformations of Rectangular axes: Translation, Rotation and theircombinations. Invariants.

02. General equation of second degree in *x* and *y*:Reduction to canonicalforms. Classification of conic.

03. Pair of straight lines: Condition that the general equation of 2^{nd} degree in *x*and *y* may represent two straight lines. Points of intersection of twointersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Equation of bisectors.Equation of two lines joining the origin to thepoints in which a line meets a conic.

04. Equations of pair of tangents from an external point, chord of contact,poles and polars in case of general conic: Particular cases for Parabola,Ellipse, Circle, Hyperbola.

05. Polar equation of straight lines and circles. Polar equation of a conic referredto a focus as pole. Equation of chord joining two points.Equations of tangentand normal.

Group B [Vector Algebra] (15 marks)

Addition of Vectors.Multiplication of a Vector by a scalar.Collinear andCoplanar Vectors.Scalar and Vector products of two and three vectors.Simpleapplications to problems of Geometry.Vector equation of plane and straight line.Volume of Tetrahedron.Application to problems of Mechanics (Work done andMoment).

Group C [Differential Calculus II] (25 marks)

01. Sequence of real numbers: Definition of bounds of a sequence and monotone sequence. Limit of a sequence. Statements of limit theorems.Concept of convergence and divergence of monotone sequences – applications of the theorems.Statement of Cauchy’s general principle ofconvergence and its application.

02. Infinite series of constant terms: Convergence and Divergence (definitions).Cauchy’s principle as applied to infinite series (application only). Series ofpositive terms:Statements of Comparison test, D’ Alembert’s Ratio test.Cauchy’s root test and Raabe’s test – Applications.Alternating series:Statement of Leibnitz test and its applications.

03.Real valued functions defined on an interval: Statement of Rolle’s theorem and its geometrical interpretation. Mean ValueTheorems of Lagrange and Cauchy. Statements of Taylors and Maclaurin’sTheorems with Lagrange’s and Cauchy’s form of remainders.Taylor’s andMaclaurin’s Infinite series for functions likee^x, sin x, cos x [with restrictions wherevernecessary].

04. Indeterminate Forms:L’Hospital’sRule : Statement and problems only.

05. Application of the principle of Maxima and Minima for a function of singlevariable in geometrical, physical and other problems.

06. Maxima and minima of functions of not more than three variables. Lagrange’s Method of undetermined multiplier – Problems only.

07. Applications of Differential Calculus: Rectilinear Asymptotes (Cartesian only).Envelope of family of straight lines and curves (problems only).Definition and examples of singular points (viz. Node, Cusp, Isolatedpoint).

Group - D [Integral Calculus] (10 marks)

01. Integration of the form: $\int \frac{dx}{a+b\cos x}$, $\int \frac{l\sin x+m\cos x}{n\sin x+p\cos x}\boldsymbol{dx}$ and Integration of Rationalfunctions.
02. Evaluation of definite integrals.

03. Integration as the limit of a sum (with equally spaced as well as unequal intervals)
04. Reduction formulae of $\int \sin^m x \cos^n x\, dx$,$\int \frac{\sin^m x}{\cos^n x}\, dx$,$\int \tan^n x\, dx and$ associated problems (*m* and *n* are non-negative integers).

Group E [Ordinary Differential EquationsI] (10 marks)

01. Order, degree and solution of an ordinary differential equation (ODE) inPresenceof arbitrary constants. Formation of ODE.

02. Solution of first order equations:
(i) Variables separable.
(ii) Homogeneous equations and equations reducible to homogeneous forms.
(iii) Exact equations and those reducible to such equation.
(iv) Euler's and Bernoulli's equations (Linear).
(v) Clairaut's Equations: General and Singular solutions

UG GEN SEM 3

Course Code: MTMG-P3 (Credit-3, Full Marks-75)

Name of the Course: Geometry 3D, L.P.P., Numerical Analysis

Course outcome:

Geometry 3D: To familiarize the equation of plane, straight line, sphere, tangents and cone.

L.P.P.: To know the basic concept of linear programming problem, simplex method, duality, transportation and assignment problem**.**

Numerical Analysis: To know the concept of operators, interpolation, integration and numerical equations.

Group A: Geometry 3D (20 Marks)

01. Rectangular Cartesian co-ordinates: Distance between two points. Divisionof a line segment in a given ratio.Direction cosines and direction ratios of a straight line. Projection of a line segment on another line.Angle between twostraight lines.

02. Equation of a Plane: General form. Intercept and Normal form. Anglebetween two planes.Signed distance of a point from a plane.Bisectors ofangles between two intersecting planes.

03. Equations of Straight line: General and symmetric form. Distance of a point from a line. Co-planarity of two straight lines.Shortest distance between twoskew-lines.

04. Sphere and its tangent plane.

05. Right circular cone.

Group B: L.P.P (40 Marks)

01. Motivation of Linear Programming problem. Statement of L.P.P. formulationof L.P.P. Slack and Surplus variables. L.P.P. is matrix form. Convex set, Hyperplane, Extreme points, Convex Polyhedron, Basic solutions and BasicFeasible Solutions (B.F.S.) Degenerate and Non-degenerate B.F.S.The set of all feasible solutions of an L.P.P. is a convex set. The objectivefunction of an L.P.P. assumes its optimal value at an extreme point of theconvex set of feasible solutions. A B.F.S. to an L.P.P. corresponds to anextreme point of the convex set of feasible solutions.

02. Fundamental Theorem of L.P.P. (Statement only). Reduction of a feasible solution to a B.F.S. Standard form of an L.P.P. Solution by graphical method(for two variables), bysimplex method and method of penalty.

03. Concept ofduality.Duality theory. The dual of the dual is the primal. Relation between the objective values of dual and the primal problems. Dual problems with at most one unrestricted variable, one constraint of equality.

04. Transportation and Assignment problem and their optimal solutions.

Group C: Numerical Analysis (15 Marks)

01. Approximate numbers, Significant figures, Rounding off numbers. Error –Absolute, Relative and Percentage.

02. Operators - Δ,$\nabla$and E (Definitions and some relations among them).
03. Interpolation: The problem of Interpolation, Equi-spaced arguments –Difference Tables, Deduction of Newton's Forward Interpolation Formula.Remainder term (expression only). Newton's Backward Interpolation formula(statement only) with remainder term. Unequally –spaced arguments –Lagrange's Interpolation Formula (statement only). Numerical problems on Interpolation with both equi- and unequally-spaced arguments.

04. Number Integration: Trapezoidal and Simpson's ⅓rd formula (statement only). Problems on Numerical Integration.

05. Solution of Numerical Equation: To find a real root of an algebraic ortranscendental equation. Location of root (Tabular method), Bisection method.Newton-Raphson method with geometrical significance. Numerical problems.**(**Note: emphasis should be given on problems**)**

Course Code: MTMG-P4 (Credit-3, Full Marks-75)

Name of the Course: Integral Calculus II, Ordinary Differential Equation II, Probability and Statistics

Course outcome:

Integral Calculus II: To know the concept of improper integration, double integration , application of integral calculus**.**

Ordinary Differential Equation II: To know the solution techniques of 2^{nd} order ODE and orthogonal trajectories.

Probability and Statistics: To learn the basics of elementary statistics, probability theory, sampling theory.

Group A: Integral Calculus II (20 Marks)

01. Definition of Improper Integrals: Statements of (i) μ -test, (ii) Comparisontest (Limit form excluded) – Simple problems only. Use of Beta and Gammafunctions (convergence and important relations being assumed).

02. Working knowledge of Double integral.

03. Applications: Rectification, Quadrature, Volume and Surface areas of solids formed by revolution of plane curve and areas – Problems only.

Group B: Ordinary Differential Equation II (10 Marks)

01. Second order linear equations: Second order linear differential equationswith constant coefficients. Euler's Homogeneous equations.

02. Simple applications: Orthogonal Trajectories.

Group C: Probability and Statistics (45 Marks)

01. Elements of Probability Theory: Random experiment, Outcome, Event,Mutually Exclusive Events, Equality like and Exhaustive, Classical definitionof Probability, theorems of Total Probability, Conditional Probability andStatistical Independence. Bayes' theorem-problems.Shortcomings of theclassical definition.Axiomatic approach – problems.Random Variable and itsExpectation.Theorems on mathematical expectation.Joint distribution of tworandom variables.Theoretical Probability Distribution – Discrete and Continuous (p.m.f. pd.d.f.)Binomial, Poisson and Normal distributions and their properties.

02. Elements of Statistical Methods. Variables, Attributes, Primary data andsecondary data.Population and sample.Census and Sample Survey.Tabulation – Chart and Diagram, graph, Bar diagram, Pie diagram etc.Frequency Distribution – Un-grouped and grouped cumulative frequencydistribution. Histogram, Frequency curve, Measure of Central Tendencies –Average : AM, GM, HM, Mean, Median and Mode (their advantages anddisadvantages). Measures of Dispersions – Range, Quartile Deviation, MeanDeviation, Variance/S.D., Moments, Skewness and Kurtosis.

03. Sampling Theory: Meaning and objects of sampling. Some ideas about themethods of selecting samples. Statistic and Parameter, Sampling Distribution– standard error of a statistic (e.g. sample mean, sample proportion). Fourfundamental distributions derived from the normal:(i) Standard NormalDistribution, (ii) Chi-square distribution, (iii) Student's distribution, (iv) Snedecor's F-distribution.Estimation and Test of Significance.Statistical Inference.Theory ofestimation – Point estimation and Interval estimation. ConfidenceInter/Confidence Limit. Statistical Hypothesis – Bull Hypothesis andAlternative Hypothesis.Level of significance.Critical Region. Type I andType II error. Problems.

04. Bivariate Frequency Distribution. Scatter Diagram, Correlation co-efficient –Definition and properties.Regression lines.

05. Time Series: Definition. Why to analyze Time series data? Components.Measurement of Trend – (i) Moving Average Method, (ii) Curve Fittings(linear and quadratic curve). (Ideas of other curves, e.g. exponential curveetc.). Ideas about the measurement of other components.

06. Index Number: Meaning of Index Number. Construction of Price IndexNumber. Consumer Price Index Number. Calculation of Purchasing Power of Rupee.