St Aloysius College (Autonomous)

Mangaluru

Re-accredited by NAAC "A" Grade

Course structure and syllabus of

B.Sc.

MATHEMATICS

CHOICE BASED CREDIT SYSTEM

(2021 – 22 ONWARDS)

PROGRAMME OUTCOME (B.Sc.)

On successful completion of Bachelor of Science programme students will be able to

- possess basic subject knowledge that is required for higher studies, professional and applied courses.
- serve in industries or may opt for establishing their own industrial unit.
- be eligible for various government exams conducted by UPSC, SSC etc.
- solve computer oriented numerical problems as it offers computer courses for students.
- be aware of and develop solution oriented approach towards various Social and Environmental issues.
- develop critical thinking, problem solving skills along with the domain knowledge in the subjects of science stream.

PROGRAMME SPECIFIC OUTCOME (Mathematics)

By the end of B.Sc. Mathematics programme, students will be able to

- familiarize the students with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences.
- provide students/learners sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics.
- be well grounded in the basic manipulative skills of algebra and advanced calculus.
- develop a positive attitude towards mathematics as a technical language and valuable subject of study.

BOS MEETING

Dear Sir

The BOS meeting of the Department of UG Mathematics, held on 13th November 2020, has approved the revised and restructured syllabus for the B.Sc. Mathematics Programme to be implemented from the academic year 2021-2022. I request you to place it before the academic council for approval.

Department of UG Mathematics

Board of Studies meeting held on 13th November 2020 chaired by Ms Priya Monteiro, Head of the Department.

Members present:

1. Dr Chandru Hegde, Assistant Professor, Department of Mathematics, Mangalore University.
2. Dr Adelaide Saldanha, HOD, Department of Mathematics, St Agnes College (Autonomous), Mangaluru.
3. Mr Udaya K, HOD of Mathematics, St Philomena College, Puttur.
4. Mr G K Baliga, Industrial Nominee
5. Dr John Edward Dsilva
6. Ms Melvita Leema Baretto
7. Ms Rollin Preetha Vaz
8. Ms Shaila Priya Rodrigues

The important changes approved in the meeting are as follows:

- To expose the students to basic programming skills and to support traditional teaching methods with modern tools, **Scilab/Maxima** of 1 credit for First and Second B.Sc. and of 2 credits for Third B.Sc. has been introduced.
- In order to balance the distribution of credits, the **Numerical Methods** course has been introduced as the main course for the **sixth semester** and the **Vector Space and Linear Transformation** course is made as a special course**.**

  (The Board Members approved the syllabus of 2019-20 for another year in case the pandemic situation continues.)

SCOPE OF THE SYLLABUS

This syllabus is framed in such a way that the students learn Calculus and Differential Equations and their applications, which help them to learn allied subjects like Physics, Computer Science, in a better way. Also, the students learn Number Theory and Algebra which can motivate the students to go for higher studies in Mathematics. A variety of optional papers are given so that the students can learn the subjects of their interest.

Semester	Paper	Paper Code	Title of the Paper
I	Paper1	G 503.1	Calculus and Number Theory
		G 503.1P	Practical
		G 503.1E	Functions and Applications
II	Paper 2	G 503.2	Calculus, Number Theory and Differential Equations
		G 503.2P	Practical
		G 503.2E	Vector Calculus
III	Paper 3	G 503.3	Group Theory, Real Analysis and Calculus
		G 503.3P	Practical
		G 503.3E	Applications of Basic Arithmetic
IV	Paper 4	G 503.4	Group Theory, Complex Analysis, Calculus and Differential Equations
		G 503.4P	Practical
		G 503.4E	Skill Development Techniques in Mathematics using Computer aided Tools
V	Paper5(a)	G 503.5(a)	Algebra, Differential Equations and Laplace Transforms
		G 503.5(a)P	Practical

	Paper5(b) Special Paper	G 503.5(b)i G 503.5(b)ii G 503.5(b)iii G 503.5(b)iv G 503.5(b)v G 503.5(b)vi	5(b)i Discrete Mathematics 5(b)ii Vector Spaces and Linear Transformation 5(b)iii Graph Theory 5(b)iv Linear Programming 5(b)v Mathematical Modeling 5(b)vi Distribution Theory
VI	Paper6(a)	G 503.6(a)	Numerical Methods
		G 503.6(a)P	Practical
	Paper6(b) Special Paper	G 503.6(b)i G 503.6(b)ii G 503.6(b)iii G 503.6(b)iv G 503.6(b)v G 503.6(b)vi	6(b)i Discrete Mathematics 6(b)ii Vector Spaces and Linear Transformation 6(b)iii Graph Theory 6(b)iv Linear Programming 6(b)v Mathematical Modeling 6(b)vi Distribution Theory

A student has to opt a special paper in paper 6(b) which is different from what was opted earlier in paper 5(b).

Course Pattern and Scheme of Examinations

Semester	Paper	Hours per week	Duration of the Exam(hrs.)	End Semester Exams	Internal Assessment*	Total	Credits
I	Paper1 Theory	4	3	80	20	100	2
	Practical	3	3	40	10	50	1
I	Open elective	2	2	40	10	50	1
II	Paper 2 Theory	4	3	80	20	100	2
	Practical	3	3	40	10	50	1
II	Open elective	2	2	40	10	50	1
III	Paper 3 Theory	4	3	80	20	100	2
	Practical	3	3	40	10	50	1
III	Open elective	2	2	40	10	50	1
IV	Paper 4 Theory	4	3	80	20	100	2
	Practical	3	3	40	10	50	1
IV	Open elective	2	2	40	10	50	1
V	Paper5(a) Theory	3	3	80	20	100	2
	Practical	4	3	80	20	100	2

	Paper5(b) Elective* Theory	3	3	80	20	100	2
VI	Paper6(a) Theory Practical	3 4	3 3	80 80	20 20	100 100	2 2
	Paper6(b) Elective* Theory	3	3	80	20	100	2
					Total	1400	

*For each paper Internal Assessment marks shall be awarded based on the marks scored in two tests and projects/assignment/Surprise tests.

*During the V & VI semester, a student can opt for any one of the special papers offered in the syllabus, except that a student studying statistics in B. Sc. cannot opt for the papers ‘distribution theory’ and ‘linear programming’.

Question Paper Pattern for Open Electives A, B, C, D

External Exam 40 marks + Internal Assessment 10 marks = 50 (Total)

Duration: 2hours Max. Marks: 40

PART -A	
I. Answer any 5 questions (5 × 2 = 10)	
Question Number	Unit Number
1 to 4	Unit -1
5 to 8	Unit -2
PART -B	
II. Answer any 3 questions (3 × 5 = 15)	
Question Number	Unit Number
1 to 5	Unit -1
III. Answer any 3 questions (3 × 5 = 15)	
6 to 10	Unit -2

QUESTION PAPER PATTERN FOR B.Sc. MATHEMATICS

(Credit based Semester Scheme for End Semester Examination)

Each Question Paper shall consist of two parts: PART A and PART B.

The number of Questions in each part is tabulated below for different papers.

Papers	Part A Number of Short Answer Questions	Part B Number of Long Answer Questions
Paper 1	14	5
Paper 2	14	5
Paper 3	14	5
Paper 4	14	5
Paper 5	14	6
Paper 6	14	6
Paper 7	14	4/6
Paper 8	14	4/6

Note 1: Fourteen Questions in part A shall equally cover all the units of the syllabus.

Any ten questions shall be answered. Each question carries two marks for paper 1 to paper 8.

Note 2: In part B, all papers shall have four/three units. Each unit shall be answered, choosing 3 (out of 5) or 4(out of 6) or 2 (out of 4).

Each unit in part B carries 15 marks for paper 1 to paper 4 and 20 marks for paper 5 to paper 8.

Mathematics Syllabus for B. Sc. Choice Based Credit System Programme from the academic year 2020-21

I SEMESTER: Calculus and Number Theory

Course outcomes:

On successful completion of the course the student will be able to

- analyze functions using limits, derivatives and integrals.
- recognize the appropriate tools of calculus to solve applied problems.
- solve Linear Diophantine equation in two variables.
- find the greatest common factor using the Euclidean Algorithm.
- investigate the proof of the Fundamental Theorem of Arithmetic.
- apply reduction formulae to evaluate integrals.
- recognize the conic sections from their functions in standard form and from their graphs.
- convert a function of a conic section to standard form to determine whether it yields a circle, a parabola, an ellipse, or a hyperbola.

Unit I (12 Hours)

Increasing & Decreasing Functions, Critical Points, Local Extrema, Rolle's Theorem, The Mean Value Theorem.

Concavity, Points of inflection, Second Derivative Test for Local Extrema, Asymptotes (horizontal, vertical and oblique), Sketching curves $y = f(x)$, Applied Optimization Problems, Cauchy mean value theorem, L'Hospital's rules.

Unit II (12 Hours)

Basic Number Theory: Well Ordering Principle, Archimedean Property, First Principle of Finite Induction, Division Algorithm, The Greatest Common Divisor (g.c.d), Euclidean Algorithm, Diophantine Equations and Fundamental Theorem of Arithmetic.

Unit III (12 Hours)

Integration: Upper and Lower Riemann sums, Limits of Riemann sums, definite integrals, Area under the graph of a non-negative function, Average value of a continuous function, Mean value theorem for definite integrals, Fundamental theorem of calculus (Part 1 and 2).

Hyperbolic functions, Derivation of Reduction Formulae for $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \tan^n x dx$, $\int \log^n x dx$, $\int \sec^n x dx$, $\int \sin^n x \cos^m dx$ etc. Evaluation of Integrals using Reduction Formulae.

Unit IV (12 Hours)

Conic sections and Quadratic equations (Recapitulation: Standard forms of equations of conics), Asymptotes of Hyperbolas and graphing, Shifting conic sections, classifying conic sections by eccentricity, Quadratic equations and rotations - The cross product term, Angle of rotation, Removal of cross product term, Discriminant test.

Textbooks:

1) Maurice D. Weir, George B. Thomas, Jr., Joel Hass, Frank R. Giordano, *Thomas' Calculus*, 11th Ed., Pearson, 2008.

References:

1) Louis Leithold, *Calculus with Analytic Geometry*, 5th Ed., Harper and Row International, 1986.
2) George B. Thomas and Ross L. Finney, *Calculus and Analytic Geometry*, Addison-Wesley, 1992.
3) David M. Burton., *Elementary Number Theory*, 7th Ed., McGraw Hill, 2011.
4) S B Malik, *Basic Number Theory*, Vikas publishing house Pvt Ltd., 1995.
5) Gareth A. Jones and J. Marry Jones, *Elementary Number Theory*, Springer, 1998.

Practicals:

1. Introduction to Maxima and Scilab.
2. Commands for plotting functions in Scilab/Maxima.
3. Plotting of standard Cartesian curves using Scilab/Maxima
4. Continuous and discontinuous functions using Scilab/Maxima.
5. Left hand and right hand limits using Scilab /Maxima.
6. Techniques of Integration in Scilab/Maxima.
7. Maxima commands for reduction formula with or without limits.
8. Solutions of optimization problems.
9. Integration of functions.
10. Conic sections, Rotation of Conics.
11. Euclidean Algorithm.
12. Divisibility tests.
13. Verification of Cauchy's mean value theorem.
14. Evaluation of limits by L'Hospital's rule.

Note: The above list may be changed annually with the approval of the BOS in UG (Mathematics).

II SEMESTER: Calculus, Number Theory and Differential Equations

Course outcomes:

On successful completion of the course the student will be able to

- understand the definitions of congruences.
- determine multiplicative inverses modulo n and use to solve linear congruences.
- determine if a function is multiplicative using the Euler Phi-function.
- evaluate the volumes of the solids using cross sections.
- convert separable and homogenous equations to exact differential equations by integrating factors.
- solve a few real world problems using the concepts of differential equations.
- write a polar double integral to evaluate the area of a given region.
- calculate the length of an arc of a curve whose equations are given in parametric and polar forms.

Unit I (12 Hours)

Number Theory: The Theory of Congruences, Basic Properties of Congruences, Binary and Decimal Representation of Integers, Linear Congruences and The Chinese Remainder Theorem, Fermat's Theorem, Wilson's Theorem.

Euler's Phi-Function, Euler's Theorem, Some Properties of Phi-Function.

Unit II (12 Hours)

Volume of solids by slicing, Disks and Washers, Volume of solids by cylindrical shell method, Length of arc of the graph of a function.

Natural Exponential Function and its Application to Single Electrical Circuit, Radioactive Decay, Bacterial growth in a culture.

Unit III (12 Hours)

Differential Equations: Variable separable and homogeneous equations, Linear equation of order one. Exact equations, Integrating Factors found by Inspection, Determination of Integrating Factors, Bernoulli's Equation, Co-efficients linear in the two variables.

Applications: Velocity of escape from the earth, Newton's law of cooling, simple chemical conversions, orthogonal trajectories - rectangular co-ordinates, orthogonal trajectories - polar co-ordinates.

Unit IV (12 Hours)

Polar coordinates: Relating Cartesian and Polar Equations, Graphing in Polar Coordinates, Symmetry and Test for Symmetry, Slope of Curves.

Areas and Lengths in Polar Coordinates: Area in the Plane, Area between the Curves, Length of a Polar Curve.

Textbooks:

1) David M. Burton., *Elementary Number Theory*, 7th Ed., McGraw Hill, 2011.
2) Maurice D. Weir, George B. Thomas, Jr., Joel Hass, Frank R. Giordano, *Thomas' Calculus*, 11th Ed., Pearson, 2008.
3) Earl D Rainville and Philip E Bedient, *A Short Course in Differential Equations*, Macmillan, Ltd., 4th Ed., 1969.

References:

1) S B Malik, *Basic Number Theory*, Vikas publishing house Pvt Ltd., 1995.
2) Gareth A. Jones and J. Marry Jones, *Elementary Number Theory*, Springer, 1998.
3) Louis Leithold, *Calculus with Analytic Geometry*, 5th Ed., Harper and Row International, 1986.
4) Narayanan and Manicavachagom Pillay, *Differential Equations*, Viswanathan (Printers and Publisher) PVT Ltd., 1991.
5) G.K. Ranganath, C S Sampangiram , *A textbook of B.Sc. Mathematics – Part II*, S Chand & Company Ltd., 1994.

Practicals:

1. Solving system of congruence's.
2. Euler's Phi-function.
3. Solving problems on volume of solids by revolutions.
4. Find the length of an arc of the graph of a function.
5. Analysis of natural exponential function.
6. Solution of Differential equation and plotting the solution - I.
7. Solution of Differential equation and plotting the solution - II.
8. Solution of Differential equation and plotting the solution - III.
9. Determination and Plotting of Orthogonal trajectories.
10. Applications of differential equations.
11. Plotting of standard Polar curves using Scilab/Maxima.
12. Plotting of standard parametric curves using Scilab/Maxima.

Note: The above list may be changed annually with the approval of the BOS in UG (Mathematics).

III SEMESTER: Group Theory, Real Analysis and Calculus

Course outcomes:

On successful completion of the course the student will be able to

- verify group properties in particular examples.
- to identify different types of groups.
- to enhance abstract thinking of students.
- solve the problems of convergence and divergence of sequences and series.
- determine whether or not real series are convergent by comparison with standard series or using the ratio test.
- explain the definition of an infinite series as a limit of a sequence of partial sums.
- use the two path criterion to show that a limit does not exist and apply it to the problems about limits
- evaluate partial derivatives including higher order derivatives and simple cases of chain rule and recognize the various notations used for partial derivatives.

Unit I (12 Hours)

Group Theory: Binary Operations, Associativity, Commutativity, Examples for Binary Operations, Definition of a Group, Examples, Right inverse, Left inverse, Some properties, Abelian and Non-abelian groups, Laws of exponents, Subgroups, Intersection of subgroups, Centralizer of an element, Normalizer of a subgroup, Product of subgroups, Order of products of subgroups, Cyclic groups, Properties, Number of generators.

Unit II (12 Hours)

Sequences: Functions, Sequences, The range, Bounds of a sequence, Convergence of sequences, Some theorems, Limit points of a sequence, Convergent sequences, Non-convergent sequences, Cauchy's general principle of convergence, Algebra of sequences, Some important Theorems, Monotonic sequences, Subsequences.

Unit III (12 Hours)

Infinite Series: A necessary condition for convergence, Cauchy's general principle of convergence for series, Some preliminary theorems, Positive term series, Geometric series, A Comparison Test, Comparison tests for positive term series (first and second type), Cauchy root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Cauchy's integral test,
Alternating series, Absolute Convergence, Conditional Convergence.

Unit IV (12 HOURS)

Functions of several variables: Domain, Range, Interior points, Boundary points, Closed, Open, Bounded and unbounded regions in the plane, Level curves and Level surfaces. Limits and Continuity, Two-Path tests for non-existence of limits, Partial derivatives, Implicit partial differentiation, Partial derivatives and continuity, Higher order partial derivatives, Mixed derivative theorem, Differentiability, Chain rule for differentiation.

Textbooks:

1) N. S Gopalakrishnan, *University Algebra*, 3rd Ed., New Age International Publications, 2015.
2) S.C Mallik, *Principles of Real Analysis*, New Age International Publications, 2008.
3) Maurice D. Weir, George B. Thomas, Jr., Joel Hass, Frank R. Giordano, *Thomas' Calculus*, 11th Ed., Pearson, 2008.

References:

1) Joseph Gallian, *Contemporary Abstract Algebra*, Narosa, 1999.
2) I. N. Herstein, *Topics In Algebra*, 2nd Ed., Wiley Publishers, 1975.
3) Ajith Kumar and S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press, 2014.
4) G.K. Ranganath, C S Sampangiram , *A textbook of B.Sc. Mathematics – Part II*, S Chand & Company Ltd., 1994.
5) Louis Leithold, *Calculus with Analytic Geometry*, 5th Ed., Harper and Row International, 1986.

Practicals:

1. Illustration of convergent, divergent and oscillatory sequences.
2. Illustration of convergent, divergent and oscillatory series.
3. Programs to find the sum of the series.
4. Using Cauchy's criterion to determine convergence of a sequence (simple examples).
5. Using Cauchy's criterion on the sequence of partial sums of the series to determine.
6. Convergence of a series.
7. Testing the convergence of binomial, exponential and logarithmic series and finding the sum.
8. Differentiability using Scilab/ Maxima.
9. Obtaining partial derivative of some standard functions.
10. Verifying whether given operator is binary or not.
11. To find identity element and inverse element of a group.
12. Finding all possible subgroups of a finite group.

Note: The above list may be changed annually with the approval of the BOS in UG (Mathematics).

IV SEMESTER: Group Theory, Complex Analysis, Calculus and Differential Equations

Course outcomes:

On successful completion of the course the student will be able to

- understand and use the terms homomorphism and isomorphism.
- use the definitions and properties of cosets and understand Lagrange's theorem.
- use the Cauchy-Riemann Equations to determine whether/where a function is differentiable and find the derivative of a function.
- perform basic mathematical operations (arithmetic, powers, roots) with complex numbers in Cartesian and polar forms.
- determine continuity/differentiability/analyticity of a function and find the derivative of a function.
- determine the area and volume by applying the techniques of double and triple integrals.
- solve the homogeneous linear differential equations with constant coefficients.
- use the method "variations of parameters" to find to solution of higher-order linear differential equations with variable coefficients.

Unit I (12 Hours)

Group Theory: Permutation groups, Transpositions, Cycles, Cayley's theorem. Cosets, Lagrange's theorem, Index of a subgroup, Homomorphism, Kernel of a homomorphism, Properties of homomorphic images of groups, Isomorphism, Automorphisms, Normal subgroups, Quotient groups, First Isomorphism Theorem.

Unit II (12 Hours)

Complex Analysis: (Recapitulation of algebra of Complex numbers.) Polar and Exponential Forms, Powers and roots, Functions of a Complex variable, Limits, Continuity, Differentiability, Cauchy Riemann Equations, Analytic functions, Entire functions, and Harmonic functions.

Elementary functions: Exponential function, Trigonometric functions, Hyperbolic functions and Logarithmic functions.

Unit III (12 Hours)

Multiple Integrals: Doubles Integrals over Rectangles, Double Integrals as Volume, The Fubini's Theorem (First Form), Double Integrals over Bounded Non-rectangular Regions, Fubini's Theorem (Stronger Form).

Finding Limits of Integration, Properties of Double Integrals. Reversing the Order of Integration.

Unit IV (12 Hours)

Differential Equations: Linear equation with constant coefficients: Definition, operator *D*, Complementary Function of a Linear Equation with Constant Coefficients, Particular integral, General method of Finding Particular Integral, Special methods for finding particular integral when RHS of the non-homogeneous differential equation is of the form: e^{ax}, $\cos ax$, $\sin ax$, x^m. Linear Equations with Variable Coefficients. Special methods to solve any second order equation: (i) Reduction to normal form, (ii) Change of independent variable, (iii) Reduction of order, (iv) Variation of parameters

Textbooks:

1) N. S Gopalakrishnan, *University Algebra*, 3rd Ed., New Age International Publications, 2015.
2) James Ward Brown, Ruel V. Churchil, *Complex Variables and Applications*, 8th Ed., Mc-Graw Hill Publications, 2009.
3) Maurice D. Weir, George B. Thomas, Jr., Joel Hass, Frank R. Giordano, *Thomas' Calculus*, 11th Ed., Pearson, 2008.
4) Earl D Rainville and Philip E Bedient, *A Short Course in Differential Equations*, Macmillan Ltd., 4th Ed., 1969.

References:

1) Joseph Gallian, *Contemporary Abstract Algebra*, Narosa, 1999.
2) I.N. Herstein, *Topics In Algebra*, 2nd Ed., Wiley Publishers, 1975.
3) H.S. Kasana, *Complex variables theory and applications*, 2nd Ed., PHI Learning Pvt Ltd., New Delhi, 2005.
4) *Complex Analysis*, Lars V. Ahlfors,Mc-Graw Hill, Inc. 1979.
5) Louis Leithold, *Calculus with Analytic Geometry*, 5th Ed., Harper and Row International, 1986.
6) Dr. M.D. Raisinghania, *Ordinary and Partial Differential Equations*, S. Chand & Company Pvt. Ltd., 1976.
7) Narayanan and Manicavachagom Pillay, *Differential Equations*, Viswanathan (Printers and Publisher) PVT Ltd., 1991.

Practicals:

1. Finding generators of a cyclic group and computation of quotient group.
2. Determination of center and all possible normal subgroups of groups.
3. Some problems on Cauchy-Riemann equations (Cartesian and polar form).
4. Illustrating orthogonality of the surfaces obtained from the real and imaginary parts of an analytic function.
5. Verifying real and imaginary parts of an analytic function being harmonic (in polar coordinates).
6. Illustrating the angle preserving property of simple entire functions such as z^2; $exp(z)$, etc.,
7. Showing nth roots of unity is a group and plotting them on the unit circle.
8. Branches of the multiple valued functions: $\sqrt{z}$ and log z.
9. Evaluation of the double integral with variable limits.
10. Solution of Differential equation and plotting the solution - IV.
11. Solution of Differential equation and plotting the solution - V.
12. Solution of Differential equation and plotting the solution - VI.

Note: The above list may be changed annually with the approval of the BOS in UG (Mathematics).

V SEMESTER: Algebra, Differential Equations and Laplace Transforms

Course outcomes:

On successful completion of the course the student will be able to

- relate the concepts of groups and rings.
- verify if a given set is a commutative ring or field or integral domain.
- apply different methods to solve the equation of the form $Pdx + Qdy + Rdz = 0$.
- explain basic properties of Laplace transform.
- find Laplace transform of a function using gamma function and step function.
- will be able to use the Laplace transform in finding the solution of linear differential equations.

Unit I (12 Hours)

Rings and Fields: Rings, unit element, commutative ring, Properties. Zero Divisors, Integral domains (Finite and infinite), Fields (finite and infinite).
Ring homomorphism: homomorphism and kernel. Ideals, Prime and Maximal Ideals.

Unit II (12 Hours)

Total Differential equations: Conditions for integrability of P dx + Q dy + R dz = 0, methods of solving P dx + Q dy + R dz=0 by (1) inspection method , (2) One variable regarded as constant, (3) Method of Auxiliary Equations, (4) Homogeneous Equations, Solutions of Simultaneous total Differential equations.

Unit III (12 Hours)

Laplace transforms: Transforms of elementary functions, Transforms of derivatives, Derivatives of the transforms of the gamma function, Periodic functions.
Inverse transforms: A step function, Convolution theorem, Simple initial value problems, Spring problems.

Textbooks:

1) N. S Gopalakrishnan, *University Algebra*, 3rd Ed., New Age International Publications, 2015.
2) Earl D Rainville and Philip E Bedient, *A Short Course in Differential Equations*, Macmillan Ltd., 4th Ed., 1969.

References:

1) Joseph Gallian, *Contemporary Abstract Algebra*, Narosa, 1999.
2) I. N. Herstein, *Topics In Algebra*, 2nd Ed., Wiley Publishers, 1975.
3) Dr. M.D. Raisinghania, *Ordinary and Partial Differential Equations*, S. Chand & Company Pvt. Ltd., 1976.
4) Murray R Spiegel, *Schaum's Outlines: Laplace Transforms*, McGraw-Hill.

Practicals:

1. Examples on different types of rings.
2. Finding zero divisors and units in finite rings.
3. Examples of integral domains and fields, and construction of finite fields.
4. Homomorphism and Kernel of rings- illustrative examples.
5. Solutions to the problems on total differential equations I.
6. Solutions to the problems on total differential equations II.
7. Solutions to the problems on simultaneous total differential equations.
8. Finding the Laplace transforms of some standard functions.
9. Functions of Class-A and properties of gamma function.
10. Finding the inverse Laplace transform of simple functions.
11. Implementing Laplace transform method of solving ordinary linear differential equations of first and second order with constant coefficient.
12. Solving spring problems.

Note: The above list may be changed annually with the approval of the BOS in UG (Mathematics).

VI SEMESTER: Numerical Methods

Course outcomes:

On successful completion of the course the student will be able to

- perform an error analysis for some method.
- approximate a function using an appropriate numerical method.
- solve a linear system of equations using an appropriate numerical method..
- derive appropriate numerical methods to solve interpolation based problems.
- calculate a definite integral using an appropriate numerical method.
- evaluate a derivative at a value using an appropriate numerical method.

Unit I (12 Hours)

Errors in Computation: Accuracy of numbers, Errors, Useful rules for estimating errors, Error propagations, Error in the approximation of a function. Errors in a series approximation.

Solutions of Algebraic and Transcendental Equations: Initial approximation, Bisection method, Regula-falsi method, Iteration method, Newton-Raphson method.

Solution of linear homogeneous equations: Direct Methods - Gauss elimination method, Gauss-Jordan method. Iterative methods of solution - Jacobi's iteration method, Gauss-Seidel iteration method.

Unit II (12 Hours)

Finite differences: Introduction, Finite differences, differences of a polynomial, to find one or more missing terms. Interpolation: Introduction, Newton's forward interpolation formula, Newton's backward interpolation formula, Interpolation with unequal intervals, Lagrange's interpolation formula.

Divided differences: Newton’s divided difference formula, Inverse interpolation. Numerical differentiation - Formulae for derivatives using forward difference and backward difference formulae, Maximum and minimum values of a tabulated function.

Unit III (12 Hours)

Numerical integration: General formula, Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 - rule.

Numerical Solution of Ordinary Differential Equations: Introduction, Solution by Taylor's series method, Picard's method, Euler's method, Modified Euler's method, Runge-Kutta Methods, Predictor-Corrector Methods - Adams Bashforth Method.

Textbooks:

1) S. S. Sastry, *Introductory Methods of Numerical Analysis*, 4th Ed., PHI Learning Pvt Ltd., 2009.

References:

1) M. K. Jain, *Numerical Methods for Scientists and Engineers*, S.B.W Publishers, Delhi, 1971.
2) Dr. B .S. Grewal, *Numerical methods in Engineering and Science with Programs in C, C + +*, 9th Ed., Khanna Publications, New Delhi, 2010.
3) Erwin Kreyszig, *Advanced Engineering Mathematics*, 8th Ed., Wiley Eastern, 2011.

Practicals:

1. Solving algebraic equation (Bisection method and Regula-Falsi).
2. Solving system of equations (Jacobi and Gauss-Seidel methods).
3. Interpolations with equal intervals.
4. Interpolations with unequal intervals.
5. Derivatives using forward difference formulae.
6. Derivatives using backward difference formulae.
7. Integrals using Trapezoidal rule, Simpson's 1/3 rule, and Simpson's 3/8 rule.
8. Solving ordinary differential equations by Picard's method.
9. Solving ordinary differential equations by Taylor's series method.
10. Solving ordinary differential equations by Euler's method and modified Euler's method.
11. Solving ordinary differential equations by Runge-Kutta Method.
12. Solving ordinary differential equations by Adam's Bashforth Method.

Note: The above list may be changed annually with the approval of the BOS in UG (Mathematics).

SPECIAL COURSE: Discrete Mathematics

Course outcomes:

On successful completion of the course the student will be able to

- verify whether an algorithm works well and perform analysis in terms of memory and time.
- formulate and model problems with the concepts and techniques of discrete mathematics.
- apply techniques for constructing mathematical proofs, illustrated by examples in discrete mathematics.
- to develop an understanding of how graph and tree concepts are used to solve problems arising in the computer science.

Unit I (12 Hours)

Graphs and Planar Graphs: Introduction, Basic Terminology, Multigraphs and Weighted graphs, Paths and Circuits, Shortest Paths in Weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, Factors of a graph, Planar graphs.

Unit II (12 Hours)

Trees and Cut-sets: Trees, Rooted trees, Path lengths in rooted trees, Prefix codes, Spanning trees and Cut-sets, Minimum Spanning Trees; Kruskal's Algorithm, Prim's algorithm, Transport Networks.

Unit III (12 Hours)

Computability and Formal Languages: Languages, Phrase Structure Grammars, Types of Grammars and Languages.

Finite state Machines: Introduction, Finite State Machines and Finite State Machines as models of physical systems, Equivalent machines. Finite State Machines as language recognizers. Analysis algorithms; Introduction, time complexity of algorithms a shortest path algorithm, Complexity of problems, Tractable and intractable problems.

Textbooks:

1) LIU (C L), *Elements of Discrete Mathematics (second edition)*, Tata McGraw-Hill Publishing Company Ltd.2006.

References:

1) J.P.Tremblay, R.Manohar, *Discrete Mathematical structures with applications to computer science*,. Tata McGraw-Hill Publishing Company Ltd.2001
2) Besnard Kolman, Robert C. Bushy, Sharan Ross, *Discrete Mathematics structures (third edition).*
3) Rosen H. Kenneth, *Discrete mathematics and its applications: With combinatorics and graph theory Ed 6*, Tata McGraw Hill Education Pvt. Ltd.2009.
4) B A. Davey and H. A. Priestley, *Introduction to Lattices and Order*, Cambridge University Press, Cambridge, 1990.
5) Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory (2nd Edition)*, Pearson Education (Singapore) Pte. Ltd., Indian Reprint 2003.

SPECIAL COURSE: Vector Spaces and Linear Transformation

Course outcomes:

On successful completion of the course the student will be able to

- recognize the concepts of the terms span, linear independence, basis, and dimension, and apply these concepts to various vector spaces and subspaces.
- use matrix algebra and the related matrices to linear transformations.
- To learn Inner Product spaces and Gram-Schmidt process of orthogonalization.
- find Eigen values and Eigen vectors of a matrix which is used in the study of various other concepts.

Unit I (12 Hours)

Vector Spaces, properties, Subspaces intersection of subspaces, L(S)- subspace generated by a subset, nature of elements of L(S) , Sum of subspaces, Direct sum of two subspaces , Characterization of direct sum , direct sum of n subspaces.

Linear Dependence, Independence and Bases**:** basis, generating set, linear independence, minimal generating set, dimension, dimensions of subspaces, dimension of a sum of subspaces.

Inner Product Spaces**:** Inner product, norm, Schwarz inequality, orthogonal vectors, normal vectors, orthonormal basis and set independence of orthonormal sets, existence of orthonormal basis in an inner product space, orthogonal complements.

Unit II (12 Hours)

Linear transformation, kernel, isomorphism, isomorphism of $f^{(n)}$ with any n-dimensional space, quotient space, First Isomorphism Theorem, dimension of a quotient space , nonsingular transformation , dimension of L(V,V')

Matrices: Identity, idempotent, nilpotent, nonsingular, diagonal, triangular and block matrices.

Matrices and Linear transformations: Matrix associated with a linear transformation ,isomorphism of l(V,V') with $M_{mn}(F)$) , matrix of a product of linear transformations , Relation between matrices of a L.T. with respect to different bases , similar matrices .

Rank : Row rank, column rank, rank, rank of a linear transformation , rank of a composition of linear transformations , rank of a product of matrices,.

Unit III (12 Hours)

Elementary Row Operations: Elementary matrices, non-singularity of elementary matrices, inverse of an elementary matrix, inverse of a matrix as a product of elementary matrices, equivalent matrices .

Linear Equations**:** Homogeneous linear Equations, condition for existence of non- trivial solutions, Non-Homogeneous Equations, condition for existence of solutions and the condition for existence of unique solution.

Minimal polynomial: existence, minimal polynomial, Uniqueness, (Min. poly. of non-singular matrices, minimal polynomial of similar matrices, minimal polynomial of a transformation.

Characteristic roots**:** Ch. roots of f(A) for a polynomial f and matrix A , number of distinct Characteristic Roots, Characteristic polynomial of a matrix, Characteristic polynomial of similar matrices, Characteristic polynomial of a linear transformation , Cayley Hamilton theorem, Characteristic polynomial of the transpose.

Textbooks:

1) N. S Gopalakrishnan, *University Algebra, 3rd Ed*., New Age International Publications, 2015

References:

1) Joseph Gallian, *Contemporary Abstract Algebra*, Narosa, 1999.
2) I. N. Herstein, *Topics In Algebra*, 2nd Ed., Wiley Publishers, 1975.

SPECIAL COURSE: Graph Theory

Course outcomes:

On successful completion of the course the student will be able to

- understand the language of graphs and trees.
- understand various types of trees and methods for traversing trees.
- solve problems using basic graph theory.
- solve problems involving vertex and edge connectivity, planarity and crossing numbers.
- model real world problems using graph theory.

Unit I (12 Hours)

Definition of a graph, Konigsberg bridge problem, Finite and infinite graphs, incidence and degree, isolated vertex, pendent vertex and null graph, isomorphism, sub graphs, walks, paths, circuits, connected graphs, disconnected graphs and components. Euler graphs, operation on graphs, Hamiltonian paths and circuits. Trees: properties, pendent vertices, Distance and center, rooted and binary tree, Spanning trees, Fundamental circuits.

Unit II (12 Hours)

Cut sets, properties, cut sets in a graph. Fundamental cut sets and circuits. Connectivity and Seperability, Kuratowski's two graphs, different representation of planar graphs, Geometrical dual.

Incidence matrix, sub matrices of $A(G)$, Circuit matrix, Fundamental circuit matrix and rank. Cut set matrix, Path matrix and Adjacency matrix.

Unit III (12 Hours)

Chromatic number, Chromatic partitioning, Chromatic polynomial coverings.

Directed graphs, Definition, types of digraph, Directed paths, connectedness and Euler digraphs, trees and directed edges. Fundamental circuits in digraphs, matrices A, B, C of digraphs, adjacency matrix of a graph

Textbooks:

1) Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*, PHI Learning Private Limited, 2004.

References:

1) S. Arumugam and S. Ramachandran, *Invitation to Graph Theory*, Scitech Publications (India) Pvt. Ltd., 2013.
2) Douglas B. West, *Introduction to Graph Theory*, Pearson, 2017.

SPECIAL COURSE: Linear Programming

Course outcomes:

On successful completion of the course the student will be able to

- explain basic concepts of optimization, modeling and linear modeling.
- distinguish the feasible solution, optimal solution and basic feasible solution.
- solve two variable linear programming problems with graphical method.
- explain the theory of simplex algorithm and approach.
- apply linear programming concepts to solve problems like transportation problems and assignment problem.

Unit I (12 Hours)

Mathematical formulation of the problem, Graphical method of solving LPP, Simplex algorithm, Non canonical LPP.

Unit II (12 Hours)

Duality equation, Duality theorem, Dual non-canonical LPP, Matrix games, Two Persons Zero sum Matrix game, The Von Neumann Minimax theorem.

Unit III (12 Hours)

Transportation problems: The balanced Transportation Problem, Vogel Advance start Method, Transportation algorithm, Unbalanced Transportation problem.

Assignment problem: The Hungarian Algorithm.

Textbooks:

1) James K. Strayer, *Linear Programming and its Applications*, Springer-Verlag, 1989.

References:

1) P. M. Karak, *Linear Programming and Theory of games*, New central book agency (P) ltd., 2012.
2) Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 2nd Ed., John Wiley and Sons, India, 2004.

SPECIAL COURSE: Mathematical Modeling

Course outcomes:

On successful completion of the course the student will be able to

- recognize the connections between Mathematics and other disciplines, how mathematical ideas are used in it.
- master principles and formulation ,analysis of mathematical model system.
- model real world problems mathematically and analyze those models.
- able to identify linear programming assumptions and constraints.

Unit I (12 Hours)

Scope of Mathematical Modeling, steps in building a mathematical model, Approximate and limited models – Gravity, Rockets and raindrops, Macro and Micro population models– exponential growth.

Unit II (12 Hours)

Macro and Micro population models I - The Leslie Matrix;

Macro and Micro population models II - Family planning models;

Descriptive and prescriptive models - Inventory policy;

The relation of models to data: Sources of error – Underground exploration of the Earth;

Adjusting data I (the easy way) – The mean and the maximum likelihood.

Unit III (12 Hours)

Robustness – The ups and downs of ancient astronomy.

Optimization – Classical optimization; Linear programming. Formulation and graphical solution; An outline of the simplex method.

Inter Programming – The Knapsack and Traveling salesman problem;

The Transportation problem;

Introduction to difference equations, Exponential population growth difference.

Textbooks:

1) Walter J. Mayer, *Concepts of Mathematical Modeling*, Dover Publications, Mineola, New York, 1984.

References:

1) J N Kapur, *Mathematical Modelling,* New Age International Publishers, 1998.

SPECIAL COURSE: Distribution Theory

Course outcomes:

On successful completion of the course the student will be able to

- define expectation, and be introduced to its important linearity property.
- understand the properties of probability density functions and cumulative distribution functions.
- apply selected probability distributions to solve problems.
- develop problem-solving techniques needed to accurately calculate probabilities.
- acquire knowledge about some probability inequalities, law of large numbers, Central Limit Theorem etc.

Unit I (12 Hours)

Definition of Random Variable, Discrete and Continuous Random Variables, Cumulative Distribution Function (c.d.f.) and its Properties (with proof), Probability Mass Function (p.m.f) and Probability Density Function (p.d.f.), Bivariate Probability Distribution, Marginal and Conditional Distributions, Mathematical Expectation, Properties of Expectation, Theorems on Sum and Product of Expectations of Random Variables and Applications.

Chebychev's inequality, Sequence of Random Variables, Convergence in Probability, Convergence in Distribution, Basic results (without proof), WLLN for i.i.d. Random Variables (statement only), Markov's inequality (statement only), and applications of all these concepts.

Unit II (12 Hours)

Discrete distributions: Uniform, Bernoulli, Binomial, Poisson, Geometric Distributions, Properties, Mean, Variance, MGF and Mode of Binomial and Poisson distribution (with proof), Genesis and Applications.

Unit III (12 Hours)

Continuous Distributions: Rectangular distribution, Normal distribution, Exponential - Single and Double Parameters, Gamma - Single and Double Parameters, Beta distribution of First and Second kind, Cauchy Distribution. Distribution function, Mean, variance, Median, Median, Mode and Moment Generating Function (wherever exists) and Additive Property, Genesis and Applications. Central Limit Theorem (statement only) and its applications.

Textbooks:

1) Gupta S. C. and Kapoor V. K., *Fundamentals of Mathematical Statistics,* Sultan Chand and sons (2013).

References:

1) Goon A.M. Gupta and Das Gupta *Fundamentals of Statistics,* vol. II World Press, Kolkata (2008).
2) Parimal Mukhopadhyay, *Mathematical Statistics,* Books and Allied (p) Ltd. Kolkata.(2011).
3) R.V. Hogy and E.A. Tansis, *Probability and Statistics,* Pearson Education Asia.(2001).

CBCS OPEN ELECTIVES

I **SEMESTER: Functions and Applications**

Unit I (15 Hours)

Straight line in economics, Parabola in Business Management, Inequalities and Absolute Value Functions.

Unit II (15 Hours)

Derivatives in Economics and Business, Maxima and Minima in Economics and Business.

Textbooks:

1)Bharadwaj (R S), *Mathematics for Economics and Business*, 2nd Ed,2013,Excel Books.

References :

1) M Ragahvacahri, *Mathematics for Management*, TMH publications.
2) Teresa Bradley, *Essential Methematics for Economics and Business*, 2nd Ed., Wiley India Publishers.
3) Frank Werner and Yuri N. Sotskov, *Mathematics of Economics and Business*, Taylor &Francis.

II SEMESTER: Vector Calculus

Unit I (15 Hours)

Path, curve, components functions, parameterization, position vector, Vector functions, Limits, Continuity, Derivatives and Motion- Definition of derivatives, Differentiable Vector function, smooth curve, tangent line, piecewise smooth curve, Derivative, Differentiation Rules.

Unit II (15 Hours)

Integration of Vector functions: Line Integrals, Vector fields, Gradient fields, Work, Circulation, Flux, Path independence, Potential Functions, Conservative fields, Exact Differential Forms, Green's Theorem, Surface Area, Surface Integrals, Parameterized surfaces, Stokes' Theorem, The Divergence Theorem.

Textbooks:

1) Maurice D. Weir, George B. Thomas, Jr., Joel Hass, Frank R. Giordano, *Thomas' Calculus*, 11th Ed., Pearson, 2008.

References:

1) Shanthi Narayan and Kapur, *A Text book of Vector Calculus*, 1969,S Chand & Company PVT.Ltd.
2) Paul C. Matthews, *Vector Calculus*, 1st ed., Springer-Verlag Publishers.
3) Murray R Spigel and Seymour Lipschutz, Vector Analysis, 2nd Ed., Schaum's Outline, McGrew Hill Publishers.

III SEMESTER: Applications of Basic Arithmetic (For other Streams)

Unit I (15 Hours)

Number System, Decimal Fractions, Simplifications, Average, Problems on numbers.

Unit II (15 Hours)

Time and distance, Time and Work, Boats and Streams, Problems on trains, Calendar, Clocks.

Textbooks:

1) Aggarwal (R. S); *Quantitative Aptitude*, 2008; S.Chand & Co.Ltd.

References :

1) H. S. Hall and F. H. Stevens, *An Elementary Course of Mathematics*, Macmillan and Co, Ltd.
2) A.Balaraju, *Mentalability*,SMVPublishers,Kolar
3) Sijwali (B. S); and Sijwali (Indu);*Verbal and Analytical Reasoning*, Arihant Publishers

IV SEMESTER: Skill Development Techniques In Mathematics using Computer aided Tools

Unit I (15 Hours)

Use of Mathematica, in computing functions, plotting graphs, finding eigen values, eigen vectors.

Unit II (15 Hours)

Elements of LaTeX; Hands-on-training of LaTex ; graphics in LaTeX; Beamer presentation.

Textbooks:

1) Michael Trott, *A Mathematica Guidebook for Programming*, Springer; 2004 edition.
2) Stefan Kottwitz, *Latex Beginners Guide*, Packt Publishing, 2011.

References :

1) Stephen Wolfram,*TheMathematica Book* ,5th Edition , Wolfram Media Inc, 2003.
2) George Gratzer, *Practical Latex*, Springer, 2014 edition.