FACULTY OF SCIENCES

SYLLABUS FOR THE

SUBJECT: MATHEMATICS

for the award of the Degree in

BACHELOR OF ARTS/ BACHELOR OF SCIENCE/ HONOURS

(Offered under 4-year UG Degree Programme)

(Credit Based Grading System)
under NEP 2020

Batch: 2024–28

GURU NANAK DEV UNIVERSITY AMRITSAR

Bachelor of Arts /Bachelor of Science/Honours Mathematics (CBGS)
(under NEP 2020) (Batch 2024-28) (Semester I-VIII)
(Faculty of Sciences)

SCHEME OF SUBJECT MATHEMATICS

SEMESTER-I				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Algebra	4-0-0	4	100
	Algebra Laboratory	0-0-1	2	25
SEMESTER-II				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Calculus	4-0-0	4	100
	Calculus Laboratory	0-0-1	2	25
SEMESTER-III				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Differential Equations	4-0-0	4	100
	Differential Equations Laboratory	0-0-1	2	25
SEMESTER-IV				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Analysis	4-0-0	4	100
	Analysis Laboratory	0-0-1	2	25

SEMESTER-V				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Statics and Dynamics	4-0-0	4	100
	Statics and Dynamics Laboratory	0-0-1	2	25
Code	**Summer Internship**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Internship/Community Outreach	0-0-2	4	50
SEMESTER-VI				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Multivariate calculus	4-0-0	4	100
	Multivariate calculus Laboratory	0-0-1	2	25
SEMESTER-VII				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Real Analysis	4-0-0	4	100
	Complex Analysis	4-0-0	4	100
	Algebra-I	4-0-0	4	100
	Number Theory	4-0-0	4	100
Code	**Minor Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Statistics-I	4-0-0	4	100
Code	**Summer Internship**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Internship/Community Outreach	0-0-2	4	50

SEMESTER-VIII				
Code	**Discipline Specific Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Measure Theory	4-0-0	4	100
	Linear Algebra	4-0-0	4	100
	Algebra-II	4-0-0	4	100
	Differential Equations and integral Transforms	4-0-0	4	100
Code	**Minor Course**	**Credits L-T-P**	**Contact Hours**	**Max. Marks**
	Statistics-II	4-0-0	4	100

*** Note : Students Opting for Mathematics subject in Bachelor of Arts / Bachelor of Science /Honours may choose any one of the following Skill Enhancement Course (SEC) in his/her degree Programme during Ist, IInd and IIIrd Year.**

SEC -1 : Statistical Analysis Using Excel (Theory)
Statistical Analysis Using Excel Laboratory (Practical)
SEC-2 : Enhancing Mathematical Skills (Theory)
SEC 3 : Latex Typesetting (Theory)
Latex Typesetting Laboratory

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LIST OF MINOR COURSES FOR MAJORS OTHER THAN MATHEMATICS

Code	MINOR COURSES	Credits L-T-P	Contact Hours	Max. Marks
SEMESTER-VII				
	NUMERICAL METHODS	3-0-0	3	75
	NUMERICAL METHODS LABORATORY	0-0-1	2	25
SEMESTER-VIII				
	FOURIER SERIES AND INTEGRAL TRANSFORMS	4-0-0	4	100

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SEMESTER I
MATHEMATICS

ALGEBRA

Time: 3 Hours **L-T-P: 4-0-0**
Marks: 100

Instructions for the Paper Setters: -
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION–A

Partitioning of Matrices, Matrices Partitioned conformably for Multiplication, Rank of a Matrix, Normal form, Row rank, Column rank of a matrix, Equivalence of column and row ranks, rank of product of matrices, Linear independence of row and column vectors Applications of matrices to a system of linear (both homogeneous and non–homogeneous) equations. Theorems on consistency of a system of linear equations.

SECTION–B

Eigenvalues, Eigenvectors, Hermitian Matrix, Skew Hermitian matrix and unitary matrix and properties of Eigen value, minimal and the characteristic equation of a matrix. Cayley Hamilton theorem and its use in finding inverse of a matrix.

SECTION–C

Quadratic Forms, quadratic form as a product of matrices. The set of quadratic forms over a field. Congruence of quadratic forms and matrices. Congruent transformations of matrices. Elementary congruent transformations. Congruent reduction of a symmetric matrix. Reduction in the real field. Classification of real quadratic forms in n variables. Definite, semi–definite and indefinite real quadratic forms. Characteristic properties of definite, semi–definite and indefinite forms.

SECTION–D

Relations between the roots and coefficients of general polynomial equation of degree n in one variable. Vieta ‘s Formula, Fundamental Theorem of Algebra (Statement only) Transformation of equations, Equations of Squared differences, Solution of cubic equations by Cardan method, Discriminant of polynomial equation, Discriminant of Cubic equation, nature of roots of cubic, Solution of Biquadratic by Ferrari’s Method with illustrations, Descartes’s Rules of Signs with illustrations.

BOOKS RECOMMENDED:-

1. Shanti Narayan and P.K. Mittal: Text Book of Matrices.
2. K.B. Datta : Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

REFERENCE BOOK RECOMMENDED:-

1. Tom M. Apostol: Calculus: An Indian Adaptation, Wiley India, 2023

SEMESTER I
MATHEMATICS

ALGEBRA LABORATORY

Time: 3 Hours **L-T-P: 0-0-1**

Marks: 25

List of Practicals (using any package)

1. Introduction to the computer package in the practicals.
2. Matrix operations: addition, multiplication, inverse. transpose, determinant of matrix.
3. Find Rank of matrix: Row Rank, Column Rank.
4. Find row reduced echelon form
5. Create the coefficient matrix A and vector b. Solve for x using the inverse, using the built-in function.
6. Solving a linear system, using Gauss elimination numerically.
7. Finding eigenvalues and eigenvectors, numerically.

BOOKS RECOMMENDED:-

1. S.S. Sastry, Engineering Mathematics - Volume I (4th Edition), PHI, 2008.
2. S.S. Sastry, Engineering Mathematics - Volume II (4th Edition), PHI, 2008.

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SEMESTER II
MATHEMATICS

CALCULUS

Time: 3 Hours **L-T-P: 4-0-0**

Marks: 100

Instructions for the Paper Setters: -

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION–A

Real number system and its order properties: lub, glb of sets of real numbers, Completeness property, Archimedean property, Dense property of Rational numbers, Limit of a function of real variable, Properties of Limits, Squeeze Theorem, Continuous function and classification of discontinuities, Differentiability of a function of real variable, Concavity and Convexity of function, Point of inflexion.

SECTION–B

Derivatives of Hyperbolic and Inverse Hyperbolic functions, nth order derivatives, Leibnitz theorem on nth derivative and its applications, Taylor's and Maclaurin theorem with Lagrange form of remainder, Application of Taylor's theorem in error estimation; Taylor's series expansions of $sinx$, $\cos x$, e^{cosx}, $\log x$ etc. Indeterminate forms and L'Hopital rule.

SECTION–C

Asymptotes, Horizontal Asymptotes, Vertical Asymptotes, Oblique Asymptotes, Asymptotes of general Rational Algebraic Curve with illustrations, Intersection of curve and its Asymptotes, de Moivre's theorem (for integer and Rational index) and its applications, primitive nth roots of unity.

SECTION–D

Integration of hyperbolic functions, Properties of definite integral, Reduction formulae of type $\tan^n x\,dx$, $\int \cot^n x\,dx$, $\int \sec^n x$, $\int \operatorname{cosec}^n x\,dx$, $\int x\cos^n x$, $\int \cos^m x \sin nx$, Reduction formulae using Rule of Smaller index +1 of type $\int_0^{\frac{\pi}{2}} \sin^n x \cos^n x\,dx$, $\int_0^{\frac{\pi}{2}} \cos^n x\,dx$, $\int_0^{\frac{\pi}{2}} \sin^n x\,dx$.

BOOKS RECOMMENDED: -

1. S. Narayan and P. K. Mittal: Integral Calculus. Sultan Chand & Sons.
2. Gorakh Prasad, Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad, 2016.

REFERENCE BOOKS RECOMMENDED: -

1. Tom M. Apostol, Calculus: An Indian Adaptation, Wiley India, 2023.
2. Murray R. Spiegel, Theory and Problems of Advanced Calculus, Schaum's outline series, Schaum Publishing Co. New York.

SEMESTER II
MATHEMATICS

CALCULUS LABORATORY

Time: 3 Hours **L-T-P: 0-0-1**

Marks: 25

List of Practicals (using any package)

1. Plotting graphs of elementary functions eax+b sin(bx+c) , log(ax+b), 1/(ax+b), sin(ax+b), cos(ax+b), |ax+b| and to illustrate the effect of a and b on the graphs.
2. Plotting the graphs of the polynomial of degree 4 and 5, the derivative graph, the second derivative graph
3. Tracing of conics in Cartesian coordinates and using the general equation of second degree in x and y.
4. Tracing of conicoids: Ellipsoid, Hyperbolic paraboloid, Elliptic paraboloid, Hyperboloid of one and two sheets etc.
5. Graphs of hyperbolic functions.
6. Approximation of limit.
7. Approximations of derivatives.

BOOKS RECOMMENDED:-

1. S.S. Sastry, Engineering Mathematics - Volume I (4th Edition), PHI, 2008.
2. S.S. Sastry, Engineering Mathematics - Volume II (4th Edition), PHI, 2008.

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SEMESTER III
MATHEMATICS

DIFFERENTIAL EQUATIONS

Time: 3 Hours **L-T-P: 4-0-0**
Marks: 100

Instructions for the Paper Setters: -
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION–A

Differential equation of first order and first degree, Linear differential equation reducible to Linear Bernoulli's equation Ordinary differential equation of first order. Exact differential equations. Necessary and sufficient conditions for Mdx + Ndy to be Exact, integrating factors by inspections, special rules to find integrating factors with proof.

SECTION–B

Geometrical meaning of a complete solution of the differential equations, General solution of homogeneous equation of second order, Orthogonal trajectories of cartesian and polar curve, Homogeneous differential equations, Linear differential equations with constant coefficients.

SECTION–C

Singular solution, p-discriminant, c- discriminant, illustrations of singular solutions Variation of Parameters method, Reduction of order. Linear differential equations with variable coefficients, Define Cauchy's linear equations, Legendre's Linear equation.

SECTION–D

First order and higher degree equations, equations solvable for y, x, p, equations not containing x, equations not containing y, Clairaut's equation and equations reducible to Clairaut's form.

System of ordinary simultaneous equations, Power Series, convergence of power series, Radius of convergence, Power Series solution about an ordinary point, solutions about singular points, Frobenius method when roots of indicial equations differ by non-integers, and when roots are equal.

TEXT BOOK RECOMMENDED: -

1. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand, (20th edition)

REFERENCE BOOK RECOMMENDED:-

1. Tom M. Apostol: Calculus: An Indian Adaptation, Wiley India, 2022

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SEMESTER III
MATHEMATICS

DIFFERENTIAL EQUATIONS LABORATORY

Time: 3 Hours **L-T-P: 0-0-1**

Marks: 25

List of Practicals (using any package)

1. Plotting solution of first order differential equation.
2. Solve the first-order differential equation $\frac{dy}{dx} =$ ay, numerically using Runge-Kutta method.
3. Solve the second-order differential equation $\frac{d^2y}{dt^2} =$ ay, numerically using Runge-Kutta method.
4. Plotting of solution of family of second order differential equation.
5. Solution of system of ordinary differential equations, numerically using Runge-Kutta method.
6. Numerical solution of the nonlinear simple pendulum equation.

BOOKS RECOMMENDED:

1. S.S. Sastry, Engineering Mathematics - Volume I (4th Edition), PHI, 2008.
2. S.S. Sastry, Engineering Mathematics - Volume II (4th Edition), PHI, 2008.

SEMESTER IV
MATHEMATICS

ANALYSIS

Time :3 Hours **L-T-P: 4-0-0**
Marks: 100

Instructions for the Paper Setters :-
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION–A

Sequence, Subsequence, Limit point of a sequence, Theorems on limits of sequences, Convergence and divergence of a sequence, Bounded and monotonic sequences and their behavior, Squeeze Theorem on sequences, Bolzano-Weierstrass theorem (statement only), Definition of Cauchy sequence, Cauchy's convergence Criterion, Cauchy's first theorem on limits with its applications, Cauchy's second theorem on limits with its applications.

SECTION–B

Series of non-negative terms, Convergence and divergence of infinite series, Cauchy convergence criterion for series, Comparison tests for convergence. Cauchy's condensation test, Cauchy's integral test, Cauchy's root test, D'Alembert's ratio test, Comparison between Cauchy's root test and D'Alembert's ratio test, Logarithmic test, Gauss test, Alternating series, Leibnitz's test.

SECTION–C

Partition of an interval, Riemann upper and lower sums, Riemann upper and lower integrals, Riemann integrability, Necessary and sufficient conditions for a bounded function to be Riemann integrable, Riemann integrability of continuous functions, monotone functions, and composition of functions, Darboux theorem, Fundamental Theorem of calculus.

SECTION–D

Improper integrals, Conditions for existence of improper integrals, Tests for the convergence of the improper integrals of different kinds, Absolute convergence.

TEXT BOOK RECOMMENDED:-

1. S.C. Malik, Mathematical Analysis, Wiley Eastern Ltd. (1991).

REFERENCE BOOK RECOMMENDED:-

1. Tom M. Apostol, Calculus: An Indian Adaptation, Wiley India, 2022.

SEMESTER IV
MATHEMATICS

ANALYSIS LABORATORY

Time: 3 Hours **L-T-P: 0-0-1**

Marks: 25

List of Practicals (using any package)

1. Generate bounded sequences.
2. Visualize bounded sequences using plots.
3. Study the convergence of sequences through plotting.
4. Visualize monotonic sequences using plots.
5. Investigate convergence of series.
6. Visualization of convergence tests: Cauchy Root test and D' Alembert Ratio test.
7. Approximating radius of convergence of a power series.

BOOKS RECOMMENDED:-

1. S.S. Sastry, Engineering Mathematics - Volume I (4th Edition), PHI, 2008.
2. S.S. Sastry, Engineering Mathematics - Volume II (4th Edition), PHI, 2008.

SEMESTER V
MATHEMATICS

STATICS AND DYNAMICS

Time :3 Hours **L-T-P: 4-0-0**
Marks: 100

Instructions for the Paper Setters:-

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION–A

Composition and resolution of forces, parallelogram law, triangle law, polygon law, Lami's Theorem and its converse, (ג-µ) theorem, Resultant of a number of coplanar forces, Condition of equilibrium of a number of coplanar forces.

SECTION–B

Parallel forces, Moment of a force about a point, Varignon’s theorem of moments, Friction, Kinds of Friction, Laws of friction, Problems of a body placed on a rough inclined plane, Equilibrium of a particle on a rough plane.

SECTION–C

Definition of velocity and acceleration, Newton’s laws of motion. Weight carried by a lift, Motion of two particles connected by a string, Motion of two bodies connected by a string. Curvilinear motion of particle in a plane, Projectile and its equation of motion, time of flight, horizontal range, greatest height attained.

SECTION–D

Simple Harmonic Motion, Work, Power and Energy; work done in stretching an elastic string, Conservative forces, Kinetic energy, Potential energy, Work done against gravity, Potential energy of a gravitational field, Principle of work and energy, Principle of conservation of energy.

BOOKS RECOMMENDED:-

1. R. S. Verma: A Text Book on Statics, Optical Pvt. Ltd., Allahabad.
2. S. R. Gupta: A text book of Dynamics

SEMESTER V
MATHEMATICS

STATICS AND DYNAMICS LABORATORY

Time: 3 Hours **L-T-P: 0-0-1**
Marks: 25

List of Practicals (using any package)

1. To simulate the motion of a particle under various forces using Newton's second law F=ma (Students can input different forces and masses to see how the particle's acceleration and trajectory change).
2. Create a simulation that analyzes the motion of a simple pendulum (Students can explore how the period and amplitude of oscillation vary with different parameters).
3. Calculate the equilibrium of forces acting on an object. (Given the forces' magnitudes, directions, and points of application, determine whether the object is in equilibrium or not).
4. Calculate the moment of force (torque) around a specified point. (Input the force magnitude, distance from the point, and direction. Compute the resulting moment).
5. Simulate the motion of particles or rigid bodies using numerical integration methods (e.g., Euler's method). (Input initial conditions (position, velocity, mass) and external forces. Observe the dynamic behavior over time).
6. Predict the trajectory of a projectile given initial conditions such as angle, velocity, and height. (This can include air resistance and show the path of the projectile in real-time.)

BOOKS RECOMMENDED:-

1. Roberts P. Adrian, Statics and Dynamics with Background Mathematics.
2. T. M. Faure and R. Nikoukhah, Numerical Methods in Engineering with Scilab.

SEMESTER VI
MATHEMATICS

MULTIVARIATE CALCULUS

Time: 3 hrs. **L-T-P: 4-0-0**

Marks: 100

Instructions for the Paper Setters:-

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding three). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION–A

Functions of several variables, limit and continuity of functions of two variables Partial differentiation, Differentiability of real valued functions of two variables, Total differentiability, sufficient condition for differentiability, Schwarz's Theorem, Young's Theorem, Euler's Theorem on homogeneous functions of two variables, Euler's Theorem on homogeneous functions of three variables, Taylor's theorem for functions of two variables.

SECTION–B

Double integration over rectangular and non-rectangular region, Change of variables in double integrals, Triple integrals, Triple integral over a parallelepiped and solid regions, Change of variables in triple integrals, Area by use of double integrals, Volume by use of triple integration, Surface Area by use of double integrals, Centre of Gravity (or Centre of Mass) in R^2, Centre of Mass in R^3.

SECTION–C

Definition of vector field, divergence and curl, directional derivatives, Divergence of a vector point function, Solenoidal Vector, Irrotational Vector, Physical interpretation of Curl of a vector point function, Laplacian operator, Integration of Vectors, the gradient, Tangential Line integrals, Applications of line integrals: Mass and Work, conservative vector fields, Circulation, Volume Integral .

SECTION–D

The Divergence theorem, Green's theorem in a plane, Stoke's theorem and problems based on these theorems.

BOOKS RECOMMENDED:-

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
4. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

SEMESTER VI
MATHEMATICS

MULTIVARIATE CALCULUS LABORATORY

Time: 3 Hours **L-T-P: 0-0-1**

Marks: 25

List of Practicals (using any package)

1. Finding and visualizing extremes of function of two variables.

2. Approximating area and volume using double integration.

3. Plotting graph of the surface z=f (x, y).

4. Approximating triple Integrals.

5. Draw vector fields in plane.

BOOKS RECOMMENDED:-

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
4. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

SEMESTER VII
MATHEMATICS

REAL ANALYSIS

Time: 3 Hrs **L-T-P: 4-0-0**
Marks: 100

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION–A

Sequence and Series of functions: Discussion of main problem, Uniform Convergence, Uniform Convergence and Integration, Uniform Convergence and Differentiation, Equicontinuous families of functions, Arzela's Theorem, Weierstrass Approximation theorem

SECTION–B

Separated sets, connected sets in a metric space, Connected subsets of real line, Components, Functions of Bounded Variation, Sequences in Metric Spaces: Convergent sequences (in Metric Spaces), subsequences, Cauchy sequences, Complete metric spaces, Cantor's Intersection Theorem

SECTION–C

Baire's theorem, Banach contraction principle, Continuity: Limits of functions (in metric spaces) Continuous functions, Continuity and Compactness, Continuity and Connectedness, Discontinuities, Monotonic functions, Uniform Continuity.

SECTION–D

The Riemann Stieltje's Integral: Definition and existence of Riemann Stieltje's integral, Properties of integral. Integration and Differentiation. Fundamental Theorem of Calculus, 1st and 2nd Mean Value Theorems of Riemann Stieltje's integral.

TEXT BOOK RECOMMENDED:-

1. Walter Rudin: Principles of Mathematical Analysis (3rd Edition) McGraw-Hill Ltd Ch.2, Ch.3, (3.1-3.12), Ch.4, Ch.6, (6.1-6.22)

REFERENCE BOOKS RECOMMENDED:-

1. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Ltd (App.1) pp 337-338, Ch.2(9-13)
2. Shanti Narayan, A course of Mathematical Analysis.
3. T. M. Apostol, Mathematical Analysis 2nd Edition 7.18 (Th.7.30 &7.31)
4. S. C. Malik, and Savita Arora.: Mathematical Analysis, Wiley Eastern Ltd.

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SEMESTER VII
MATHEMATICS

COMPLEX ANALYSIS

Time: 3Hrs **L-T-P: 4-0-0**
Marks: 100

Instructions for the Paper Setters:

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION–A

Functions of complex variables, continuity and differentiability. Analytic functions, Conjugate function, Harmonic function. Cauchy Riemann equations (Cartesian and Polar form). Construction of analytic functions, Complex line integral, Cauchy's theorem, Cauchy's integral formula and its generalized form.

SECTION–B

Cauchy's inequality. Poisson's integral formula, Morera's theorem. Liouville's theorem, Conformal transformations. Bilinear transformations. Critical points, fixed points, cross-ratio. Problems on cross-ratio and bilinear transformation, Analytic Continuation, Natural Boundary, Schwartz Reflection Principle.

SECTION–C

Power Seires, Taylor's theorem, Laurent's theorem. Maximum Modulus Principle. Schwarz's lemma. Theorem on poles and zeros of meromorphic functions. Argument principle. Fundamental theorem of Algebra and Rouche's theorem.

SECTION–D

Zeros, Singularities, Residue at a pole and at infinity. Cauchy's Residue theorem, Jordan'slemma. Integration round Unit circle. Evaluation of integrals of the type of $\int_{-\infty}^{\infty} f(x)dx$ and integration involving many valued functions.

BOOKS RECOMMENDED:

1. E.T. Copson, Theory of functions of complex variables.
2. D. V. Ahlfors, Complex analysis.
3. H. S. Kasana, Complex variables theory and applications.
4. J. B. Conway, Functions of one complex variable
5. Shanti Narayan: Functions of Complex Variables.

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SEMESTER VII
MATHEMATICS

ALGEBRA-I

Time: 3Hrs **L-T-P: 4-0-0**
Marks 100

Instructions for the Paper Setters:

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION–A

Groups: Definition & examples, Subgroups, Normal subgroups and Quotient Groups, Lagrange's Theorem, Generating sets, Cyclic Groups.

SECTION–B

The Commutator subgroups, Homomorphism, Isomorphism Theorems, Automorphisms, inner Automorphisms, Permutation groups, the alternating groups, Simplicity of A_n, $n \geq 5$, Cayley's theorem.

SECTION–C

Structure of finite Abelian groups. Conjugate elements, class equation with applications, Cauchy's Theorem, Sylow's Theorems and their simple applications, Composition Series, and Jordan Holder Theorem, Solvable Groups.

SECTION–D

Direct Products: External and Internal. Fundamental theorem of finite Abelian groups and its applications; Semidirect Products, Recognition Theorems on semidirect products.

TEXT BOOK RECOMMENDED:-

1. J.B. Fraleigh, An Introduction to Abstract Algebra.

REFERENCE BOOKS RECOMMENDED:-

1. I. N. Herstein, Topics in Algebra, Willey Eastern 1975.
2. Surjit Singh and Qazi Zameeruddin. Modern Algebra.
3. M. Artin, Algebra

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SEMESTER VII

MATHEMATICS

NUMBER THEORY

Time: 3Hrs **L-T-P: 4-0-0**
Marks :100

Instructions for the Paper Setters:

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION–A

Simultaneous Linear Congruences, Chinese Remainder theorem with applications, Wolsten-Holme's theorem, Lagrange's proof of Wilson theorem, Fermat numbers, The order of an integer modulo *n*. Primitive roots, Existence and number of primitive roots.

SECTION–B

Indices and their applications, Quadratic residues , Euler's criterion, Product of quadratic residues and quadratic non-residues, The Legendre symbol and its properties, Gauss's Lemma, Quadratic reciprocity law, Jacobian symbol and its properties.

SECTION–C

Arithmetic functions $\tau(n)$, $\phi(n)$, $\sigma_k(n)$, $\mu(n)$, Perfect numbers, Mobius inversion formula, Diophantine equation $x^2+y^2=z^2$ and its applications to $x^n+y^n=z^n$ when n = 4. Criterion for an integer to be expressible as sum of two squares.

SECTION–D

Farey series, Farey dissection of a circle and its applications to approximations of irrationals by rationals, Finite and Infinite simple continued fractions, periodic and purely periodic continued fractions, Lagrange's Theorem on periodic continued fractions. Applications to Pell's equation. The fundamental solution of Pell's equation.

BOOKS RECOMMENDED:

1. G.H. Hardy and H.S. Wright, Theory of Numbers.
2. I. Niven and E.M. Zuckerman, An introduction to number theory.
3. David M. Burton, Elementary Number Theory, McGraw Hill 2002.

SEMESTER VII
MATHEMATICS
(MINOR COURSE)

STATISTICS-I

Time: 3 Hours **L-T-P: 4-0-0**
Marks 100

Instructions for the Paper Setters:

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION-A

Random experiment, sample space, sigma field, probability axioms, elementary properties, Combinatorics: probability on finite sample space, conditional probability and Bayes theorem. Random variable, probability mass function, probability density function, cumulative distribution function, Distribution of functions of random variable.

SECTION-B

Two and higher dimensional random variables, joint distribution, marginal and conditional distributions, bivariate and multivariate transformation of random variables Stochastic independence. Expectations, moments, moment generating function, characteristic function, Conditional expectation, Chebyshev's and Cauchy Schwartz Inequality, Jenson's inequality.

SECTION-C

Discrete Distribution: Uniform, Binomial, Poisson, Geometric, Hyper geometric, Multinomial. Continuous Distributions: Uniform, Exponential, Normal distributions, Gamma distribution, Beta distribution, Bivarirte normal distribution.

SECTION-D

Chi-square distribution, t-distribution, F-distribution, sampling distribution of mean and variance of sample from normal distribution, Convergence in probability and convergence in distribution, central limit theorem (Laplace theorem Linderberg, Levy's Theorem).

BOOKS RECOMMENDED:-

1. R.V.Hogg, J.W. Mckean, and A.T. Craig, Introduction to Mathematical Statistics.
2. V.K. Rohtagi, A.K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics
3. G. Casella and R.L. Berger, Statistical Inference.

SEMESTER VIII
MATHEMATICS

MEASURE THEORY

Time: 3Hrs **L-T-P: 4-0-0**
Marks :100

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION–A

Review of the topology of real line, the extended real numbers, σ-algebra, Borel-algebra and Borel sets, Lebesgue Outer Measure, Measurable Sets and their properties, σ-algebra of Lebesgue measurable sets, Outer and Inner Approximation of the Lebesgue Measurable Sets, Countable additivity of Lebesgue measure, Continuity of measure, Non-Measurable Sets, The Cantor set and The Cantor-Lebesgue function, Comparison of σ-algebra of measurable sets and the Borel σ-algebra of subsets of real line.

SECTION–B

Motivation behind Lebesgue Measurable Functions, various Characterizations and Properties of Measurable functions: Sum, Product and Composition, Sequential Point-wise Limits and Simple Approximations to Measurable Functions, Littlewood's three Principles.

SECTION–C

Lebesgue Integral (**Stage I**): Lebesgue Integral of a simple function, Comparison of Riemann and Lebesgue Integral, linearity and monotonicity of Lebesgue integration. Lebesgue Integral (**Stage II**): Lebesgue Integral of a bounded measurable function over a set of finite measure, linearity, monotonicity, and additivity over domain of integration, The Bounded Convergence Theorem. Lebesgue Integral (**Stage III**): Lebesgue Integral of a measurable function of finite support, Lebesgue Integral of a non-negative measurable function, linearity, monotonicity, and additivity over domain of integration, Fatou's Lemma, The Monotone convergence Theorem.

SECTION–D

Lebesgue Integral (**Stage IV**): The General Lebesgue Integral, the integral comparison test, linearity, monotonicity, and additivity over domain of integration, The Lebesgue Dominated Convergence Theorem, Countable Additivity and Continuity of Integration. Uniformly integrable family of functions, The Vitali convergence Theorem. Characterizations of Riemann and Lebesgue integrability.

TEXT BOOK RECOMMENDED:-

1. H.L. Royden and P.M. Fitzpatrick, Real Analysis (Fourth Edition), Pearson Education Inc. New Jersey, U.S.A. (2010). (Scope as in Ch.1-6)

SEMESTER VIII
MATHEMATICS

LINEAR ALGEBRA

Time: 3Hrs **L-T-P: 4-0-0**
Marks :100

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION–A

Vector spaces, Subspaces, Quotient Spaces, Basis and Dimension Theorems, Sum of subspaces, Direct sum decompositions, Linear transformations, The Algebra of linear transformations.

SECTION–B

Matrices associated with linear transformations, effect of change of ordered bases on the matrix of linear transformation, Elementary matrix operations and Elementary matrices, Row rank, Column rank and their equality, system of linear equations

SECTION–C

Eigen values and Eigen vectors of linear operators, Characteristic and minimal polynomials, companion matrix, subspaces invariant under linear operators, triangulation, Diagonalization, Linear Functionals, Dual Spaces and dual basis, the double dual

SECTION–D

Inner Product Spaces, The Gram-Schmidt Orthogonalization, Orthogonal Complements, The Adjoint of a linear operator on an inner product space, Normal and Self-Adjoint Operators, Unitary and Normal Operators, Spectral Theorem

BOOKS RECOMMENDED:-

1. K. Hoffman and R. Kunze, Linear Algebra, Second Edition, Prentice Hall, 1971.
2. S. Axler, Linear Algebra Done Right, Second Edition, Springer-Verlag, 1997.
3. S.H. Friedberg, A.J. Insel, and L.E. Spence, Linear Algebra, Fourth Edition, Prentice Hall, 2003.
4. S. Lang, Linear Algebra, Third Edition, Springer-Verlag, 1987.
5. Vivek Sahai and Vikas Bist, Linear Algebra, Narosa Publishing House, 2008

SEMESTER VIII
MATHEMATICS

ALGEBRA-II

Time: 3 Hrs **L-T-P: 4-0-0**
Marks:100

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION-A

Rings, Subrings, Ideals, Factor Rings, Homomorphism, Integral Domains. Maximal and prime ideals.

SECTION-B

The field of Quotients of an integral domain. Principal Ideal domains, Euclidean Rings. The ring of Gaussian Integers, Unique Factorization domains, Polynomial Rings, Gauss's theorem and irreducibility of a polynomial.

SECTION-C

Extension Fields: Finite and Infinite, Simple and Algebraic Extensions, Splitting fields: Existence and uniqueness theorem.

SECTION-D

Separable and inseparable extensions, perfect fields, finite fields, Existence of GF (p^n), construction with straight edge ruler and compass.

BOOKS RECOMMENDED:-

1. I.N. Herstein, Topics in Algebra, Willey Eastern1975.
2. J.B. Fraleigh, An Introduction to Abstract Algebra.

REFERENCE BOOKS RECOMMENDED:-

1. Surjit Singh, Modern Algebra.
2. P.B. Bhattacharya, S.K. Jain, and S.R. Nagpal, Basic Abstract Algebra (1997); Ch-14 (Sec.1-5).

SEMESTER VIII
MATHEMATICS

DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS

Time: 3Hrs **L-T-P: 4-0-0**

Marks:100

Instructions for the Paper Setters:

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION-A

Existence and uniqueness theorem for IVP in ODE's, The method of successive approximation, general properties of solution of linear differential equation of order n, adjoint and self-adjoint equations, Total differential equations. Simultaneous differential equations, orthogonal trajectories, Sturm Liouville's boundary value problems. Sturm comparison and Separation theorems, Orthogonality solution.

SECTION-B

Laplace Transform: Definition, existence, and basic properties of the Laplace transform, Inverse Laplace transform, Convolution theorem, Laplace transform solution of linear differential equations and simultaneous linear differential equations with constant coefficients.

SECTION-C

Fourier Transform: Definition, existence, and basic properties, Convolution theorem, Fourier transform of derivatives and Integrals, Inverse Fourier transform, solution of linear ordinary differential equations, Complex Inversion formula.

SECTION-D

Special Functions: Solution, Generating function, recurrence relations and othogonality of Legendre polynomial, Bessel functions, Hermite and Laguerre polynomials.

BOOKS RECOMMENDED:-

1. E.D. Rainvile, Special Functions.
2. H. T. H. Piaggio, Differential equations.
3. S.L. Ross, Differential equations.
4. Allan Pinkus & Samy Zafrany, Fourier series and Integral Transforms, Cambridge University Press, 1997.

SEMESTER -VIII
MATHEMATICS
(MINOR COURSE)

STATISTICS-II

Time: 3 Hours **L-T-P: 4-0-0**

Marks 100

Instructions for the Paper Setters:

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each section. The fifth question may be attempted from any section.

SECTION-A

Point Estimation: Sufficient statistics, Neyman factorization theorem, minimal sufficient statistics, ancillary statistics, complete statistics, Basu's theorem, unbiasedness, Consistent estimator.

SECTION-B

Mean squared error, Minimum variance unbiased estimators, Rao Blackwell Theorem, Lehmann-Scheffe theorem, Cramer-Rao lower bound., efficiency, Methods of estimation: maximum likelihood estimator (restricted and non-restricted), properties of MLE (without proof).

SECTION-C

Concepts of testing of hypotheses, critical region, test function, two types of errors, power function, level of significance, p-value, most powerful test, Neyman-Pearson theory, Uniformly most powerful test.

SECTION-D

Likelihood ratio property, Karlin Rubin theorem and its applications. Likelihood tests (excluding properties of Likelihood Ratio Tests), Confidence intervals, confidence level, construction of confidence intervals using pivots and inverting a test statistic.

BOOKS RECOMMENDED:-

1. R.V.Hogg, J.W. Mckean, and A.T. Craig, Introduction to Mathematical Statistics.
2. V.K. Rohtagi, A.K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics
3. G. Casella and R.L. Berger, Statistical Inference.

SEMESTER VII
MATHEMATICS
(MINOR COURSE FOR MAJORS OTHER THAN MATHEMATICS)

NUMERICAL METHODS

Time: 3Hours **L-T-P: 3-0-0**

Marks: 75

Instructions for the Paper Setters: -

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION–A

Solution of non-linear equations, Bisection method, Iteration method, Newton-Raphson Method, Method of false position, Secant method, Order of convergence of these methods.

SECTION–B

Solution of linear system of equations: Direct method, Gauss elimination method, Jordon's method, Triangular Method, Jacobi's Method, Gauss Seidel Method.

SECTION–C

Finite Differences: Forward difference, Backward difference, Divided difference, Shift operator, Interpolation, Numerical differentiation, Method based on interpolation. Numerical Integration, Trapezoidal rule, Simpson's1/3rd and 3/8th rules, Weddle rule, Error analysis of Trapezoidal and Simpson's 1/3rd rules.

SECTION–D

Gaussian integration method, Gaussian Legendre integration. Double numerical integration. Numerical solution of Initial value problems in ODEs: Taylor's method, Euler's method, Modified Euler's method, Runge-Kutta method.

BOOKS RECOMMENDED:-

1. S. S. Sastry: Introductory Methods of Numerical Analysis, 2003 (3rdEdition), Prentice Hall of India.
2. G. Shanker Rao: Numerical Analysis, 2006 (Revised 3rd Edition).

SEMESTER VII
MATHEMATICS
(MINOR COURSE FOR MAJORS OTHER THAN MATHEMATICS)

NUMERICAL METHODS LABORATORY

Time: 3 Hours **L-T-P: 0-0-1**

Marks 25

List of Practicals (using any package)

1. Solution of algebraic equations in one variable: Bisection method, Regula Falsi method, Newton Raphson method, and Secant method.
2. Solution of system of Linear Equations: Gauss Elimination method, Gauss Seidel iterative method.
3. Interpolation: Newton's forward & backward interpolation, Lagrange's interpolation.
4. Numerical integration: Trapezoidal rule, Simpson's $1/3^{rd}$ and $3/8^{th}$ rules, Weddle rule.
5. Numerical solutions of Initial value problems in ODEs: Euler's method, Modified Euler's method, Runge Kutta method.
6. Error Analysis of the practicals at no. 5.

TEXT BOOK RECOMMENDED:-

1. S. S. Sastry, Introductory Methods of Numerical Analysis, 2003 (3rdEdition), Prentice Hall of India.

REFERENCE BOOK RECOMMENDED:-

1. Ralston, A first course in Numerical Analysis, McGraw Hill, 1985.

SEMESTER VIII
MATHEMATICS
(MINOR COURSE FOR MAJORS OTHER THAN MATHEMATICS (MINOR 2))

FOURIER SERIES AND INTEGRAL TRANSFORMS

Time: 3 Hours **L-T-P: 4-0-0**
Marks: 100

Instructions for the Paper Setters: -
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
Norm, Cauchy-Schwartz inequality, Inner Product Space, orthogonal and orthonormal systems, Pythagorean theorem, Orthogonal Projections, The Gram-Schmidt Process, Infinite orthonormal systems.

SECTION-B
Fourier Series: Periodicity and orthogonality of the Sine and Cosine functions, the Euler-Fourier formulas, the Fourier Convergence Theorems, Evenness and oddness Fourier Sine Series, Fourier Cosine Series.

SECTION-C
Fourier Transform: Definition, existence, and basic properties, Convolution theorem, Fourier transform of derivatives and Integrals, Inverse Fourier transform, solution of linear ordinary differential equations

SECTION-D
Laplace Transform: Definition, existence, and basic properties of the Laplace transform, Inverse Laplace transform, Convolution theorem, Laplace transform solution of linear differential equations and simultaneous linear differential equations with constant coefficients.

TEXT BOOK RECOMMENDED: -

1. A.Pinkus, S.Zafrany, Fourier Series and Integral Transforms, Cambridge University Press (1997)

REFERENCE BOOKS RECOMMENDED:-

1. V. Serov, Fourier Series, Fourier Transform and their applications to Mathematical Physics.
2. A.R. Vasishtha and R.K. Gupta, Integral Transforms,10^{th} edition.