COURSE STRUCTURE OF FOUR YEAR UNDER GRADUATE PROGRAM (FYUGP) MATHEMATICS
VINOBA BHAVE UNIVERSITY, HAZARIBAG

SEMESTER	MAJOR(MJ)				MINOR(MN)				SKILL ENHACEMENT COURSE(SEC)			
	CODE	PAPER	FULL MARKS	CREDIT	CODE	PAPER	FULL MARKS	CREDIT	CODE	PAPER	CREDIT	FULL MARKS
I	MJ-1	CALCULUS	100	4	MN-1A	CALCULUS	100	4	SEC-1	LOGIC AND SETS	3	75
II	MJ-2	ALGEBRA	100	4					SEC-2	GRAPH THEORY	3	75
	MJ-3	REAL ANALYSIS-1	100	4								
III	MJ-4	DIFFERENTIAL EQUATIONS	100	4	MN-1B	ALGEBRA	100	4	SEC-3	MATHEMATICAL MODELING	3	75
	MJ-5	MULTIVARIATE CALCULUS	100	4								
IV	MJ-6	INTRODUCTION TO GROUP THEORY	100	4								
	MJ-7	PARTIAL DIFFERENTIAL EQUATION	100	4								
	MJ-8	NUMERICAL ANALYSIS	100	4								
V	MJ-9	RING THEORY	100	4	MN-1C	REAL ANALYSIS	100	4				
	MJ-10	REAL ANALYSIS-2	100	4								
	MJ-11	MECHANICS	100	4								
VI	MJ-12	LINEAR PROGRAMING PROBLEM	100	4								
	MJ-13	LINEAR ALGEBRA	100	4								
	MJ-14	PROBABILITY AND STATISTICS	100	4								
	MJ-15	LAPLACE TRANSFORM	100	4								
VII	MJ-16	METRIC SPACE	100	4	MN-1D	GROUP THEORY	100	4				
	MJ-17	COMPLEX ANALYSIS	100	4								
	MJ-18	ADVANCE GROUP THEORY	100	4								
	MJ-19	REAL ANALYSIS-3	100	4								
VIII	MJ-20	DIFFERENTIAL GEOMETRY AND TENSOR	100	4								
	AMJ-01	TOPOLOGY	100	4								
	AMJ-02	SPECIAL FUNCTIONS	100	4								
	AMJ-03	ANALYTICAL DYNAMICS AND GRAVITATION	100	4								
	OR											
	RC-01	RESEARCH METHODOLOGY	100	4								
	RC-02	PROJECT DISSERTATION/RESEARCH INTERNSHIP/FIELD WORK	200	8								
TOTAL MARKS/CREDIT			2300	92			400	16			09	225

UNIVERSITY DEPARTMENT OF MATHEMATICS
VINOBA BHAVE UNIVERSITY
HAZARIBAG - 825301 (JHARKHAND)

Ref: .... Date: ....

INSTRUCTION TO QUESTION SETTER

There will be one semester internal examination {SIE} and end semester examination {ESE} in every minor and major paper.

❖ **For semester internal examination (SIE – 20+5 = 25 marks)**

Group A [Compulsory]

01. 05 very short answer type question Carry one mark each
02. 01 short answer type question Carry 05 marks

Group B [Answer any one]

03. Long answer type question Carry 10 marks.
04. Long answer type question Carry 10 marks.

Note: 05 marks decided by the Department for class Attendance score (CAS) as per regularity of the student.

❖ **For End semester examination (ESE – 75 marks)**

Group A [Compulsory]

01. 05 very short answer type question Carry one mark each
02. Short answer type question Carrey 05 marks
03. Short answer type question Carrey 05 marks

Group B [Answer any Four]

04.
05.
06. Long answer type question Carry 15 marks each.
07. (Six questions will be set as indicated in the syllabus)
08.
09.

Note: There may be subdivisions in each question.

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23.08.23

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
I	CALCULUS	MJ-1	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

(i) Calculate the limit and examine the continuity of a function at a point.

(ii) Understand the consequences of various mean value theorems for differentiable functions.

(iii) Sketch curves in Cartesian and polar coordinate systems.

(iv) Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life sciences and a host of other disciplines.

(v) Various integration techniques appearing in engineering and research.

UNIT-I: Differential calculus

Hyperbolic functions, higher order derivatives, Leibnitz Theorem and its applications, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates and polar coordinates, L'Hospital's rule.

(2 Questions)

UNIT-II: Integral calculus

Reduction formulae, derivations and illustrations of reduction formulae of the types $\int sin^n x\, dx$, $\int cos^n x\, dx$, $\int tan^n x\, dx$, $\int sin^n x\, cos^m\, dx$, $\int sin^n x\, cosmx\, dx$, $\int (logx)^n\, dx$, parameterizing a curve, arc length, arc length of parametric curves, volume and area of surface of revolution. **(2 Questions)**

UNIT-III: Conics

Techniques of sketching conics, reflection properties of conics, transformation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics. **(1 Question)**

UNIT-IV: Vector calculus

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration. **(1 Question)**

References:

1. R. K. Dwivedi, Calculus, 1st Edition, Pragati Prakashan, Meerut, India, 2019.

2. Howard Anton, I. Bivens & Stephan Davis (2016). *Calculus* (10th edition). Wiley India.

3. Gabriel Klambauer (1986). *Aspects of Calculus*. Springer-Verlag.

4. Wieslaw Krawcewicz & Bindhyachal Rai (2003). *Calculus with Maple Labs*. Narosa.

5. Gorakh Prasad (2016). *Differential Calculus* (19th edition). Pothishala Pvt. Ltd.

6. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). *Thomas' Calculus* (14th edition). Pearson Education.

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FYUGP MAJOR MATHEMATICS SYLLABUS
VINOBA BHAVE UNIVERSITY, HAZARIBAG

SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
II	ALGEBRA	MJ-2	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Learn and apply De Moivre's theorem.
b) Understand relation and functions.
c) Basic concept of theory of Numbers.
d) Rank of matrix and solution of system of linear equations.
e) Evaluation of Eigen values and Eigen vectors of a matrix.
f) Introduction to vector space and linear transformations.

UNIT I: Trigonometry: Polar form of complex number, n-th roots of unity, De Moivre's Theorem, Applications of De Moivre's Theorem, Logarithmic of complex numbers. **(1 Question)**

UNIT II: Relation and function: Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set. **(1 Question)**

UNIT III: Theory of numbers: Well-ordering property (WOP) of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, Fundamental Theorem of Arithmetic. **(1 Question)**

UNIT IV: Matrices and System of linear equations: Rank of a matrix, , row rank, column rank, Matrix form of system of linear equations, augmented matrix, consistent and inconsistent system of linear equations, necessary and sufficient condition for consistency of a system of linear equations, solution of homogeneous and non-homogeneous linear equations. **(2 Question)**

UNIT V: Eigen values and Eigen vectors of matrices: Inverse of a matrix, Characterization of invertible matrices, Characteristic polynomial of a matrix, Eigen values and Eigen vectors, Theorems on Eigen values and Eigen vectors. **(1 Question)**

References:

1. Pankaj Kumar Manjhi, Algebra, 1st edition, Pragati Prakashan, Meerut, 2018.
2. Dr. Manoranjan Kumar Singh, A Text Book of Advanced Trigonometry, 1st Edition, Kedar Nath Ram Nath Publication, 2015.
3. Dr. Manoranjan Kumar Singh, A Text Book of Matrices, 1st Edition, Kedar Nath Ram Nath Publication, 2015.
4. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
6. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
7. A.R. Vashistha, Matrices, Krishna Prakashan, Meerut.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
II	REAL ANALYSIS - 1	MJ-3	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand many properties of the real line $\mathbb{R}$ and learn to define sequence in terms of functions from $\mathbb{R}$ to a subset of $\mathbb{R}$.

b) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

c) Apply the ratio, root, and alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

d) Learn some of the properties of continuous and uniformly continuous functions.

UNIT-I: Real Number System: Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$, Definition and types of intervals, Nested intervals property; Neighbourhood of a point in $\mathbb{R}$, Open, closed and perfect sets in $\mathbb{R}$, Connected subsets of $\mathbb{R}$, Cantor's set. **(2 Questions)**

UNIT-II: Sequences of Real Numbers: Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequence, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's convergence criterion. **(2 Questions)**

UNIT-III: Infinite Series: Convergence and divergence of infinite series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series; Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's *n*th root test, Raabe's test, De Morgan and Bertrand test, Integral test, Alternating series, Leibnitz test, Absolute and conditional convergence. **(2 Questions)**

References:

1. R. K. Dwivedi, Real Analysis, 1st Edition, Pragati Prakashan, Meerut, India, 2020.
2. Robert G. Bartle & Donald R. Sherbert, Introduction to Real Analysis (4th edition), Wiley India, 2015.
3. Gerald G. Bilodeau, Paul R. Thie & G. E. Keough, An Introduction to Analysis (2nd edition), Jones and Bartlett India Pvt. Ltd., 2015
4. K. A. Ross, Elementary Analysis: The Theory of Calculus, 2nd edition, Springer, 2013

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
III	DIFFERENTIAL EQUATIONS	MJ-4	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: The course will enable the students to:

a) Understand the genesis of ordinary differential equations.
b) Learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
c) Know Picard's method of obtaining successive approximations of solutions of first order differential equations, passing through a given point in the plane and Power series method for higher order linear equations, especially in cases when there is no method available to solve such equations.
d) Grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

UNIT-I: First Order Differential Equations: Differential equations of first order and first degree, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor, First order higher degree equations solvable for *x*, *y* and *p*. Clairaut's form and singular solutions. Picard's theorem for the existence and uniqueness of the solutions. **(1 Question)**

UNIT-II: Second Order Linear Differential Equations: Statement of existence and uniqueness theorem for linear differential equations, General theory of linear differential equations of second order with variable coefficients, Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients, Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters and method of undetermined coefficients. **(2 Questions)**

UNIT-III: Higher Order Linear Differential Equations: Principle of superposition for a homogeneous linear differential equation, Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties, Concept of a general solution of a linear differential equation, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler-Cauchy equation, Method of variation of parameters and method of undetermined coefficients, Inverse operator method. **(2 Questions)**

UNIT-IV: Series Solutions of Differential Equations Power series method, Legendre's equation, Legendre polynomials, Rodrigue's formula, Orthogonality of Legendre polynomials, Bessel's equation, Bessel functions and their properties, Recurrence relations. **(1 Question)**

References:

1. G.K.Jha and Sarita Jha, Undergraduate differential Equation, 1st Edition, Pragati prakashan, meerut, 2019
1. Belinda Barnes & Glenn Robert Fulford (2015). Mathematical Modelling with Case 9 Studies: A Differential Equation Approach Using Maple and MATLAB (2nd edition). Chapman & Hall/CRC Press, Taylor & Francis.
2. H. I. Freedman (1980). Deterministic Mathematical Models in Population Ecology. Marcel Dekker Inc.
3. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
4. Daniel A. Murray (2003). Introductory Course in Differential Equations, Orient.
5. B. Rai, D. P. Choudhury & H. I. Freedman (2013). A Course in Ordinary Differential Equations (2nd edition). Narosa.
6. Shepley L. Ross (2007). Differential Equations (3rd edition), Wiley India.
7. George F. Simmons (2017). Differential Equations with Applications and Historical

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
III	MULTIVARIATE CALCULUS	MJ-5	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Learn conceptual variations while advancing from one variable to several variables in calculus.
b) Apply multivariable calculus in optimization problems.
c) Inter-relationship amongst the line integral, double and triple integral formulations.
d) Understanding importance of Green, Gauss and Stokes' theorems.

UNIT-I: Partial Differentiation

Functions of several variables, Limits and continuity, Partial differentiation, Chain rule, Directional derivatives, Gradient, Tangent planes and normal lines.

(1 Question)

UNIT-II: Differentiation

Higher order partial derivatives, Total differential and differentiability, Jacobians, Change of variables, Euler's theorem for homogeneous functions, Taylor's theorem for functions of two variables. **(1 Question)**

UNIT-III: Extrema of Functions

Extrema of functions of two and more variables, Method of Lagrange multipliers, constrained optimization problems. **(1 Question)**

UNIT- IV: Vector Calculus: Definition of vector field, Divergence, curl, gradient and vector identities, Vector integration. **(1 Question)**

UNIT-V: Double and Triple Integrals

Double integration and triple integral, Change of order of integration, Surface area by double integrals, Volume by triple integrals, Change of variables in double and triple integrals, Dirichlet integral. **(1 Question)**

UNIT-VI: Green's, Stokes' and Gauss Divergence Theorem

Line integrals, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem. **(1 Question)**

References:

1. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein, *Basic Multivariable Calculus*, Springer India Pvt. Limited, 2009.

2. James Stewart, *Multivariable Calculus* (7th edition). Brooks/Cole. Cengage, 2012

3. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith, *Calculus* (3rd edition), Pearson Education. Dorling Kindersley (India) Pvt. Ltd., 2011

4. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir, *Thomas' Calculus* (14th edition). Pearson Education, 2018.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
IV	Introduction to group Theory	MJ-6	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: The course will enable the students to:

a) Recognize the mathematical objects called groups.
b) Link the fundamental concepts of groups and symmetries of geometrical objects.
c) Explain the significance of the notions of cosets, normal subgroups, and factor groups.
d) Analyze consequences of Lagrange's theorem.

UNIT I: Symmetries of a square, Dihedral groups, definition and examples of groups, abelian groups, permutation groups, Cycle notation for permutations, even and odd permutations, quaternion group and its matrix representation, elementary properties of groups. Order of a group element and order of a group, Subgroups and examples, theorems on subgroups, normal subgroups and their properties, centralizer (normalizer) of a group element, Centre of a group. **(2 Questions)**

UNIT II: Properties of cyclic groups, classification of subgroups of cyclic groups. Cosets and their properties, Lagrange's theorem and consequences including Fermat's little theorem. **(1 Question)**

UNIT III: Group homomorphism, kennel of homomorphism, properties of homomorphism, isomorphism, Factor group (quotient groups) and isomorphism Theorem: Quotient group, Cauchy's theorem for finite abelian groups, Group isomorphism, properties of isomorphisms, First, Second and Third isomorphism theorems, Cayley theorem. **(2 Questions)**

UNIT V: Direct Product: External direct product of a finite number of groups, Properties of external direct products, the group of units modulo n as an external direct product, internal direct products.

(1 Question)

References:

1. Pankaj Kumar Manjhi (2019), Introduction to Group Theory, 1st edition, Pragati Prakashan, meerut.
2. Dr. Manoranjan Kumar Singh, Shubh Narayan Singh, Group Theory I, 1st Edition, S. Chand Publication 2015.
2. John B. Fraleigh (2007). *A First Course in Abstract Algebra* (7th edition). Pearson.
3. Joseph A. Gallian (2017). *Contemporary Abstract Algebra* (9th edition). Cengage.
4. I. N. Herstein (2006). *Topics in Algebra* (2nd edition). Wiley India.
5. Nathan Jacobson (2009). *Basic Algebra* I (2nd edition). Dover Publications

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
IV	PARTIAL DIFFERENTIAL EQUATION	MJ-7	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Apply a range of techniques to solve first and second order partial differential equations.
b) Understand problems, methods and techniques of calculus of variations.

UNIT-I: First Order Partial Differential Equations

Order and degree of Partial differential equations (PDE), Concept of linear and non-linear partial differential equations, Partial differential equations of the first order, Lagrange's method, some special type of equation which can be solved easily by methods other than the general method, Charpit's general method.

(1 Question)

UNIT-II: Second Order Partial Differential Equations with Constant Coefficients

Classification of linear partial differential equations of second order, Homogeneous and nonhomogeneous equations with constant coefficients. **(1 Question)**

UNIT-III: Second Order Partial Differential Equations with Variable Coefficients

Partial differential equations reducible to equations with constant coefficient, Second order PDE with variable coefficients, Classification of second order PDE, Reduction to canonical or normal form; Monge's method.

(2 Question)

UNIT-IV: Calculus of Variations-Variational Problems with Fixed Boundaries

Euler's equation for functional containing first order and higher order total derivatives, Functional containing first order partial derivatives, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation. **(1 Question)**

UNIT-V: Calculus of Variations-Variational Problems with Moving Boundaries

Variational problems with moving boundaries, Functionals dependent on one and two variables, one sided variation. Sufficient conditions for an extremum-Jacobi and Legendre conditions, Second variation.

(1 Question)

References:

1. G.K.Jha and Sarita Jha, Partial Differential Equation and system of ordinary differential Equation, 1st Edition, Pragati prakashan, meerut, 2019.
2. A. S. Gupta (2004). Calculus of Variations with Applications. PHI Learning.
3. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
4. TynMyint-U & Lokenath Debnath (2013). Linear Partial Differential Equation for Scientists and Engineers (4th edition). Springer India.
5. S. B. Rao & H. R. Anuradha (1996). Differential Equations with Applications. University Press.
6. Ian N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
IV	NUMERICAL ANALYSIS	MJ-8	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Obtain numerical solutions of algebraic and transcendental equations.
b) Find numerical solutions of system of linear equations and check the accuracy of the solutions.
c) Learn about various interpolating and extrapolating methods.
d) Solve initial and boundary value problems in differential equations using numerical methods.
e) Apply various numerical methods in real life problems.

UNIT-I: Numerical Methods for Solving Algebraic and Transcendental Equations

Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations. **(1 Question)**

UNIT-II: Numerical Methods for Solving Linear Systems

Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a Matrix and its applications, Thomas method for tridiagonal systems; Gauss-Jacobi, Gauss-Seidel and successive over-relaxation (SOR) methods. **(1 Question)**

UNIT-III: Interpolation

Lagrange and Newton interpolations, Piecewise linear interpolation, Cubic spline interpolation, Finite difference operators, Gregory-Newton forward and backward difference interpolations. **(1 Question)**

UNIT-IV: Numerical Differentiation and Integration

First order and higher order approximation for first derivative, Approximation for second derivative, Numerical integration: Trapezoidal rule, Simpson's rules and error analysis.

(2 Questions)

UNIT-V: Initial and Boundary Value Problems of Differential Equations

Euler's method, Runge-Kutta methods, higher order one step method, Multi-step methods, Finite difference method. **(1 Question)**

References:

1. H. K. Mishra and G. K. Jha (2023), An introduction to numerical Analysis and Technique, 1st Ed., Walnut Publication.
2. Brian Bradie (2006), *A Friendly Introduction to Numerical Analysis.* Pearson.
3. C. F. Gerald & P. O. Wheatley (2008). *Applied Numerical Analysis* (7th edition), Pearson Education, India.
4. F. B. Hildebrand (2013). *Introduction to Numerical Analysis*: (2nd edition). Dover Publications.
5. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). *Numerical Methods for Scientific and Engineering Computation* (6th edition). New Age International Publishers.
6. Robert J. Schilling & Sandra L. Harris (1999). *Applied Numerical Methods for Engineers Using* MATLAB *and C.* Thomson-Brooks/Cole.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
V	RING THEORY	MJ-9	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			**PASS MARKS: Th (SIE: 10+ ESE:30)=40**	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand the basic concepts of rings and their properties.
b) Recognize factorization and integral domain.
c) Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
d) Learn in detail about polynomial rings, fundamental properties.

UNIT I: Introduction to ring: Definition and examples of rings, properties of rings, ring with Unity, commutative ring, subrings, Theorems on subrings, characteristic of a ring, theorem on characteristic of a ring, examples. **(1 Question)**

UNIT II: Factorization and Euclidean Domain: Divisibility in a ring, associates, irreducible elements, prime elements, GCD of two elements, relatively prime elements, theorems, Units, divisors of zero, Integral domain, Field, Theorem on integral domain, examples, Left and right ideals, Ideals, ideal generated by a subset of a ring, quotient rings. **(1 Question)**

UNIT III: Ring homomorphism: Ring homomorphism Examples on ring homomorphism, properties of ring homomorphism, Kernel of homomorphism, Isomorphism theorems. **(1 Question)**

UNIT IV: Quotient Field: Imbedding of a ring, subfield, quotient field, embedding theorems, examples on quotient fields. **(1 Question)**

UNIT V: PID and UFD: Prime and maximal ideals, theorems on prime and maximal ideals, Euclidean domain. Principal ideal, factorization domain, Principal ideal domain (PID), Unique Factorization domain (UFD), Theorems and examples. **(1 Question)**

UNIT VI: Polynomial Rings: Polynomial rings over commutative rings, division algorithm and consequences, factorization of polynomials, reducibility tests, irreducibility tests, Einstein criterion, unique factorization in Z[x]. Divisibility in integral domains, irreducibility, primes, unique factorization domains, Euclidean domains. **(1 Question)**

References:

1. Pankaj Kumar Manjhi (2023), Introduction to ring Theory, 1st Ed., Pragati Prakashan Meerut, India.
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). Basic Abstract Algebra (2nd edition). Cambridge University Press.
3. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd edition). Wiley.
4. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
5. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.
6. N. S. Gopalakrishnan (1986). University Algebra, New Age International Publishers.
7. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
8. Thomas W. Hungerford (2004). Algebra (8th edition). Springer.
9. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
10. Serge Lang (2002). Algebra (3rd edition). Springer-Verlag.
11. I. S. Luthar & I. B. S. Passi (2013). Algebra: Volume 1: Groups. Narosa.
12. I. S. Luthar & I. B. S. Passi (2012). Algebra: Volume 2: Rings. Narosa.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
V	REAL ANALYSIS-2	MJ-10	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100				PASS MARKS: Th (SIE: 10+ ESE:30)=40

Course Objective & Learning Outcomes: This course will enable the students to:

a) Calculate the limit and examine the continuity of a function at a point.

b) Understand the consequences of various mean value theorems for differentiable functions.

UNIT-I: Limit and Continuity

$\varepsilon - \delta$ Definition of limit of a real valued function, Limit at infinity and infinite limits; Continuity of a real valued function, Properties of continuous functions, Intermediate value theorem, Geometrical interpretation of continuity, Types of discontinuity; Uniform continuity. **(2 Questions)**

UNIT-II: Differentiability

Differentiability of a real valued function, Geometrical interpretation of differentiability, Relation between differentiability and continuity, Differentiability and monotonicity, Chain rule of differentiation Darboux's theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems

(2 Questions)

UNIT-III: Expansions of Functions

Maclaurin's and Taylor's theorems for expansion of a function in an infinite series, Taylor's theorem in finite form with Lagrange, Cauchy and Roche–Schlomilch forms of remainder.

(2 Questions)

References:

1. G.K.Jha and Sarita Jha, Theory of Functions, 1st Edition, Pragati prakashan, meerut, 2019.
2. Howard Anton, I. Bivens & Stephan Davis (2016). *Calculus* (10th edition). Wiley, India.
3. Gabriel Klambauer (1986). *Aspects of Calculus*. Springer-Verlag.
4. Wieslaw Krawcewicz & Bindhyachal Rai (2003). *Calculus with Maple Labs*. Narosa.
5. Gorakh Prasad (2016). *Differential Calculus* (19th edition). Pothishala Pvt. Ltd.
6. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). *Thomas' Calculus* (14th edition). Pearson Education.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
V	MECHANICS	MJ-11	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Familiarize with subject matter, which has been the single Centre, to which were drawn mathematicians, physicists, astronomers, and engineers together.

b) Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.

c) Determine the centre of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.

d) Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.

e) Learn that a particle moving under a central force describes a plane curve and know the Kepler's laws of the planetary motions, which were deduced by him long before the mathematical theory given by Newton.

UNIT-I: Statics

Equilibrium of a particle, Equilibrium of a system of particles, Necessary conditions of equilibrium, Moment of a force about a point, Moment of a force about a line, Couples, Moment of a couple, Equipollent system of forces, Work and potential energy, Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.

(1 Question)

UNIT-II: Centers of Gravity and Common Catenary

Centre of gravity of plane area including a uniform thin straight rod, triangle, circular arc, semicircular area and quadrant of a circle, Centre of gravity of a plane area bounded by a curve, Centre of gravity of a volume of revolution; Flexible strings, Common catenary, Intrinsic and Cartesian equations of the common catenary, Approximations of the catenary. **(2 Questions)**

UNIT-III: Rectilinear Motion

Simple harmonic motion (SHM) and its geometrical representation, SHM under elastic forces, Motion under inverse square law, Motion in resisting media, Concept of terminal velocity, Motion of varying mass.

(1 Question)

UNIT-IV: Motion in a Plane

Kinematics and kinetics of the motion, Expressions for velocity and acceleration in Cartesian, polar and intrinsic coordinates; Motion in a vertical circle, projectiles in a vertical plane and cycloidal motion. **(1 Question)**

UNIT-V: Central Orbits

Equation of motion under a central force, Differential equation of the orbit, (p, r) equation of the orbit, Apses and apsidal distances, Areal velocity, Characteristics of central orbits, Kepler's laws of planetary motion.

(1 Question)

References:

1. S. L. Loney (2006). An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies. Read Books.
2. P. L. Srivatava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad.
3. J. L. Synge & B. A. Griffith (1949). Principles of Mechanics. McGraw-Hill.
4. A. S. Ramsey (2009). Statics. Cambridge University Press.
5. A. S. Ramsey (2009). Dynamics. Cambridge University Press.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VI	LINEAR PROGRAMING PROBLEM	MJ-12	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Analyze and solve linear programming models of real-life situations.
b) Provide graphical solution of linear programming problems with two variables, and illustrate the concept of convex set and extreme points.
c) Solve linear programming problems using simplex method.
d) Learn techniques to solve transportation and assignment problems.
e) Solve two-person zero sum game problems.

UNIT-I: Linear Programming Problem, Convexity and Basic Feasible Solutions

Formulation and examples, Canonical and Standard forms, Graphical solution, Convex and polyhedral sets, Extreme points, Basic solutions, Basic Feasible Solutions, Correspondence between basic feasible solutions and extreme points. **(1 question)**

UNIT-II: Simplex Method

Optimality criterion, improving a basic feasible solution, Unboundedness, Simplex algorithm and its tableau format, artificial variables, Two-phase method, Big-*M* method. **(1 question)**

UNIT-III: Duality

Formulation of the dual problem, Duality theorems, Unbounded and infeasible solutions in the primal, solving the primal problem using duality theory. **(1 question)**

UNIT-IV: Transportation and Assignment Problems

Formulation of transportation problems, Methods of finding initial basic feasible solutions: North-west corner rule, least cost method, Vogel approximation method, Algorithm for obtaining optimal solution; Formulation of assignment problems, Hungarian method. **(2 questions)**

UNIT-V: Game Theory

Formulation of two-person zero-sum games, Games with mixed strategies, Graphical method for solving matrix game, Dominance principle, Solution of game problem, Linear programming method of solving a game.
(1 question)

References:

1. Mokhtar S. Bazaraa, John J. Jarvis & Hanif D. Sherali (2010). Linear Programming and Network Flows (4th edition). John Wiley & Sons.
2. G. Hadley (2002). Linear Programming. Narosa Publishing House.
3. Frederick S. Hillier & Gerald J. Lieberman (2015). Introduction to Operations Research (10th edition). McGraw-Hill Education.
4. Hamdy A. Taha (2017). Operations Research: An Introduction (10th edition). Pearson.
5. Paul R. Thie & Gerard E. Keough (2014). An Introduction to Linear Programming and Game Theory (3rd edition). Wiley India Pvt. Ltd.

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FYUGP MAJOR MATHEMATICS SYLLABUS
VINOBA BHAVE UNIVERSITY, HAZARIBAG

SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VI	LINEAR ALGEBRA	MJ-13	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			**PASS MARKS: Th (SIE: 10+ ESE:30)=40**	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
b) Relate matrices and linear transformations, compute eigen values and eigen vectors of linear transformations.
c) Learn properties of inner product spaces and determine orthogonality in inner product spaces.
d) Realize importance of adjoint of a linear transformation and its canonical form.

UNIT-I: Vector Spaces

Definition and examples, Subspace, Linear span Quotient space and direct sum of subspaces, linearly independent and dependent sets, Bases and dimension. **(2 questions)**

UNIT-II: Linear Transformations

Definition and examples, Algebra of linear transformations, Matrix of a linear transformation, Change of coordinates, Rank and nullity of a linear transformation and rank-nullity theorem. **(1 question)**

UNIT-III: Further Properties of Linear Transformations

Isomorphism of vector spaces, Isomorphism theorems, Dual and second dual of a vector space, Transpose of a linear transformation, Eigen vectors and Eigen values of a linear transformation, Characteristic polynomial and Cayley-Hamilton theorem, Minimal polynomial. **(1 question)**

UNIT-IV: Inner Product Spaces

Inner product spaces and orthogonality, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalization, Diagonalization of symmetric matrices. **(1 question)**

UNIT-V: Adjoint of a Linear Transformation and Canonical Forms

Adjoint of a linear operator; Hermitian, UNITary and normal linear transformations; Jordan canonical form, Triangular form, Trace and transpose, Invariant subspaces. **(1 question)**

References:

1. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence (2003). Linear Algebra (4thedition). Prentice-Hall of India Pvt. Ltd.
2. Dr. Manoranjan Kumar Singh, Group Theory II, 1 st Edition, S. Chand, Publication 2022.
3. Kenneth Hoffman & Ray Kunze (2015). Linear Algebra (2nd edition). Prentice-Hall.
4. I. M. Gel'fand (1989). Lectures on Linear Algebra. Dover Publications.
5. Nathan Jacobson (2009). Basic Algebra I & II (2nd edition). Dover Publications.
6. Serge Lang (2005). Introduction to Linear Algebra (2nd edition). Springer India.
7. Vivek Sahai & Vikas Bist (2013). Linear Algebra (2nd Edition). Narosa Publishing House.
8. Gilbert Strang (2014). Linear Algebra and its Applications (2nd edition). Elsevier.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VI	PROBABILITY AND STATISTICS	MJ-14	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand distributions in the study of the joint behavior of two random variables.
b) Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.
c) Understand central limit theorem.

UNIT-I: Probability Functions and Moment Generating Function

Basic notions of probability, Conditional probability and independence, Baye's theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function. **(2 questions)**

UNIT-II: Univariate Discrete and Continuous Distributions

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution. **(2 questions)**

UNIT-III: Bivariate Distribution

Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations. **(1 question)**

UNIT-IV: Correlation, Regression and Central Limit Theorem

The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers. **(1 question)**

References:

1. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th edition), Pearson Education.
2. Irwin Miller &Marylees Miller (2014). John E. Freund's Mathematical Statistics with Applications (8thedition). Pearson. Dorling Kindersley Pvt. Ltd. India.
3. Jim Pitman (1993). Probability, Springer-Verlag.
4. Sheldon M. Ross (2014). Introduction to Probability Models (11th edition). Elsevier.
5. A. M. Yaglom and I. M. Yaglom (1983). Probability and Information. D. Reidel Publishing Company. Distributed by Hindustan Publishing Corporation (India) Delhi.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VI	LAPLACE TRANSFORM	MJ-15	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Know about piecewise continuous functions, Dirac delta function, Laplace transforms and its properties.
b) Know about the inversion of Laplace Transform.
c) Solve ordinary differential equations using Laplace transforms.

UNIT-I: Laplace Transforms

Laplace transform, Linearity, Existence theorem, Laplace transforms of elementary functions Laplace transforms of derivatives and integrals, shifting theorems, change of scale property, Laplace transforms of periodic functions, Dirac's delta function. **(2 questions)**

UNIT-II: Further Properties of Laplace Transforms

Differentiation and integration of transforms, Convolution theorem, Integral equations, Inverse Laplace transform, Lerch's theorem, Linearity property of inverse Laplace transform, Translations theorems of inverse Laplace transform, Inverse transform of derivatives. **(2 questions)**

UNIT-III Applications of Laplace Transform in the solution of ODE

Applications of Laplace transform in obtaining solutions of ordinary differential equations and integral equations. **(1 question)**

UNIT-IV Applications of Laplace Transform in the solution of BVP

Applications of Laplace transform in obtaining solutions of boundary value Problems. **(1 question)**

References:

1. Pankaj Kumar Manjhi (2019), *Integral Transforms, 1st Ed.,* Ayushman Publication House.
2. Charles K. Chui (1992). *An Introduction to Wavelets*. Academic Press.
3. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VII	METRIC SPACE	MJ-16	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Learn basic facts about the cardinality of a set.

b) Understand several standard concepts of metric spaces and their properties like openness, closed-ness, completeness, Bolzano-Weierstrass property, compactness, and connectedness.

UNIT I: Basic Set theory

Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, Schröder-Bernstein theorem, Cantor's theorem, Order relation in cardinal numbers, Arithmetic of cardinal numbers, Partially ordered set, Zorn's lemma and Axiom of choice, Various set theoretic paradoxes. **(2 questions)**

UNIT II: Metric spaces

Definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's intersection theorem. Subspaces. **(2 questions)**

UNIT III:

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach Fixed point Theorem. **(1 question)**

UNIT IV:

Compact metric spaces, Properties, Arzela-Ascoli Theorem and the Baire Category Theorem. **(1 question)**

Books Recommended

1. Satish Shirali and Harikishan L. Vasudeva, *Metric Spaces*, Springer Verlag, London, 2006.
2. S. Kumaresan, *Topology of Metric Spaces*, 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications,* 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, *Complex Analysis,* 2nd Ed., Undergraduate Texts in 21 Mathematics, Springer-Verlag New York, Inc., NewYork, 1997

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VII	COMPLEX ANALYSIS	MJ-17	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			**PASS MARKS: Th (SIE: 10+ ESE:30)=40**	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Visualize complex numbers as points of $\mathbb{R}^2$, stereographic projection of complex plane on the Riemann sphere and various geometric properties of linear fractional transformations.

b) Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations.

UNIT I

Geometry of complex numbers, regions in the complex plane, Limits and continuity of functions of complex variable, Derivatives, Necessary and sufficient conditions for differentiability. **(1 question)**

UNIT II

Analytic functions, examples of analytic functions, Cauchy-Riemann equations, exponential function, Logarithmic function, trigonometric function, derivatives of functions, bilinear transformation, cross ratio, conformal mapping. **(1 question)**

UNIT III

Complex integration, Cauchy-Goursat Theorem, Cauchy's Integral formula, Higher order derivatives, Morera's Theorem, Cauchy's inequality and Liouville's theorem. **(1 question)**

UNIT IV

The fundamental theorem of algebra, Taylor's theorem, Maximum modulus principle, Schwarz lemma. Laurent's series. **(1 question)**

UNIT V

Isolated singularities. Meromorphic functions. The argument principle Rouche's theorem, Poles and Zeros. Fundamental theorem. Residues. Cauchy's residue theorem. Evaluation of integrals. **(2 questions)**

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VII	ADVANCE GROUP THEORY	MJ-18	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: The course will enable the students to:

a) Recognize automorphism and inner automorphism on groups.
b) Link the concepts of quotient groups to automorphism group.
c) Explain the significance direct product and class equation.
d) Analyze sylow's theorem and their applications.

UNIT I

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties. **(2 question)**

UNIT II

Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups. **(2 questions)**

UNIT III

Class equation and consequences, conjugacy in Sn, *p*-groups, Sylow's 1st , 2nd and 3rd theorems, Applications of Syllow's theorem. **(2 questions)**

Books Recommended

1. Pankaj Kumar Manjhi, Introduction to Group Theory, 1st Ed., Pragati Prakashan, 2019
2. Dr. Manoranjan Kumar Singh, Group Theory II, 1 st Edition, S. Chand Publication, 2022.
2. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
3. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
4. Joseph A. Gallian, *Contemporary Abstract Algebra,* 4th Ed., Narosa Publishing House, 1999.
5. David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
6. J.R. Durbin, *Modern Algebra*, John Wiley & Sons, New York Inc., 2000.
7. D. A. R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VII	REAL ANALYSIS-3	MJ-19	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand Riemann integration.
b) Learn some of the properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.
c) Learn the concept of pointwise and uniform convergence of sequence of functions.
d) Learn some of the properties of Riemann – Stieltjes integrable functions, and the applications of the fundamental theorems of integration.

UNIT I (Riemann Integration)

Riemann integral, R-Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, first mean value theorem, second mean value theorem. **(2 question)**

UNIT II (Uniform convergence)

Pointwise and uniform convergence of sequence and series of functions, Weierstrass's M-test, Dirichlet test and Abel's test for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiability. **(1 question)**

UNIT III (Improper integrals)

Convergence of improper integral at end points, point of infinite discontinuity, Comparison test, Dirichlet test and Abel's test for improper integrals. Convergence of Beta and Gamma functions. Test for uniform convergence of the integral of a product, Frullani integral. **(2 questions)**

UNIT IV (Riemann – Stieltjes integral)

Definition and existence of Riemann – Stieltjes integral, Conditions for R–S integrability, Properties of the R-S integral, R-S integrability of functions of a function Integration and differentiation.

(1 questions)

Reference books:

1. R. K. Dwivedi, Riemann Integral and Series of functions, 1st Edition, Pragati prakashan, Meerut, 2020.
1. Robert G. Bartle & Donald R. Sherbert (2015). *Introduction to Real Analysis* (4th edition).Wiley India.
2. Gerald G. Bilodeau, Paul R. Thie & G. E. Keough (2015). *An Introduction to Analysis* (2nd edition), Jones and Bartlett India Pvt. Ltd.
3. K. A. Ross (2013). *Elementary Analysis: The Theory of Calculus* (2nd edition). Springer.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VIII	DIFFERENTIAL GEOMETRY AND TENSOR	MJ-20	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100		PASS MARKS: Th (SIE: 10+ ESE:30)=40		

Course Objective & Learning Outcomes: This course will enable the students to:

a) Explain the basic concepts of tensors.
b) Understand role of tensors in differential geometry.
c) Learn various properties of curves including Frenet-Serret formulae and their applications.
d) Know the Interpretation of the curvature tensor, Geodesic curvature, Gauss and Weingarten formulae.
e) Understand the role of Gauss's Theorem and its consequences.

UNIT I

Space curves-curvature and torsion. Serret-Frenet formula. Circular helix, the circle of curvature. Osculating sphere, Bertrand curves. **(1 question)**

UNIT II

Curves on a surface-parametric curves. fundamental magnitude, curvature of normal section. Principal directions and principal curvatures, lines of curvature, Rodrigue's formula, Dupin's theorem, theorem of Euler, Conjugate directions and asymptotic lines. **(2 questions)**

UNIT III

One parameter family of surfaces – Envelope the edge of regression, Developable associated with space curves. Geodesics-differential equation of Geodesic, Torsion of a Geodesic. **(2 questions)**

UNIT IV

Tensors, Tensor Algebra, Quotient theorem, Metric Tensor, Angle between two vectors. **(1 question)**

References:

1. Christian Bär (2010). *Elementary Differential Geometry*. Cambridge University Press.
2. Manfredo P. do Carmo (2016). *Differential Geometry of Curves & Surfaces* (Revised and updated 2nd edition). Dover Publications.
3. Alferd Gray (2018). *Modern Differential Geometry of Curves and Surfaces with Mathematica* (4th edition). Chapman & Hall/CRC Press, Taylor & Francis.
4. Richard S. Millman & George D. Parkar (1977). *Elements of Differential Geometry*. Prentice-Hall.
5. R. S. Mishra (1965). *A Course in Tensors with Applications to Riemannian Geometry*. Pothishala Pvt. Ltd.
6. Sebastián Montiel & Antonio Ross (2009). *Curves and Surfaces*. American Mathematical Society.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VIII	TOPOLOGY	AMJ-21	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			**PASS MARKS: Th (SIE: 10+ ESE:30)=40**	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Concepts of Topology, Topological spaces, Open Sets, closed sets, and Subspaces.
b) To learn Basis, Product Topology and Subbasis.
c) To understand Metrics, Metric spaces, Hausdorff Space, Sequences in Topological Spaces, Metrizability Problem and Examples of Metrizable Spaces.
d) Concepts of Continuity, and Homeomorphisms Compactness.

UNIT I

Definition and examples of topological spaces. Closed sets, Closure. Dense subsets. Neighbourhoods, Interior, exterior and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topologies. **(1 question)**

UNIT II

First and second countable spaces. Lindelof's theorem, separable spaces, second countability and separability. Separation axioms to, T_1, T_2, T_3, T_4 : their Characterizations and basic properties. Urysohn's Lemma. Tietze extension theorem. **(2 questions)**

UNIT III

Compactness, continuous functions and compact sets, conjugacy of functions, Basic property of compactness, Heine-Borel Theorem, Compactness and finite intersection property, Product of spaces, Tychonoff's Theorem. **(1 question)**

UNIT IV

Connected and disconnected spaces and their basic properties. Connectedness and product spaces. Connectedness and continuity, connectedness of R, R^n and C^n. Intermediate Value Theorem, Fixed Point Theorem. **(2 questions)**

References :

1. K.D. Joshi. Introduction to General Toplogy Wiley Eastern Ltd. 1983.
2. Singh and Singh , An Introduction To General Topology, 1 st Ed., Anushandhan Prakashan, Kanpur, 2016.
3. J.L. Kelley, General Topology. Van Nostrand. Reinhold Co, New York 1995.
4. W.J.Pervin. Foundations of General Topology. Academic Press Inc. New York 1964.
5. K.K. Jha, Advanced General Topology, Nav Bharat Prakashan, Delhi.
6. G.F. Simmons, Introduction to Topology and Modern Analysis, Mc Graw Hill Int.book company.
7. J.R.Munkres, Topolygy A first course, Prentice hall India Pvt. Ltd.
8. S.Lipschutz, General Topology, Schaum's out line series.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VIII	SPECIAL FUNCTIONS	AMJ-22	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			**PASS MARKS: Th (SIE: 10+ ESE:30)=40**	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand the properties of special functions like hypergeometric, Hermite Polynomials with their integral representations.
b) Understand the concept of Laguerre polymials, Hermite Polynomials etc, with its properties like recurrence relations, orthogonal properties, generating functions etc.
c) Understand how special function is useful in differential equations.

UNIT I

Introduction of generalized Hypergeometric function. Differential equation satisfied by pFq. Saalschutz's Theorem, Whipples theorem Dixon's theorem. Integrals involving generalized Hypergeometric function. Kummer's Theorem. Ramanujan's theorem. **(2 questions)**

UNIT II

Introduction of Hermite Polynomials. Recurrence relation. Orthogonal properties, expansion of polynomials generating function. Rodrigues formula for Hermite polynomials. **(1 question)**

UNIT III

Introduction of Laguerre polynomials. Recurrence relations, generating relating. Rodrigues formula and orthogonality. Laguerre's associated differential equation. More generating function.

(1 question)

UNIT IV

Introduction of Jacobi Polynomials generating function. Rodrigues formula and orthogonality. Introduction of Elliptic function and its Properties. Jacobian theta function, zeros of theta function.

(2 questions)

References :

1. W. T. Reid. Ordinary Differential Equations. John Wiley & Sons. NY.(1971).
2. E.A. Coddington and N.Levinson. Theory of Ordinary Differential Equations. Mc Graw-Hill, NY (1955).
3. Sneddon, I. N. (1961) Special Function of Mathematical Physics and Chemistry: Oliver and Boyd. Edinburgh.
4. Morse. P.M. and H. Fash bach (1953) Methods of theoretical Physics. Part-I, Mc-Graw Hill, Book, Conv. Lue.
5. Labedev, N.N. (1965) Special function and their applications : Printice- Hall, Englewodd cliff. N.J.
6. Bailey, W.N. (1963) Generalised Hyper geometric Cambridge Tracks in Mathematics and Mathematical Physics. Cambridge University, Press London.
7. Bell. W.W. (1966) Special function for Scientific and Engineers; D. Van Nontrand Conv. Ltd. London.

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SEMESTER	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VIII	ANALYTICAL DYNAMICS AND GRAVITATION	AMJ-23	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100		PASS MARKS: Th (SIE: 10+ ESE:30)=40		

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand the concepts of Generalized coordinates Holonomic and Non-holonomic systems etc.
b) Understand the concept of Hamiltonian and Lagrangian.
c) To learn Minimum surface of revolution.
d) Understand Attraction and potential of rod.

UNIT I

Generalized coordinates Holonomic and Non-holonomic systems. Scleronomic and Rheonomic systems. Generalized potential. Lagrange's equations of first kind. Lagrange's equations of second kind. Energy equation of conservative fields. **(1 question)**

UNIT II

Hamilton's variables, Hamilton canonical equations. Cyclic coordinates Routh's equations, Jacobi-Poisson Theorem. Canonical transformation and generating function. Fundamental lemma of calculus of variations. Motivating problems of calculus of variations. Shortest distance. Minimum surface of revolution. Brachistochrone problem, Geodesic. **(2 questions)**

UNIT III

Hamilton's Principle, Principle of least action. Jacobi's equations. Hamilton-Jacobi equations. Jacobi theorem. Lagrange brackets and Poisson brackets. Invariance of Lagrange brackets and Poisson brackets under canonical transformations. **(1 question)**

UNIT IV (Gravitation)

Attraction and potential of rod, spherical shells and sphere. Laplace and Poisson equations. Work done by self-attracting systems. Distributors for a given potential. Equipotential surfaces.

(2 questions)

References

1. H. Goldstein, Classical Mechanics (2nd edition), Narosa Publishing House, New Delhi.
2. I. M. Gelfand and S. V. Fomin Calculus of variation, prentice Hall.
3. S.L. Loney, An elementary treatise on Statics, Kalyani Publishers, N. Delhi 1979.
4. A. S. Ramsey, Newtonian Gravitation. The English Language Book Society and the Cambridge University Press.
5. N.C. Rana & P. S. Chandra Joag, Classical Mechanics. Tata McGraw Hill 1991.

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FYUGP MINOR SYLLABUS MATHEMATICS
VINOBA BHAVE UNIVERSITY, HAZARIBAG

SEMESTER I	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
I	CALCULUS	MN-1A	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Assimilate the notions of limit of a sequence and convergence of a series of real numbers.

b) Calculate the limit and examine the continuity of a function at a point.

c) Understand the consequences of various mean value theorems for differentiable functions.

d) Sketch curves in Cartesian and polar coordinate systems.

e) Various integration techniques appearing in engineering and research.

UNIT-I: Differential calculus

Hyperbolic functions, higher order derivatives, Leibniz Theorem and its applications, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinate and polar coordinate system, L'Hospital's rule.

(2 Questions)

UNIT-II: Integral calculus

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\, dx$, $\int \cos^n x\, dx$, $\int \tan^n x\, dx$, $\int \sin^n x . \cos^m x\, dx$, $\int \sin^m x \cos nx\, dx$, $\int (\log x)^n\, dx$, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, volume and area of surface of revolution. **(2 Questions)**

UNIT-III: Vector calculus

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration. **(2 Question)**

References:

1. R. K. Dwivedi, Calculus, 1st Edition, Pragati Prakashan, Meerut, India, 2019.

2. Howard Anton, I. Bivens & Stephan Davis (2016). *Calculus* (10th edition). Wiley India.

3. Gabriel Klambauer (1986). *Aspects of Calculus*. Springer-Verlag.

4. Wieslaw Krawcewicz & Bindhyachal Rai (2003). *Calculus with Maple Labs*. Narosa.

5. Gorakh Prasad (2016). *Differential Calculus* (19th edition). Pothishala Pvt. Ltd.

6. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018). *Thomas' Calculus* (14th edition). Pearson Education.

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FYUGP MINOR SYLLABUS MATHEMATICS
VINOBA BHAVE UNIVERSITY, HAZARIBAG

SEMESTER I	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
III	ALGEBRA	MN-1B	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Learn and apply DeMoivre's theorem.

b) Understand relation and functions.

c) Basic concept of theory of Numbers.

d) Rank of matrix and solution of system of linear equations.

e) Evaluation of Eigen values and Eigen vectors of a matrix.

UNIT I: Trigonometry: Polar form of complex number, Nth roots of unity, De Moivre's Theorem, Applications of De Moivre's Theorem in expansions of and , and in expansions of and , Logarithmic of complex numbers. **(1 question)**

UNIT II: Relation and function: Equivalence relations, Functions, Composition of functions, Invertible functions; One to one correspondence and cardinality of a set. **(1 question)**

UNIT III: Theory of numbers: Well-ordering property (WOP) of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, Fundamental Theorem of Arithmetic. **(1 question)**

UNIT IV: Matrices and System of linear equations: : Rank of a matrix, row space, column space, row rank, column rank , Matrix form of system of linear equations, augmented matrix, consistent and inconsistent system of linear equations, necessary and sufficient condition consistency of a system of linear equations, method of solving of homogeneous and non-homogeneous linear equations. **(2 questions)**

UNIT V: Eigen values and Eigen vectors of matrices: Inverse of a matrix, Characterization of invertible matrices, Characteristic polynomial of a matrix, Eigen values and Eigen vectors, Theorems on Eigen values and Eigen vectors. **(1 question)**

References:

1. Pankaj Kumar Manjhi, Algebra, 1st edition, Pragati Prakashan, Meerut, 2018.
2. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to Z*, Birkhauser, 2006.
3. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
4. David C. Lay, *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

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SEMESTER I	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
V	REAL ANALYSIS	MN-1C	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: This course will enable the students to:

a) Understand many properties of the real line $\mathbb{R}$ and learn to define sequence in terms of functions from $\mathbb{R}$ to a subset of $\mathbb{R}$.

b) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

c) Apply the ratio, root, and alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Unit-I: Real Number System: Algebraic and order properties of $\mathbb{R}$, Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of $\mathbb{R}$, The completeness property of $\mathbb{R}$, Archimedean property, Density of rational numbers in $\mathbb{R}$, Definition and types of intervals, Nested intervals property, Neighborhood of a point in $\mathbb{R}$, Open, closed and perfect sets in $\mathbb{R}$, Cantor set.

(2 questions)

Unit-II: Sequences of Real Numbers: Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequence, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's convergence criterion. **(2 questions)**

Unit-III: Infinite Series: Convergence and divergence of infinite series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series; Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy's *n*th root test, Alternating series, Leibniz test, Absolute and conditional convergence.

(2 questions)

1.R. K. Dwivedi, Real Analysis, 1st Edition, Pragati Prakashan, Meerut, India, 2020.
2. Robert G. Bartle & Donald R. Sherbert (2015). Introduction to Real Analysis (4th edition).Wiley India.
3. Gerald G. Bilodeau, Paul R. Thie & G. E. Keough (2015). An Introduction to Analysis (2nd edition), Jones and Bartlett India Pvt. Ltd.
4. K. A. Ross (2013). Elementary Analysis: The Theory of Calculus (2nd edition). Springer.

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SEMESTER I	SUBJECT NAME	PAPER CODE	CREDIT	Number of Lectures
VII	GROUP THEORY	MN-1D	4	60
FULLMARKS: 25 (5 Attd +20 SIE: 1 Hr) + 75 (ESE: 3 Hrs)=100			PASS MARKS: Th (SIE: 10+ ESE:30)=40	

Course Objective & Learning Outcomes: The course will enable the students to:

a) Recognize the mathematical objects called groups.
b) Link the fundamental concepts of groups and symmetries of geometrical objects.
c) Explain the significance of the notions of cosets, normal subgroups, and factor groups.
d) Analyse consequences of Lagrange's theorem.

UNIT I : Symmetries of a square, Dihedral groups, definition and examples of groups, abelian groups, permutation groups, Cycle notation for permutations, even and odd permutations, quaternion group and its matrix representation, elementary properties of groups. Order of a group element and order of a group, Subgroups and examples, theorems on subgroups, normal subgroups and their properties, centralizer (normalizer) of a group element, centre of a group. **(2 questions)**

UNIT II : Properties of cyclic groups, classification of subgroups of cyclic groups. Cosets and their properties, Lagrange's theorem and consequences including Fermat's Little theorem. **(2 questions)**

UNIT III : Group homomorphism, kennel of homomorphism, properties of homomorphism ,Factor group (quotient groups) and isomorphism Theorem: Quotient group Cauchy's theorem for finite abelian groups; Group isomorphism, properties of isomorphisms, First, Second and Third isomorphism theorems, Cayley theorem. **(2 questions)**

References:

1. Pankaj Kumar Manjhi (2019), Introduction to Group Theory, 1st edition, Pragati Prakashan, meerut.
2. John B. Fraleigh (2007). *A First Course in Abstract Algebra* (7th edition). Pearson.
3. Joseph A. Gallian (2017). *Contemporary Abstract Algebra* (9th edition). Cengage.
4. I. N. Herstein (2006). *Topics in Algebra* (2nd edition). Wiley India.
5. Nathan Jacobson (2009). *Basic Algebra* I (2nd edition). Dover Publications

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