माँ शाकुम्भरी विश्वविद्यालय, सहारनपुर
Maa Shakumbhari University, Saharanpur

B.Sc. Honours in Mathematics

Under FYUP-NEP2020 PROGRAMME

CURRICULUM & SYLLABUS

For

Department of Mathematics

Affiliated Colleges

Maa Shakumbhari University, Saharanpur

(Effective from Session 2025-26)

Members, Board of Studies (Mathematics)

Maa Shakumbhari University, Saharanpur

S.No.	Name	Designation	College/Universit	Signature
1.	Prof. Sanjay Kumar	Convener	M.S. College, Saharanpur	
2.	Prof. Praveen Kumar	Member	J. V. Jain College, Saharanpur	27/2/25
3.	Prof. Naveen Sharma	Member	D.A.V. College Muzaffarnagar	27/02/25
4.	Prof. Mridul Gupta	Member(External)	C.C.S. University, Meerut	
5.	Prof. Shivraj Singh	Member(External)	C.C.S. University, Meerut	27/2/25

Four Year Program under FYUP-NEP2020

Syllabus Four Year B.Sc. Honours (Mathematics) as per NEP2020

SEMESTER	PAPER CODE	PAPER TYPE	COURSE NAME	TH/ PRC/ PR	CR	IE	EE (MinMarks)	Total	Min Marks	Lecture Hours
			CERTIFICATE IN MATHEMATICS							
Sem-I	0120301	CC	Differential Calculus & Integral Calculus	TH	4	25	75(25)	100	33	4x15=60
	0120380	CC	Practical	PRC	2		100	100	33	4x15=60
Sem-II	0220301	CC	Matrices and Differential Equations & Geometry	TH	6	25	75(25)	100	33	4x15=60
			DIPLOMA IN MATHEMATICS							
Sem-III	0320301	CC	Algebra & Mathematical Methods	TH	6	25	75(25)	100	33	4x15=60
Sem-IV	0420301	CC	Differential Equation & Mechanic	TH	6	25	75(25)	100	33	4x15=60
			DEGREE IN MATHEMATICS							
Sem-V	0520301	CC	Group and Ring Theory & Linear Algebra	TH	5	25	75(25)	100	33	4x15=60
			Any one of the Following							
	0520302	EL	Number Theory & Game Theory	TH	5	25	40	100	33	4x15=60
	0520303	EL	Graph Theory & Discrete Mathematics	TH	5	25	75(25)	100	33	4x15=60
	0520304	EL	Differential Geometry & Tensor Analysis	TH	5	25	75(25)	100	33	4x15=60
Sem-VI	0620301	CC	Metric Space & Complex Analysis	TH	4	25	75(25)	100	33	4x15=60
	0620302	CC	Numerical Analysis & Operations Research	TH	4	25	75(25)	100	33	4x15=60
	0620380	CC	Practical	PRC	2		100	100	40	4x15=60
			B.Sc. Honours in Mathematics							
Sem-VII	0720321	CC	Abstract Algebra	TH	4	25	75(25)	100	40	4x15=60

	0720322	CC	Real Analysis	TH	4	25	75(25)	100	40	4x15=60
	0720323	CC	Advance Differential Equation	TH	4	25	75(25)	100	40	4x15=60
	0720324	CC	Metric Space	TH	4	25	75(25)	100	40	4x15=60
	Choose Any One									
	0720325	EL	Mathematical Statistics	TH	4	25	75(25)	100	40	4x15=60
	0720326	EL	Advance Numerical Analysis	TH	4	25	75(25)	100	40	4x15=60
Sem-VIII	0820321	CC	Topology	TH	4	25	75(25)	100	40	4x15=60
	0820322	CC	Advance Complex Analysis	TH	4	25	75(25)	100	40	4x15=60
	0820323	CC	Number Theory	TH	4	25	75(25)	100	40	4x15=60
	Core Elective G-1 Any One of the following									
	0820324	EL	1. Mechanics	TH	4	25	75(25)	100	40	4x15=60
	0820325	EL	2. Financial Mathematics	TH	4	25	75(25)	100	40	4x15=60
	0820326	EL	3. Fluid Dynamics	TH	4	25	75(25)	100	40	4x15=60
	Core Elective G-2 Any One of the following									
	0820327	EL	1. Linear Algebra	TH	4	25	75(25)	100	40	4x15=60
	0820328	EL	2. Data Structure with C	TH	4	25	75(25)	100	40	4x15=60
	0820329	EL	3. Dynamical systems	TH	4	25	75(25)	100	40	4x15=60

Minor Elective Paper for Other Faculty Students

SEMESTER	PAPER CODE	PAPER TYPE	COURSE NAME	TH	CR	IE	EE (MinMarks)	Total	Min Marks	Lecture Hours
		EL	Fundamental of Computers	TH	6	25	75(25)	100	33	90
		EL	Vedic Mathematics	TH	6	25	75(25)	100	33	90
		EL	Elementary Mathematics	TH	6	25	75(25)	100	33	90

CC-Core Compulsory, EL-Elective, CR-Credits, IE-Internal Evaluation, EE-External Evaluation, TH-Theory, PRC-Practical, PR-Project

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Maa Shakumbhari University, Saharanpur

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3.	Prof. Naveen Sharma	Member	D.A.V. College Muzaffarnagar	
4.	Prof. Mridul Gupta	Member(External)	C.C.S. University, Meerut	On Line
5.	Prof. Shivraj Singh	Member(External)	C.C.S. University, Meerut	

Four Year Program under FYUP-NEP2020

Syllabus Four Year B.Sc. Honours with Research (Mathematics) as per NEP2020

SEMESTER	PAPER CODE	PAPER TYPE	COURSE NAME	TH/ PRC/ PR	CR	IE	EE (MinMarks)	Total	Min Marks	Lecture Hours
			CERTIFICATE IN MATHEMATICS							
Sem-I	0120301	CC	Differential Calculus & Integral Calculus	TH	4	25	75(25)	100	40	4x15=60
	0120380	CC	Practical	PRC	2			100	40	4x15=60
Sem-II	0220301	CC	Matrices and Differential Equations & Geometry	TH	6	25	75(25)	100	40	4x15=60
			DIPLOMA IN MATHEMATICS							
Sem-III	0320301	CC	Algebra & Mathematical Methods	TH	6	25	75(25)	100	40	4x15=60
Sem-IV	0420301	CC	Differential Equation & Mechanic	TH	6	25	75(25)	100	40	4x15=60
			DEGREE IN MATHEMATICS							
Sem-V	0520301	CC	Group and Ring Theory & Linear Algebra	TH	5	25	75(25)	100	40	4x15=60
			Any one of the Following							
	0520302	EL	Number Theory & Game Theory	TH	5	25	40	100	40	4x15=60
	0520303	EL	Graph Theory & Discrete Mathematics	TH	5	25	75(25)	100	40	4x15=60
	0520304	EL	Differential Geometry & Tensor Analysis	TH	5	25	75(25)	100	40	4x15=60
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	0620302	CC	Numerical Analysis & Operations Research	TH	4	25	75(25)	100	40	4x15=60
	0620380	CC	Practical	PRC	2			100	40	4x15=60

27/2/25

	B.Sc. Honours with Research in Mathematics									
Sem-VII	0720321	CC	Abstract Algebra	TH	4	25	75(25)	100	40	4x15=60
	0720322	CC	Real Analysis	TH	4	25	75(25)	100	40	4x15=60
	0720323	CC	Advance Differential Equation	TH	4	25	75(25)	100	40	4x15=60
	0720324	CC	Metric Space	TH	4	25	75(25)	100	40	4x15=60
	0720365	CC	Project-I	PR	4			100	40	
Sem-VIII	0820321	CC	Topology	TH	4	25	75(25)	100	40	4x15=60
	0820322	CC	Advance Complex Analysis	TH	4	25	75(25)	100	40	4x15=60
	0820323	CC	Number Theory	TH	4	25	75(25)	100	40	4x15=60
	Core Elective -Any One of the following									
	0820324	EL	1. Mechanics	TH	4	25	75(25)	100	40	4x15=60
	0820325	EL	2. Financial Mathematics	TH	4	25	75(25)	100	40	4x15=60
	0820326	EL	3. Fluid Dynamics	TH	4	25	75(25)	100	40	4x15=60
	0820327	EL	4. Linear Algebra	TH	4	25	75(25)	100	40	4x15=60
	0820328	EL	5. Data Structure with C	TH	4	25	75(25)	100	40	4x15=60
	0820329	EL	6. Dynamical systems	TH	4	25	75(25)	100	40	4x15=60
	0820365	CC	Project-II	PR	4			100	40	
	Minor Elective Papers for other Faculty Students									
SEMESTER	**PAPER CODE**	**PAPER TYPE**	**COURSE NAME**	**TH**	**CR**	**IE**	**EE (MinMarks)**	**Total**	**Min Marks**	**Lecture Hours**
		EL	Fundamental of Computers	TH	6	25	75(25)	100	33	90
		EL	Vedic Mathematics	TH	6	25	75(25)	100	33	90
		EL	Elementary Mathematics	TH	6	25	75(25)	100	33	90

CC-Core Compulsory, EL-Elective, CR-Credits, IE-Internal Evaluation, EE-External Evaluation, TH-Theory, PRC-Practical, PR-Project

27/2/25

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Proceeding Board of Studies(Mathematics)

Today on date 27/02/2025 Board of Studies meeting has been conducted in hybrid mode in the Academic Block Maa Shakumbhari University, Punwarka Saharanpur. Following members have attended the meeting.

1. Prof. Sanjay Kumar
2. Prof. Praveen Kumar
3. Prof. Naveen Sharma
4. Prof. M K Gupta
5. Prof. Shivraj Singh

All the members have discussed in detail to form the following syllabus as per FYUP-NEP2020 guidelines.

1. Design four year B.Sc. Honours in Mathematics program.
2. Design four year B.Sc. Honours with research in Mathematics program.
3. Design three minor elective papers for other faculty students.

(Prof. Sanjay Kumar)
Convener

(Prof. Praveen Kumar)
Member

(Prof. Naveen Sharma)
Member

Prof. M K Gupta
External Expert

Prof. Shivraj Singh
External Expert

Maa Shakumbhari University, Saharanpur

Syllabus- B.Sc.(Mathematics) Honours

Programme Outcome/ Programme Specific Outcome
Programme Outcome: **PO1:** It is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for the same. **PO2:** It is to develope enhanced quantitative skills and pursuing higher mathematics and research as well. **PO3:** Students will be able to develop solution oriented approach towards various issues related to their environment. **PO4:** Students will become employable in various govt. and private sectors **PO5:** Scientific temper in general and mathematical temper in particular will be developed in students. **Programme Specific Outcome:** **PSO1:** Student should be able to possess recall basic idea about mathematics which can be displayed by them. **PSO2:** Student should have adequate exposure to many aspects of mathematical sciences. **PSO3:** Student is equipped with mathematical modeling ability, critical mathematical thinking, and problem solving skills etc. **PSO4:** Student should be able to apply their skills and knowledge in various fields of studies including, science, engineering, commerce and management etc.

B.Sc.(Mathematics)-I Year
Certificate in Mathematics

B.Sc. I (SEMESTER-I) PAPER-I Differential Calculus & Integral Calculus

Programme: Certificate Class: B.Sc.	Year: First	Semester: First
Subject: Mathematics		
NEP Code: B030101T Course Code: 0120301	Course Title: Differential Calculus & Integral Calculus	

Course outcomes:

CO1: The programme outcome is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for developing enhanced quantitative skills and pursuing higher mathematics and research as well.

CO2: By the time students complete the course they will have wide ranging application of the subject and have the knowledge of real valued functions such assequence and series. They will also be able to know about convergence of sequence and series. Also, they have knowledge about curvature, envelope and evolutes and trace curve in polar, Cartesian as well as parametric curves.

CO3: The main objective of the course is to equip the student with necessary analytic and technical skills. By applying the principles of integral he learns to solve a variety of practical problems in science and engineering.

CO4: The student is equipped with standard concepts and tools at an intermediate to advance level that will serve him well towards taking more advance level course in mathematics.

Credits: 4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Part- A Differential Calculus

Unit	Topics	No. of Lectures
I	**Introduction to Indian Ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE).** Definition of a sequence, theorems on limits of sequences, bounded and monotonic sequences, Cauchy's convergence criterion, Cauchysequence, limit superior and limit inferior of a sequence, subsequence, Series of non-negative terms, convergence and divergence, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic test, de Morgan and Bertrand's tests, alternating series, Leibnitz's theorem, absolute and conditional convergence.	9
II	Limit, continuity and differentiability of function of single variable, Cauchy's definition, Heine's definition, equivalence of definition of Cauchy and Heine, Uniform continuity, Borel's theorem, boundedness theorem, Bolzano's theorem, Intermediate value theorem, extreme value theorem, Darboux's intermediate value theorem for derivatives, Chain rule, indeterminate forms.	7
III	Rolle's theorem, Lagrange and Cauchy Mean value theorems, mean value theorems of higher order, Taylor's theorem with various forms of remainders, Successive differentiation, Leibnitz theorem, Maclaurin's and Taylor's series, Partial differentiation, Euler's theorem on homogeneous function.	7
IV	Tangent and normals, Asymptotes, Curvature, Envelops and evolutes, Tests for concavity and convexity, Points of inflexion, Multiple points, Parametric representation of curves and tracing of parametric curves, Tracing of curves in Cartesian and Polar forms.	7

Part-B. Integral Calculus

Unit	Topics	No. of Lectures
V	Definite integrals as limit of the sum, Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Differentiation under the sign of Integration.	9
VI	Improper integrals, their classification and convergence, Comparison test, μ-test, Abel's test, Dirichlet's test, quotient test, Beta and Gamma functions.	7
VII	Rectification, Volumes and Surfaces of Solid of revolution, Pappus theorem, Multiple integrals, change of order of double integration, Dirichlet's theorem, Liouville's theorem for multiple integrals.	7
VIII	Vector Differentiation, Gradient, Divergence and Curl, Normal on a surface, Directional Derivative, Vector Integration, Theorems of Gauss, Green, Stokes (without proof) and related problems.	7

Suggested Readings (Part- A Differential Calculus):

1. R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons
2. T.M. Apostal, Calculus Vol. I, John Wiley & Sons Inc.
3. S. Balachandra Rao & C. K. Shantha, Differential Calculus, New Age Publication.
4. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc., 2002.
5. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2007.
6. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS
7. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Integral Calculus):

1. T.M. Apostal, Calculus Vol. II, John Wiley Publication
2. Shanti Narayan & Dr. P.K. Mittal, Integral Calculus, S.Chand
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Chemistry/Biochemistry/Life Sciences(UG),

Economics(UG/PG), Commerce(UG), BBA/BCA, B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/ Objective Tests**	5
3	**Presentation**	5
4	**Assignment (Introduction to Indian ancient Mathematics and Mathematicians).**	5

Course prerequisites: To study this course, a student must have subject Mathematics in class 12th

Suggested equivalent online courses:

B.Sc. I (SEMESTER-I) Paper-II Practical

Programme: Certificate Class: B.Sc.	Year: First	Semester: First
Subject: Mathematics		
Course Code: 0120380 NEP Code: B030102P	Course Title: Practical	

Course outcomes:

CO1: The main objective of the course is to equip the student to plot the different graph and solve the different types of equations by plotting the graph using different computer software such as Mathematica /MATLAB /Maple /Scilab/Maxima etc.

CO2. After completion of this course student would be able to know the convergence of sequences through plotting, verify Bolzano-Weierstrass theorem through plotting the sequence, Cauchy's root test by plotting n^{th} roots and Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

CO3. Student would be able to plot Complex numbers and their representations, Operations like addition, substraction, Multiplication, Division, Modulus and Graphical representation of polar form.

CO4: Student would be able to perform following task of matrix as Addition, Multiplication, Inverse, Transpose, Determinant, Rank, Eigenvectors, Eigenvalues, Characteristic equation and verification of the Cayley-Hamilton theorem, Solving the systems of linear equations.

Credits: 2	Core Compulsory / Elective
Max. Marks: 100	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4

Unit	Topics	No. of Lectures
	Practical / Lab work to be performed in Computer Lab. List of the practicals to be done using Mathematica /MATLAB /Maple /Scilab/Maxima etc. 1. Plotting the graphs of the following functions: (i) ax (ii) [x] (greatest integer function) (iii) x^{2n}; $n \in N$ (iv) x^{2n-1} ; $n \in N$ (v) $\frac{1}{x^{2n-1}}$; $n \in N$ (vi) $\frac{1}{x^{2n}}$; $n \in N$ (vii) $\sqrt{ax+b}$, $|ax+b|$, $c \pm |ax+b|$ (ix) $\frac{1}{x}$, $\sin\left(\frac{1}{x}\right)$, $x \sin\left(\frac{1}{x}\right)$, e^x, e^{-x} for $x \neq 0$. (x) e^{ax+b}, $\log(ax+b)$, $\frac{1}{ax+b}$, $\sin(ax+b), \cos(ax+b), |\sin(ax+b)|, |\cos(ax+b)|$.	

	Observe and discuss the effect of changes in the real constants a and b on the graphs. (2) By plotting the graph find the solution of the equation $x = e^x$, $x^2 + 1 = e^x$, $1 - x^2 = e^x$, $x = \log_{10}(x)$, $\cos(x) = x$, $\sin(x) = x$, $\cos(y) = \cos(x)$, $\sin(y) = \sin(x)$ etc (3) Plotting the graphs of polynomial of degree 2,3, 4 and 5, and their first and second derivatives. (4) Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid and Hypocycloid etc. (5) Tracing of conic in Cartesian coordinates. (6) Graph of circular and hyperbolic functions. (7) Obtaining surface of revolution of curves. (8) Complex numbers and their representations, Operations like addition, Multiplication, Division, Modulus. Graphical representationof polar form. (9) Matrix Operations: Addition, Multiplication, Inverse, Transpose, Determinant, Rank.	
Suggested Readings		

B.Sc. I (SEMESTER-II) PAPER-I Matrices and Differential Equations & Geometry

Programme: Certificate Class: B.Sc.	Year: First	Semester: Second
Subject: Mathematics		
Course Code: 0220301 NEP Code: B030201T	Course Title: Matrices and Differential Equations & Geometry	

Course outcomes:

CO1: The subjects of the course are designed in such a way that they focus on developing mathematical skills in algebra, calculus and analysis and give in depth knowledge of geometry, calculus, algebra and other theories.

CO2: The student will be able to find the rank, eigen values of matrices and study the linear homogeneous and non-homogeneous equations. The course in differential equation intends to develop problem solving skills for solving various types of differential equation and geometrical meaning of differential equation.

CO3: The subjects learn and visualize the fundamental ideas about coordinate geometry and learn to describe some of the surface by using analytical geometry.

CO4: On successful completion of the course students have gained knowledge about regular geometrical figures and their properties. They have the foundation for higher course in Geometry.

Credits: 6	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0

PART-A. Matrices and Differential Equations

Unit	Topics	No. of Lectures
I	Types of Matrices, Elementary operations on Matrices, Rank of a Matrix, Echelon form of a Matrix, Normal form of a Matrix, Inverseof a Matrix by elementary operations, System of linear homogeneous and non-homogeneous equations, Theorems on consistency of a system of linear equations.	12
II	Eigen values, Eigen vectors and characteristic equation of a matrix, Caley-Hamilton theorem and its use in finding inverse of a matrix,Complex functions and separation into real and imaginary parts, Exponential and Logarithmic functions Inverse trigonometric and hyperbolic functions.	11
III	Formation of differential equations, Geometrical meaning of a differential equation, Equation of first order and first degree, Equationin which the variables are separable, Homogeneous equations, Exact differential equations and equations reducible to the exact form, Linear equations.	11
IV	First order higher degree equations solvable for x, y, p, Clairaut's equation and singular solutions, orthogonal trajectories, Linear differential equation of order greater than one with constant coefficients, Cauchy- Euler form.	11

PART-B. Geometry

Unit	Topics	No. of Lectures
V	General equation of second degree, System of conics, Tracing of conics, Confocal conics in two dimentional geometry.	12
VI	Three-Dimensional Coordinates, Projection and Direction Cosine, Plane (Cartesian and vector form), Straight line in three dimension.	11
VII	Sphere and Cone with related problems	11
VIII	Cylinder, Definition only: Central conicoids, Paraboloids, Plane section of conicoids, Generating lines, Confocal conicoids.	11

Suggested Readings (PART-A Matrices and Differential Equations):

1. Stephen H. Friedberg, A.J Insel & L.E. Spence, Linear Algebra, Person
2. B. Rai, D.P. Choudhary & H. J. Freedman, A Course in Differential Equations, Narosa
3. D.A. Murray, Introductory Course in Differential Equations, Orient Longman
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
5. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Geometry):

1. Robert J.T Bell, Elementary Treatise on Coordinate Geometry of three dimensions, Macmillan India Ltd.
2. P.R. Vittal, Analytical Geometry 2d & 3D, Pearson.
3. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London.
4. R.J.T. Bill, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan India Ltd., 1994.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Economics(UG/PG), Commerce(UG), BBA/ BCA,

B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	**Class Tests**	**10**
2	**Online Quizzes/ Objective Tests**	**5**
3	**Presentation**	**5**
4	**Assignment**	**5**

Course prerequisites: To study this course, a student must have subject Mathematics in class 12th

Suggested equivalent online courses:

Further Suggestions:

B.Sc.(Mathematics)-II Year
Diploma in Mathematics

B.Sc.II (SEMESTER-III) PAPER-I Algebra & Mathematical Methods

Programme: Diploma Class: B.Sc.	Year: Second	Semester: Third
Subject: Mathematics		
Course Code: 0320301 NEP Code: B030301T	Course Title: Algebra & Mathematical Methods	

Course outcomes:

CO1: Group theory is one of the building blocks of modern algebra. Objective of this course is to introduce students to basic concepts of Group, Ring theory and their properties.

CO2: A student learning this course gets a concept of Group, Ring, Integral Domain and their properties. This course will lead the student to basic course in advanced mathematics and Algebra.

CO3: The course gives emphasis to enhance students' knowledge of functions of two variables, Laplace Transforms, Fourier Series.

CO4: On successful completion of the course students should have knowledge about higher different mathematical methods and will help him in going for higher studies and research.

Credits: 6	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0	

Part- A. Algebra

Unit	Topics	No. of Lectures
I	**Introduction to Indian ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE).** Equivalence relations and partitions, Congruence modulo n, Definition of a group with examples and simple properties, Subgroups, Generators of a group, Cyclic groups.	12
II	Permutation groups, Even and odd permutations, The alternating group, Cayley's theorem, Direct products, Coset decomposition, Lagrange's theorem and its consequences, Fermat and Euler theorems	11
III	Normal subgroups, Quotient groups, Homomorphism and isomorphism, Fundamental theorem of homomorphism, Theorems on isomorphism.	11
IV	Rings, Subrings, Integral domains and fields, Characteristic of a ring, Ideal and quotient rings, Ring homomorphism, Field of quotient of an integral domain.	11

Part- B
Mathematical Methods

Unit	Topics	No. of Lectures
V	Limit and Continuity of functions of two variables, Differentiation of function of two variables, Necessary and sufficient condition for differentiability of functions two variables, Schwarz's, Young theorem, Taylor's theorem (Statements only) for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange multiplier method(without proof), Jacobians.	12
VI	Existence theorems for Laplace transforms, Linearity of Laplace transform and their properties, Laplace transform of the derivatives and integrals of a function, Convolution theorem, inverse Laplace transforms, Solution of the differential equations using Laplace transforms.	11
VII	Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Fourier transforms (finite and infinite).	11
VIII	Calculus of variations-Variational problems with fixed boundaries- Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives.	11

Suggested Readings(Part-A Algebra):

1. J.B. Fraleigh, A first course in Abstract Algebra, Addison-weley
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons
3. Suggested digital plateform: NPTEL/SWAYAM/MOOCS
4. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part- B Mathematical Methods):

1. T.M. Apostal, Mathematical Analysis, Person
2. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata -McGrawHill
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4. Suggested digital plateform: NPTEL/SWAYAM/MOOCs
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/ Objective Tests**	5
3	**Presentation**	5
4	**Assignment (Introduction to Indian ancient Mathematics and Mathematicians)**	5

Course prerequisites: To study this course, a student must have subject Mathematics in class 12th

Suggested equivalent online courses:

Further Suggestions:

B.Sc. II (SEMESTER-IV) PAPER-I Differential Equations & Mechanics

Programme: Diploma Class: B.Sc.	Year: Second	Semester: Fourth
Subject: Mathematics		
Course Code: 0420301 NEP Code: B030401T	Course Title: Differential Equations & Mechanics	

Course outcomes:

CO1: The objective of this course is to familiarize the students with various methods of solving differential equations, partial differential equations of first order and second order and to have qualitative applications.

CO2: A student doing this course is able to solve differential equations and is able to model problems in nature using ordinary differential equations. After completing this course, a student will be able to take more courses on wave equation, heat equation, diffusion equation, gas dynamics, non linear evolution equation etc. These entire courses are important in engineering and industrial applications for solving boundary value problem.

CO3: The object of the paper is to give students knowledge of basic mechanics such as simple harmonic motion, motion under other laws and forces.

CO4: The student, after completing the course can go for higher problems in mechanic such as hydrodynamics, this will be helpful in getting employment in industry.

Credits: 6	Core Compulsory / Elective
Max. Marks: 25+75	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0	

Part- A

Differential Equations

Unit	Topics	No. of Lectures
I	Second order linear differential equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters.	11
II	Elementary idea of Power series solutions of second order ordinary differential equations(ODE); Bessels and Legender functions and their properties	12
III	Origin of first order partial differential equations. Partial differential equations of the first order and degree one, Lagrange's solution, Partial differential equation of first order and degree greater than one. Charpit's method of solution,	11
IV	Origin of second order PDE, Solution of partial differential equations of the second and higher order with constant coefficients, Classification of linear partial differential equations of second order, Solution of second order partial differential equations with variable coefficients, Monge's method of solution.	11

Part- B

Mechanics

Unit	Topics	No. of Lectures
V	Frame of reference, work energy principle, Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines and planes.	11
VI	Virtual work, Stable and Unstable equilibrium.	11
VII	Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other law of forces. Elastic strings, Motion in resisting medium,	11
VIII	Constrained motion, Motion on smooth and rough plane curves. Central orbit, Kepler's laws of motion, Motion of particle in three dimensions	12

Suggested Readings(Part-A Differential Equations):

1. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata –McGrawHill
2. B. Rai, D.P. Choudhary & H. J. Freedman, A Course of Ordinary Differential Equations, Narosa
3. Ian N. Snedden, Elements of Partial Differential Equations, Dover Publication
4. L.E. Elsgolts, Differential Equation and Calculus of variations, University Press of the Pacific.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings(Part-B Mechanics):

1. R.C. Hibbeler, Engineering Mechanics-Statics, Prentics Hall Publishers
2. R.C. Hibbeler, Engineering Mechanics-Dynamics, Prentics Hall Publishers
3. A. Nelson, Engineering Mechanics Statics and Dynamics, Tata McGraw Hill
4. J.L. Synge & B.A. Griffith, Principles of Mechanics, Tata McGraw Hill
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Economics(UG/PG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Certificate Course in Applied Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc.(Mathematics)-III Year
Degree in Mathematics

B.Sc. III (SEMESTER-V) PAPER-I Group and Ring Theory & Linear Algebra

Programme: Degree Class: B.Sc.	Year: Third	Semester: Fifth
Subject: Mathematics		
Course Code: 0520301 NEP Code: B030501T	Course Title: Group and Ring Theory & Linear Algebra	

Course outcomes:

CO1: Liner algebra is a basic course in almost all branches of science. The objective of this course is to introduce a student to the basics of linear algebra andsome of its applications.
CO2: Students will be able to know the concepts of group, ring and other related properties which will prepare the students to take up further applications in the relevant fields.
CO3: The student will use this knowledge in computer science, finance mathematics, industrial mathematics and bio mathematics. After completion of this course students appreciate its interdisciplinary nature.

Credits: 5	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0

PART-A

Group and Ring Theory

Unit	Topics	No. of Lectures
I	**Introduction to Indian ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE).** Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups.	10
II	Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.	10
III	Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion.	9
IV	Divisibility in integral domains, Irreducibles, Primes, Unique factorization domains, Euclidean domains.	9

PART-B

Linear Algebra

Unit	Topics	No. of Lectures
V	Vector spaces, Subspaces, Linear independence and dependence of vectors, Basis and Dimension, direct sum and Quotient space.	10
VI	Linear transformations, The Algebra of linear transformations, rank and null space.	9
VII	Rank nullity theorem, their representation as matrices., Change of basis, Characteristic values, Cayley Hamilton Theorem.	9
VIII	Inner product spaces and norms, Cauchy-Schwarz inequality, Orthogonal vectors, Orthonormal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process.	9

Suggested Readings:

1. Topics in Algebra by I. N. Herstein.

2. Linear Algebra by K. Hoffman and R. Kunze.

3. Suggested digital plateform:NPTEL/SWAYAM/MOOCs

4. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), BCA, B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment (Introduction to Indian ancient Mathematics and Mathematicians)	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-V) PAPER-II (i) Number Theory & Game Theory

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0520302 Code: B030502T	Course Title: Number Theory & Game Theory	

Course outcomes:

CO1: Upon successful completion, students will have the knowledge and skills to solve problems in elementary number theory and also apply elementary

number theory to cryptography.

CO2: This course provides an introduction to Game Theory. Game Theory is a mathematical framework which makes possible the analysis of the decision making process of interdependent subjects. It is aimed at explaining and predicting how individuals behave in a specific strategic situation, and therefore help improve decision making.

CO3: A situation is strategic if the outcome of a decision problem depends on the choices of more than one person. Most decision problems in real life are strategic.

CO4: To illustrate the concepts, real-world examples, case studies, and classroom experiments might be used.

Credits: 5	Elective
Max. Marks: 25+75	Min. Passing Marks: 33
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0	

Part- A

Number Theory

Unit	Topics	No. of Lectures
I	**Theory of Numbers** Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem.	10
II	**Congruences** Congruence modulo powers of prime; primitive roots and their existence; quadratic residues; Legendre symbol, Jacobi symbol, Mobious Function and Euler's phi Function.	9
III	**Diophantine Equations** Solutions of $ax + by = c$, $x^n + y^n = z^n$; properties of Pythagorean triples; sums of two and four squares; assorted examples of diophantine equations.	9
IV	**Generating Functions and Recurrence Relations** Generating Function Models, Calculating coefficient of generating functions, Partitions, Exponential Generating Functions, A Summation Method. Recurrence Relations: Recurrence Relation Models, Divide and conquer Relations, Solution of Linear, Recurrence Relations, Solution of Inhomogeneous Recurrence Relations, Solutions with Generating Functions.	9

Part- B
Game Theory

Unit	Topics	No. of Lectures
V	Introduction, overview, uses of game theory, some applications and examples, and formal definitions of: the normal form, payoffs, strategies, pure strategy Nash equilibrium.	10
VI	Introduction, characteristic of game theory, Two- person zero-sum game, Pure and Mixed strategies, Saddle point and its existence.	10
VII	Fundamental Theorem of Rectangular games, Concept of Dominance, Dominance and Graphical method of solving Rectangulargames.	9
VIII	Relationship between rectangular game and Linear Programming Problem, Solving rectangular game by Simplex method, reduction ofm x n game and solution of 2x2, 2 x s, and r x 2 cases by graphical method.	9

Suggested Readings (Part-A Number Theory):

1. Niven, I., Zuckerman, H. S. and Montegomery, H. L. (2003) An Int. to the Theory of Numbers (6th edition) John Wiley and sons, Inc., New York.
2. Burton, D. M. (2002) Elementary Number Theory (4th edition) Universal Book Stall, New Delhi.
3. Balakrishnan, V. K. (1994) Schaum's Outline of Theory and Problems of Combinatorics Including Concepts of Graph Theory, Schaum's Outline.
4. Balakrishnan,V. K. (1996) Introductory Discrete Mathematics, Dover Publications.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Game Theory):

1. Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003
2. Vijay Krishna, Game Theory, Academic Press.
3. Prajit Dutta, Strategies and Games, MIT Press, (Website 1) http://www.ccc.stevens-tech.edu/~ccomanic/ee800c.html
5. Allan MacKenzie, Game Theory for Wireless Engineers, Synthesis lectures on Communications, 2006
6. Suggested digital plateform:NPTEL/SWAYAM/MOOCS
7. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-V) PAPER-II (ii) Graph Theory & Discrete Mathematics

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0520303 NEP Code: B030502T	Course Title: Graph Theory & Discrete Mathematics	

Course outcomes:

CO1: Upon successful completion, students will have the knowledge of various types of graphs, their terminology and applications.

CO2: After Successful completion of this course students will be able to understand the isomorphism and homomorphism of graphs. This course covers the basic concepts of graphs used in computer science and other disciplines. The topics include path, circuits, adjacency matrix, tree, coloring.. After successful completion of this course the student will have the knowledge graph coloring, color problem, vertex coloring.

CO3: After successful completion, students will have the knowledge of Logic gates, Karnaugh maps and skills to proof by using truth tables. After Successful completion of this course students will be able to apply the basics of the automation theory, transition function and table.

CO4: This course covers the basic concepts of discrete mathematics used in computer science and other disciplines that involve formal reasoning. The topics include logic, counting, relations, hasse diagram and Boolean algebra. After successful completion of this course the student will have the knowledge in

Mathematical reasoning, combinatorial analysis, discrete structures and Applications.

Credits: 5	Elective
Max. Marks: 25+75	Min. Passing Marks: 33
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0	

Part- A

Graph Theory

Unit	Topics	No. of Lectures
I	Introduction to graphs, basic properties of graphs, Simple graph, multi graph, graph terminology, representation of graphs, Bipartite,regular, planar and connected graphs, connected components in a graph, Euler graphs, Directed, Undirected, multi-graph, mixed graph.	10
II	Walk and unilateral components, unicursal graph, Hamiltonian path and circuits, Graph colouring, chromatics number, isomorphism and homomorphism of graphs, Incidence relation and degree of the graph.	9
III	Operation of graph circuit, Path and circuits, Eulerian circuits, Hamiltonian path and cycles, Adjacency matrix, Weighted graph,Travelling salesman problem, Shortest path, Dijkstra's algorithm.	9
IV	Tree, Binary and Spanning trees, Coloring, Color problems, Vertex coloring and important properties.	9

Part- B
Discrete Mathematics

Unit	Topics	No. of Lectures
V	**Propositional Logic-** Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification, proofby implication, converse, inverse contrapositive, contradiction, direct proof by using truth table.	10
VI	**Relation-** Definition, types of relation, domain and range of a relation, pictorial representation of relation, properties of relation, partial ordering relation, Representation of Posets using Hasse Diagram, Chains, Maximal and Minimal Point, Glb, Lub, Lattices and its basic properties	10
VII	**Boolean Algebra-** Basic definitions, Sum of products and products of sums, Logic gates Switching Circuits and Karnaugh maps	9
VIII	**Combinatories-** Inclusion- exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relations using G.F. solution of combinatorial problem using G.F.)	9

Suggested Readings (Part-A Graph Theory):

1. "Graph Theory with Applications to Engineering and Computer Science" by Narsingh Deo
2. "Introduction to Graph Theory" by Douglas B West
3. "Graph Theory with Algorithms and Its Applications: In Applied Science and Technology" by Santanu Saha Ray
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
5. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Discrete Mathematics):

1. Discrete Mathematics by C. L.Liu.
2. Discrete Mathematics with computer application by Trembley and Manohar.3.Discrete Mathematics and Its Applications by Kenneth H. Rosen
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCS
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-V) PAPER-II (iii) Differential Geometry & Tensor Analysis

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0520304 NEP Code: B030502T	Course Title: Differential Geometry & Tensor Analysis	

Course outcomes:

CO1: After Successful completion of this course, students should be able to determine and calculate curvature of curves in different coordinate systems.
CO2: This course covers the Local theory of Curves, Local theory of surfaces, Geodesics, Geodesics curvature, Geodesic polars, Curvature of curves on surfaces, Gaussian curvature, Normal curvature etc.

CO3: After Successful completion of this course, students should have the knowledge of tensor algebra, different types of tensors, Riemannian space, Ricci tensor, Einstein space and Einstein tensor etc.

Credits: 5	Elective
Max. Marks: 25+75	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0

Part- A

Differential Geometry

Unit	Topics	No. of Lectures
I	Local theory of curves-Space curves, Examples, Plane Curves, tangent and normal and binormal, Osculating Plane, normal plane and rectifying plane, Osculating circle, osculating sphere Helices, Serret-Frenet apparatus, contact between curve and surfaces, tangent surfaces, involutes and evolutes of curves, Bertrand curves, Intrinsic equations, fundamental existence theorem for space curves.	10
II	Local Theory of Surfaces- Parametric patches on surface curve of a surface, family of surfaces (one parameter), edge of regression,ruled surfaces, skew ruled surfaces and developable surfaces, surfaces of revolution, Helicoids.	9
III	Metric-first fundamental form and arc length, Direction coefficients, families of curves, intrinsic properties, geodesics, canonicalgeodesic equations, normal properties of geodesics, geodesics curvature, Geodesic polars.	9
IV	Gauss-Bonnet theorem, curvature of curves on surfaces, Gaussian curvature, normal curvature, Meusneir's theorem, mean curvature,Gaussian curvature, umbilic points, lines of curvature, Rodrigue's formula, Euler's theorem.	9

Part- B
Tensor Analysis

Unit	Topics	No. of Lectures
V	Tensor algebra: Vector spaces, the dual spaces, tensor product of vector spaces, transformation formulae, contraction, special tensors-symmetric tensor, inner product, associated tensor with examples.	10
VI	Tensor Analysis: Contravariant and covariant vectors and tensors, Mixed tensors, Symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Quotient theorem, Reciprocal tensors, Christoffel's symbols, Law of transformation of Christoffel's symbols, Covariant differentiation, non- commutativity of Covariant derivative.	10
VII	Gradient of scalars, Divergence of a contravariant vector, covariant vector and conservative vectors, Laplacian of an invariant, curl of acovariant vector, irrotational vector, with examples.	9
VIII	Riemannian space, Riemannian curvatures and their properties, geodesics, geodesic curvature, geometrical interpretation of curvaturetensor, Ricci tensor, scalar curvature, Einstein space and Einstein tensor.	9

Suggested Readings (Part-A Differential Geometry):

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
3. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
4. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
5. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
6. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003.
7. An Introduction to Differential Geometry (with the use of tensor Calculus), L. P. Eisenhart, Princeton University Press, 1940.
8. Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continua, 2nd Edition, I. S. Sokolnikoff, John Wiley and Sons., 1964.
9. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
10. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Tensor Analysis):

1. Tensors- Mathematics of Differential Geometry by Z. Ahsan, PHI,2015
2. David C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill 1988.
3. R. S, Mishra, A Course in Tensors with Applications to Reimannian Geometry, Pothishala Pvt. Ltd, Allahabad.
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCS
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

Sn	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-VI) PAPER-I METRIC SPACES & COMPLEX ANALYSIS

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0620301 NEP Code: B030601T	Course Title: METRIC SPACES & COMPLEX ANALYSIS	

Course outcomes:

CO1: The course is aimed at exposing the students to foundations of analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics.

CO2: After completion of this course the student will have rigorous and deeper understanding of fundamental concepts in Mathematics. This will be helpful to the student in understanding pure mathematics and in research.

CO3: Students will be able to know the concepts of metric space, basic concepts and developments of complex analysis which will prepare the students to take up further applications in the relevant fields.

Credits: 4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Part- A. Metric Spaces

Unit	Topics	No. of Lectures
I	**Basic Concepts** Metric spaces: Definition and examples, diameters in Metric Space, Bounded and Unbounded Metric Space.	8
II	**Topology of Metric Spaces** Open and closed ball, Neighborhood, Open set, Interior of a set, limit point of a set, derived set, closed set, closure of a set,Subspaces, Dense set.	8
III	**Completeness in Metric Spaces** Sequences in metric spaces, Cauchy sequences, Complete metric space with Examples, Cantor intersection Theorem	7
IV	**Continuity & Uniform Continuity in Metric Spaces** Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mapping, Banach fixed point theorem	7

Part- B
Complex Analysis

Unit	Topics	No. of Lectures
V	Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae,	8
VI	Cauchy-Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples, Harmonic Function, method of construction of a regular function(Milne-Thomson's Method..	8
VII	Conformal Mapping, necc. & suff. Condition; inverse point, bilinear transformation, critical point, cross ratio, fixed point.	7
VIII	Exponential functions, Logarithmic functions, branches and derivative of logarithmic function, Trigonometric functions, Derivative of functions. Definite integral of functions, contours, contour integrals and its examples, upper bound for moduli of contour integrals	7

Suggested Readings (Part-A Metric Space):

1. Mathematical Analysis by Shanti Narain.
2. Shirali, Satish & Vasudeva, H. L. (2009). Metric Spaces, Springer, First Indian Print.
3. Kumaresan, S. (2014). Topology of Metric Spaces (2nd ed.). Narosa Publishing House. New Delhi.
4. Simmons, G. F. (2004). Introduction to Topology and Modern Analysis.Tata McGraw Hill. New Delhi.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCS.
6. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Complex Analysis):

1. Function of Complex Variable by Shanti Narain.
2. Complex variable and applications by Brown & Churchill.
3. Suggested digital plateform:NPTEL/SWAYAM/MOOCS.
4. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

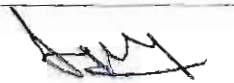
Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:



B.Sc. III (SEMESTER-VI) PAPER-II Numerical Analysis & Operation Research

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0620302 NEP Code: B030602T	Course Title: Numerical Analysis & Operations Research	

Course outcomes:

CO1: The aim of this course is to teach the student the application of various numerical technique for variety of problems occurring in daily life. At the end ofthe course the student will be able to understand the basic concept of Numerical Analysis and to solve algebraic and differential equation.

CO2: The main outcome will be that students will be able to handle problems and finding approximated solution. Later he can opt for advance course in Numerical Analysis in higher Mathematics.

CO3: The student will be able to solve various problems based on convex sets and linear programming. After successful completion of this paper will enable the students to apply the basic concepts of transportation problems and its related problems to apply in further concepts and application of operations research.

Credits: 4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks: 33
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0	

PART-A

Numerical Analysis

Unit	Topics	No. of Lectures
I	Errors in computations, floating point representation of numbers, significant digits, rounding and chopping errors, absolute and relative errors, computation of errors using differentials, truncation errors. Solution of algebraic and transcendental equations; bisection, Secant, Regular Falsi, Newton Raphson's method, Newton's method for multiple roots.	8
II	Caculus of finite differences, Interpolation,Lagrange and Hermite interpolation, Newton's Divided difference formula, Interpolation formula using differences.	8
III	Numerical differentiation using Newton's forwarded and backward formula, differentiation by central and divided difference formula. Numerical Integration: Trapezoidal, Weddle, Simpsons Newton Cotes Formulas, Gaussian Quadratic Formulas.	7
IV	System of Linear equations: Direct method for solving systems of linear equations (Gauss elimination, LU Decomposition, Cholesky Decomposition),Iterative methods (Jacobi, Gauss Seidel, Relaxation methods).	7

PART-B. Operations Research

Unit	Topics	No. of Lectures
V	Introduction, Linear programming problems, statement and formation of general linear programming problems, graphical method, slack and surplus variables, standard and matrix forms of linear programming problem, basic feasible solution.	8
VI	Convex sets, fundamental theorem of linear programming, basic solution, Simplex method, introduction to artificial variables, two phase method Big-M method and their comparison.	8
VII	Resolution of degeneracy, duality in linear programming problems, primal dual relationships, revised simplex method, sensitivity analysis.	7
VIII	Transportation problems, assignment problems.	7

Suggested Readings(Part-A Numerical Analysis):

1. Numerical Methods for Engineering and scientific computation by M. K. Jain, S.R.K. Iyengar & R.K. Jain.
2. Introductory methods of Numerical Analysis by S. S. Sastry
3. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
4. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings(Part-B Operation Research):

1.Taha, Hamdy H, "Opearations Research- An Introduction ", Pearson Education.
2.Kanti Swarup , P. K. Gupta , Man Mohan Operations research, Sultan Chand & Sons
3.Hillier Frederick S and Lieberman Gerald J., "Operations Research", McGraw Hill Publication.
4.Winston Wayne L., "Operations Research: Applications and Algorithms", Cengage Learning, 4th Edition.
5.Hira D.S. and Gupta Prem Kumar, "Problems in Operations Research: Principles and Solutions", S Chand & Co Ltd.
6. Kalavathy S., "Operations Research", S Chand.
7. Suggested digital plateform:NPTEL/SWAYAM/MOOCs.
8. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Economics(UG/PG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Certificate Course in Applied Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-VI) PAPER-III Practical

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0620380 NEP Code: B030603P	Course Title: Practical	
Course outcomes: The main objective of the course is to equip the student to solve the transcendental and algebraic equations, system of linear equations, ordinary differential equations, Interpolation, Numerical Integration, Method of finding Eigenvalue by Power method (up to 4×4), Fitting a Polynomial Function (up to third degree).		
Credits: 2	Core Compulsory	
Max. Marks: 100	Min. Passing Marks: 33	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		

Unit	Topics	No. of Lectures
	Practical / Lab work to be performed in Computer Lab. List of the practicals to be done using computer algebra software (CAS), for example Mathematica/MATLAB/Maple/ Maxima/ Scilabetc 1. Solution of transcendental and algebraic equations by i) Bisection method ii) Newton Raphson method (Simple root, multiple roots, complex roots). iii)Secant method. iv)Regula Falsi method. 2. Solution of system of linear equations i) LU decomposition method ii) Gaussian elimination method iii)Gauss-Jacobi method iv)Gauss-Seidel method 3. Numerical Integration (i) Trapezoidal (ii) Simpson's 1/3 (iii) Simpson's 3/8 (iv) Weddle, Newton Cotes Formulae	

Suggested Readings:

B.Sc.(MATHEMATICS) Honours

Or

Graduate in Mathematics Honours

COURSE-I : Abstract Algebra

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720321	Course Title: Abstract Algebra	Theory

Course Objectives: Acquiring ability for defining algebraic structures, constructing substructures, analyzing a given structure, developing new structures based on given structures, and comparing structures.

Course Outcomes (CO's):

CO1. Ability to solve non-trivial problems based on various concepts in the course.
CO2. Determining the connection and transit amid formerly studied mathematics (discrete mathematics) and advanced mathematics (advanced abstract mathematics).
CO3. Ability to apply abstract algebra to solve problems in other branches of mathematics and also in other disciplines.
CO4. Describing relationship between Abstract Algebra and other courses in mathematics.
CO5. Understanding the dependency of results based on earlier results, and thereby developing a correct approach towards life realizing the deep connection among past, present and future. For example, in ring theory, the ring of polynomials over a field is a gift of the division algorithm.
CO6. Possessing pre-requisites for pursuing research in Cryptography

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4–0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definitions of a group, Subgroups, Cyclic group, Permutation group, Even and odd permutation; statement of Cayley's theorem, Lagrange's theorem; definitions of Normal subgroup, Quotient group, Ring, Subrings, Integral domain and field, Ideal and quotient ring, automorphism, inner automorphism, Polynomial ring over commutative ring, definition of division algorithm, principal ideal domain, Reducibility tests, Irreducibility tests, Eisenstein criterion. Unique factorization domains, Euclidean domain	15
II	Cauchy's theorem for finite abelian group, Cauchy's theorem for an arbitrary finite group, Fundamental theorem on homomorphism of groups, Second and third law of isomorphism of groups, Maximal subgroup, Composition series, Jordon Holder's theorem, Subnormal and normal series, Solvable groups, Characteristic property of solvable groups	15
III	Direct products, External Direct products, Internal Direct products, Sylow p-subgroups, Sylow's first theorem, Double cosets, Sylow's second and third theorem, Applications of Sylow's theorem.	15
IV	The fundamental theorem on finite abelian groups, Invariants of finite abelian groups, Isomorphic abelian groups of order , non-isomorphic abelian groups of order, Decomposable groups. Imbedding of rings, Field of quotients of an integral domain, Maximal Ideal,. Field extensions, Finite field extensions, Simple field extensions, Algebraic and transcendental extensions, Minimal polynomial, Remainder theorem, Factor theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **David S. Dummit & Richard M. Foote:** Abstract Algebra, Wiley, 3rd Edition, 2011
2. **Joseph A. Gallian:** Contemporary Abstract Algebra 9th Edition, 2019.
3. **Khanna, Vijay K & Bhambri, S K** A Course in Abstract Algebra, S Chand and Company Ltd; Fifth edition (2022)
4. **Herstein, I.N.: Topics in Algebra,** Wiley, 2nd Edition, 2006.
5. **Bhattacharya, P.B., Nagpaul, S.K.** Basic Abstract Algebra (2nd Edition) Cambridge University Press, Indian Edition, 1997.
6. **Lang, S.:** Algebra, Pearson Education 3rd Edition, 1992
7. **J. B. Fraleigh** : A first course in Abstract Algebra.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-II : Real Analysis

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720322	Course Title: Real Analysis	Theory

Course Objectives:
This course puts forward some basic concepts of real-valued functions and its applications. The purpose of this course is to provide a foundation for understanding the different branches of mathematics.

Course outcomes:
CO1. To provide a topological study of real-valued functions.
CO2. To study the concepts of convergence and uniform convergence of series and sequence of real-valued functions and their applications.
CO3. To provide the methods for finding the maxima and minima values of multivariate real-valued functions with their applications.
CO4. To study the concept of integrability of real-valued functions over the closed and bounded interval and their applications in different areas, such as quantum physics.
CO5. This course gives a wide study of different concepts of functions of serval variables, such as limit and continuity, differentiability, partial differentiability and integrability.
CO6. This course lays a foundation to study other important courses such as functional analysis, complex analysis and differential equations. This course plays a central role to get the employment for the students because it is available with a great importance in the syllabi of different competitive exams

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definition and existence of Riemann-Stieltjes integral. Properties of the integral, integration and differentiation, The fundamental theorem of calculus, and Integration of vector-valued functions.	15
II	Sequences and series of functions. Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Uniform convergence and continuity, Uniform convergence and Riemann-Stieltjes integration, Uniform convergence and differentiation, Weierstrass Approximation Theorem.	15
III	Power series, Algebra of power series, Uniqueness theorem for power series. Abel's and Tauber's theorems.	15
IV	Functions of several variables, Linear transformation, Derivatives in an open subset of R^n, Chain rule, Partial derivatives, Interchange of the order of differentiation.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Apostol, T. M.:** Mathematical Analysis, Narosa Publishing, New Delhi, 1985
2. **Brown, W., Churchill ,R.V.,** Fourier Series and Boundary Value Problems, 8th 3rd Edition, 2015, McGraw Hill Education, New Delhi
3. **Royden, H. L.:** Real Analysis, (4th Edition), Macmillan Publishing Co. Inc. New York, 1993.
4. **Rudin, W.:** Principles of Mathematical Analysis, (3rd edition) McGraw-Hill, Kogaku Sha, 1903, International student edition.
1. **White, J.:** Real Analysis, An Introduction, Addison-Wesley Publishing, Co. Inc., 1968.

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:
There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-III : Advanced Differential Equation

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720323	Course Title: Advanced Differential Equation	Theory

Course Objectives:

1. To explore the basic ideas of Differential Equations combined with some real-life problems
2. Differential equations are very important in the mathematical modeling of physical systems.
3. Many fundamental laws of physics and chemistry can be formulated as differential equations.
4. In biology and economics, differential equations are used to model the behavior of complex systems.
5. Ordinary Differential Equations are used to calculate the movement or flow of electricity, motion of an object to and fro like a pendulum, to explain thermodynamics concepts.

Course outcomes:

CO1. The use of the differential equation theory is to solve various types of Mathematical modeling problems.
CO2. The use of the differential equation theory is to solve many problems presented in different sciences such as Biology, Chemical sciences and Physics.
CO3. The use of this theory is to solve many real-life based problems such as population problem, control problems and networking security problems etc.
CO4. This theory can solve many engineering problems such as the exact trajectory path of a rocket or a missile.
CO5. Students will be able to formulate and solve differential equations arising from changes in physical world.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4--0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Ordinary Differential Equations (ODEs), General theory of homogenous and non-homogeneous linear ODEs, System of first order ODEs, The method of variation of parameters, Wronskian, Sturm-liouville boundary value problem, Picard's method of successive approximation, Picard's Theorem.	15
II	Ordinary points, Singularities, Regular and Irregular singular points, Series solutions about ordinary points, Frobenius series solution Green function.	15
IV	Origin of first order Partial Differential Equations (PDEs), Lagrange method for solving first order PDEs, Integral surfaces passing through a given curve, Surface orthogonal to a given system of surface, Non-linear PDEs of the first order, Charpit's method for first order PDEs, Jacobi Mathod, Cauchy problem for first order PDEs, Origin of second order partial differential equation and their classification, linear PDEs with constant and variable coefficients.	15
V	General solution of higher order PDEs with constant coefficient, Diffusion, Wave and Laplace equations by the method of separation of variables, Reduction of second order partial differential equation into its canonical form, Non-linear partial differential equations of second order.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Coddington, Earl A. & Levinson, Norman:** Theory of Ordinary Differential equations, Tata McGraw-Hill Publication.
2. **Rai,B., Chaudhary ,D.P. and Freedman, H.I.:** A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi 2013.
3. **Simmons, G.F.:** Differential Equations with Applications and Historical Notes, Second Edition, Tata Mcgraw-Hill Publishing Company Ltd. New Delhi (2017).
4. **Sneddon, Ian:** Elements of Partial Differential Equation, McGraw-Hill Book Company.
5. **Wirkus Stephen A. & Swift , Randall J.:** A Course in Ordinary Differential Equations 1st Edition, CRC Press, Taylor & Francis Group, 2015.
6. **Ross, S. L.:** Differential Equations, 3rd Edition, Wiley. (1980)

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:
There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-IV : Metric Space

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720324	Course Title: Metric Space	Theory

Course Objectives:

The beauty of the subject is to gain proficiency in dealing with abstract concepts, with emphasis on clear explanations of such concepts to others; to introduce the theory of metric and topological spaces; to show how the theory and concepts grow naturally from idea of distance; to be able to give examples which show that metric spaces are more general than Euclidean spaces; to be able to work with continuous functions, and to recognize whether spaces are connected, compact or complete. Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

Course outcomes:

CO1: To show how the theory and concepts grow naturally from idea of distance

CO2: Differentiate between functions that define a metric on a set and those that do not.

CO3: Use the Banach fixed point theorem to demonstrate the existence and uniqueness of solutions to differential equations

CO4: Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty

CO5: Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

CO6: Understand sequentially compact spaces, Countable compactness, BWP and compactness and explain the relation between the three types of compactness in metric spaces.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4--0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Metric Space: Metric on a set, pseudo-metrics and metrics Distance between two sets. Equivalent metrics. Limit points and closure: closed sets, Derived set of a set. Adherent points and closure of a set, Dense subsets, Interior of a set and its properties, Subspaces, Product spaces, Structure of Open balls in a product space. Closures and interiors in a product space, Finite product of metric spaces.	15
II	Convergent sequences. Cauchy sequences. Characterization of adherent points and limit points in terms of convergent sequences. Convergence in products. Convergence in Euclidean spaces Cluster points of a sequence. Subsequences. Cluster points and convergent subsequences. Algebra of convergent real sequences. Spaces of sequences.	15
III	Continuity at a point. Continuity over a space. Continuity of composite, graph and projection maps. Algebra of real valued continuous functions in a metric space. Homeomorphisms. Isometries. Relation between isometries and Homeomorphism. Uniform continuity. Complete metric spaces. Completeness and Continuous mappings. Completeness and subspaces. Cantor's Intersection Theorem. Contraction Mapping Principle. Connectedness: Connected metric spaces. Connected sets. Characterization of connected subsets of the real line. Properties of Connectedness	15
IV	Compact spaces and Compact subsets. Compact subsets of the real line. Sequential compactness and its characterization. Countable compactness, Bolzano-Weierstrass property. Sequential characterization of BWP. Equivalence of BWP and sequential compactness. Covering characterization of the BWP. Bolzano-Weierstrass Property and Total boundedness. BolzanoWeierstrass Property and compactness. Lebesgue covering lemma. Compactness and completeness, Compactness and uniform continuity. Boundedness of continuous real-valued functions on compact metric spaces	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Copson, E.T: Metric Spaces, Cambridge tracts, 2010.
2. Dieudonne ,J.: Foundation of Modern Analysis, Academic Press, New York, 1960.
3. Kasriel ,R. H.: Metric Spaces, Dover Publications, New York, 2009.
1. Kumaresan S. Topology of Metric Spaces, 2nd Edition, Narosa (2011).

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective Course -V : Mathematical Statistics

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720325	Course Title: Mathematical Statistics	Theory

Course Objectives: The aim of this course is to extend and master students' knowledge of probability and statistical methods and to provide theoretical background for studying advanced statistical methods, Upon successful completion of this course, students will be able to study, correctly apply and interpret different statistical methods.

Course outcomes:

CO1: Explore the basic ideas about measures of central tendency, dispersion and their applications in other statistical problems.
CO2: Explain the different types of discrete and continuous distributions and their utilization.
CO3: Tackle big data and draw inferences form it by applying appropriate statistical techniques.
CO4: Apply the knowledge of statistical techniques in various experimental and industrial requirements

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Probability: Set theoretic approach, Sample spaces, Events; Dependent and Independent events, The concept of Probability, Statistical or empirical definition, Conditional probability, Bay's theorem, Probability mass and density functions, Chebyshev's inequality.	15
II	Random variables, Distribution functions, Joint probability distribution function, Conditional distribution function, Probability density function, Expectation, Covariance, Variance of variables, standard discrete and continuous univariate distributions, standard errors, marginal and conditional distributions.	15
III	Basics concept of Moment generating function, Probability generating function and Universal generating function, Discrete distributions: Geometric, Bernoulli, Binomial, Poisson and uniform distributions, Continuous distributions: Normal, Exponential, Gumma, Chi-square, student's t and F, and Beta distributions.	15
IV	Curve Fitting, Correlation and regression: Curve fitting, The Method of Least Squares, fitting of a straight Line and second-degree Parabola, Correlation coefficients, Simple and multiple linear Regression, lines of regression, regression coefficient, Scatter diagram, test for slop and correlation	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Rohatgi, V.K., Saleh, A.K. Md. Ehsanes:** An Introduction to Probability and Statistics, Second Edition Wiley-Indersclence. (2008)
2. **Kennedy and Gentle:** Statistics Computing, Published by CRC Press. (2021)
3. **Mayer, P.L.:** Introductory Probability and Statistical Applications, IBH. 2nd Edition (1970)
4. **Mood, A.M. and Graybill, F.:** Introduction to the Theory of Statistics, McGraw Hill Education; 3rd edition (2017).
1. **Hogg, R.V., Craig, A. and McKean, Joseph W.:** Introduction to Mathematical Statistics, Pearson Education, .8th Edition New Delhi (2019)

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective Course – II: Advance Numerical Analysis

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720326	**Course Title: Advance Numerical Analysis**	Theory

Course Objectives:
This course aims to provide students with the techniques for finding approximate numerical solutions to mathematical problems for which exact or analytical solutions are unavailable or inappropriate. Successful students will have an appreciation of the difficulties involved in finding reliable solutions and will gain practical knowledge of how to apply the techniques and methods to specific problemssuch as finding roots of equations, quadrature and numerical solution of differential equations.

Course outcomes:

CO1. Apply their knowledge of computer programming to develop and implement their own computer codes of numerical methods for solving different types of complex problems viz. nonlinear equations, a system of linear equations, interpolation and extrapolation, initial and boundary value problems of ordinary differential equations, etc.

CO2. Find the solution of linear and nonlinear equations and solution of differential equations.

CO3. Demonstrate understanding of common numerical methods and how they are used to obtain approximate.

CO4: Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find theirappropriate solutions accurately and efficiently using computer codes.

CO5: Identify use of spline interpolation and difference equations in numerical analysis

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Modified Newton-Raphson method. Convergence of Newton Raphson Method, Bairstow method. Graffe's root squaring method for polynomial equations. Matrix Inversion: Gauss Jordan Method, Triangularization Method, Choleski's Method.	15
II	Algebraic Eigen values and Eigen vectors: Power methods, Jacobi's method, Given's method, Householder'smethod, Q-R method; Approximation: Least square polynomial approximation, polynomial approximation using orthogonal polynomials, Legendre's approximation, Approximation with trigonometric functions, Exponential functions, Rational functions. Approximation by Chebyshev polynomials, Max-min principle.	15
III	Numerical Solutions of initial value problems, Picard's method, Taylor's method, Single and multistep methods, Euler's and modified Euler's method, Runge-Kutta second order method and statement of fourth order Runge Kutta methods, Milne's method, Adams-Bash forth method.	15
IV	Spline approximation, construction of cubic spline, application to differential equation by spline method, introduction to difference equation and method of solution to find $y^{(1)}$ and y^{p}	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Froberg, C.E.:** Introduction to Numerical Analysis, Addison-Wesley Pub. Co., 2016.
2. **Gupta, Radhey S.:** Elements of Numerical Analysis, Macmillan India Ltd. New Delhi, 2015.
3. **Jain, M.K., Iyengar, S.R.K and Jain, R.K.:** Numerical Methods for Scientific and Engineering Computations, New Age International (P) Ltd. New Delhi, 2014.
4. **Sastry, S.S.:** Introductory Methods of Numerical Analysis, UBS Publishers, 2012.

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.

FurtherSuggestions: .....

COMPULSORY COURSE- I : Topology

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820321	Course Title: Topology	Theory

Course Objectives:

The beauty of the subject is to gain proficiency in dealing with abstract concepts, with emphasis on clear explanations of such concepts to others; to introduce the theory of metric and topological spaces; to show how the theory and concepts grow naturally from idea of distance, to be able to give examples which show that metric spaces are more general than Euclidean spaces; to be able to work with continuous functions, and to recognize whether spaces are connected, compact or complete.Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

Course outcomes:

CO1: To show how the theory and concepts grow naturally from idea of distance

CO2: Differentiate between functions that define a metric on a set and those that do not.

CO3: Use the Banach fixed point theorem to demonstrate the existence and uniqueness of solutions to differential equations

CO4: Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty

CO5: Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

CO6: Understand sequentially compact spaces, Countable compactness, BWP and compactness and explain the relation between the three types of compactness in metric spaces.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definition and examples of topological space, Closed sets, Closure, Dense subset, Neighborhoods, interior, exterior, boundary and accumulation points, Derived sets, Bases and sub-bases. Subspaces, product spaces and relative topology.	15
II	Continuous functions, homeomorphisms, the pasting lemma, Connected and disconnected sets, connectedness on the real line, components, locally connected spaces.	15
III	Countability axioms – First and second countable spaces, Lindelof's theorems, Separable spaces, second countability and separability. Separation axioms – T0, T1, T2, T3, T3½, T4, their characterizations and basic properties. Urysohn's lemma and Teitze extension theorem, Statement of Urysohn's metrization theorem.	15
IV	Compactness – Continuous functions and compact sets, basic properties of compactness, compactness and finite intersection property, sequentially and countably compact sets, local compactness and one point compactification. Statements of Tychonoff's Product theorem and Stone-cech compactification theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Simmons, G. F:** Introduction to Topology and Modern Analysis, Tata McGraw Hill, India,2016
2. **Dieudonne ,J.:** Foundation of Modern Analysis, Academic Press, New York, 1960.
3. **Munkres. James.:** Topology, 2nd Edition, Pearson Education, 2021.
2. **Kumaresan S.** Topology of Metric Spaces, 2nd Edition, Narosa (2011).

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COMPULSORY COURSE-II : Advanced Complex Analysis		
Programme/Class: B.Sc.	**Year:** B.Sc. Mathematics Honours	**Semester:** Eight
Course Code: 0820322	**Course Title:** Advanced Complex Analysis	**Theory**

Course Objectives:
This course aims to provide an understanding of the basic facts of complex analysis, in particular the nice properties enjoyed by the derivatives and integrals of functions of a complex variable, and to show how complex analysis can be used to evaluate complicated real integrals via residue calculus.

Course outcomes:

CO1. Know the fundamental concepts of complex analysis.

CO2. Prove the Cauchy-Riemann equations and apply them to complex functions in order to determine whether a given continuous function is complex differentiable.

CO3. Extend their knowledge to pursue research in this field.

CO4.Solve the problems using complex analysis techniques applied to different situations in engineering and other mathematical contexts.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Complex integration, Regular Arc, Contour, Cauchy-Goursat theorem, Simply connected domains, Multiply connected domains, Cauchy's integral formula, An extension of the Cauchy's integral formula, Significance of Cauchy's integral formula, Morera's Theorem, Cauchy's inequality, Liouville's theorem and its applications, The fundamental theorem of Algebra, Maximum modulus principle.	15
II	Properties and classifications of bilinear transformations, Bilinear transformation as conformal mappings, Riemann- Mapping Theorem, Examples of conformal mappings, Meromorphic functions, Entire functions, Taylor's theorem and its applications, Laurent's Theorem and its applications.	15
III	Singularities, Categorization of Singularities using Laurent's series, Isolated singularities, Residues, Cauchy's residue theorem, Evaluation of integrals, Many valued functions, branch points, branch cuts and branches of many valued functions, and with special reference to arg z, log z and z^a, The argument principle, Rouche's theorem. Analytic continuation, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation.	15
IV	Canonical products, Jensen's formula, Poisson-Jensen formula, Hadamard's three circles theorem, Order of an entire function, Exponent of convergence, Borel's theorem, Hadamard's factorization Theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

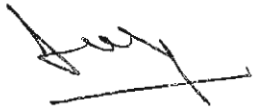
Suggested Readings:

1. **Ahlfors, L.V.:** Complex Analysis, McGraw Hill Education; 3rd Edition, 2017.
2. **Brown, J., Churchill, R.V.:** Complex Variable and Applications, McGraw-Hill Education; 9th Edition, 2013.
3. **Conway, J. B.:** Functions of One Complex Variable, Springer-Verlag, International student Edition, 2nd Edition, 1996.
4. **Priestly, H. A.:** Introduction to Complex Analysis, Oxford University Press, 2008.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....



Compulsory Course – III : Number Theory

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820323	**Course Title: Number Theory**	Theory

Course Objectives:
The aim of the course is to acquaint students with almost all basic concepts of number theory and to demonstrate applications of number theory. It will help students to grasp rigorous and tricky proofs of many important results that have been used by them from quiet long time. The students will learn the use of Chinese remainder theorem, Fermat's Theorem, Wilson's theorem, Lagrange theorem, Quadratic reciprocity, etc. It will supply methods to solve linear Diophantine equations, linear congruences, system of linear congruences, quadratic congruences, etc. Students will be able to detect the primality of a large integer. It will show how various number theoretic concepts and theorems are applicable in cryptography.

Course outcomes:

CO1. Identify the challenging problems in modern mathematics and find their appropriate solutions.

CO2. Formulate and prove conjectures about numeric patterns, and produce rigorous arguments centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.

CO3. Apply the knowledge of Number theory and Cryptography to attain a good mathematical maturity and enables to build mathematical thinking and skill.

CO4. Design, analyse and implement the concepts of Diophantine equations for solving different types of problems, for example, sum of two and four squares

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	The division algorithm, Definition and theory of the GCD, Euclid's Lemma, Definition and theory of the LCM, the extended Euclidean algorithm, Distribution of primes, the fundamental theorem of arithmetic, The Sieve of Eratosthenes, The Goldbach conjecture, Consequences of Dirichlet theorem, Statement of Prime Number theorem, Solutions of word problems using the theory of linear Diophantine equation, Solution of simultaneous system of linear congruences.	15
II	Number Theoretic Functions: The number (), sum (), and product of the divisors, Multiplicative function, Mobius function, Morten's Lemma, The Mobius inversion formula and its applications, The greatest integer function, Legendre formula and its application.	15
III	The order of an integer modulo n and order of higher powers of the integer modulo n , Primitive roots for primes, Finding all primitive roots of a prime, Composite numbers having primitive roots, The theory of indices, Properties of index, Solutions of non-linear congruences, Euler's criterion, Solutions of quadratic congruences with prime moduli	15
IV	Pseudoprimes and absolute pseudoprimes, Perfect numbers, even perfect numbers, The Fibonacci sequence and its properties, Continued fractions: representation of rational number as a finite simple continued fraction, Solution of linear Diophantine equation by means of simple continued fractions	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Burton, David M.: Elementary Number Theory** (7th Edition), McGraw Hill Education, 2017.
2. **Dudley U.: Elementary Number Theory** (2nd edition) Dover Publications, 2008.
3. **E. George, Andrews: Number Theory**, Dover Publications, 1994.

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests, quizzes and Presentation.
Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.

FurtherSuggestions: .....

Core-Elective (Group - 1) COURSE-I : Mechanics

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820324	Course Title: Mechanics	Theory

Course Objectives:
Mechanics is the oldest branch of the Physics discipline and is as well important in the discipline of Mathematics. It is actually an intermediate course in classical mechanics intended for mathematics majors. The core is the new formulation of mechanics and the substantial range of new techniques in the applications.

Course outcomes:

CO1. To distinguish between inertia frame of reference and non-inertial frame of reference.
CO2. To frame the mathematical constraints on the bases of physical restrictions imposed on a system, which simplifies the process of solution of a physical problem.
CO3. To understand the mechanics of a system of particles falling under classical mechanics.
CO4. To differentiate between Newtonian, Lagrangian, Hamiltonian and Routhian approach of solving a mechanical problem.
CO5. To determine the Lagrangian and Hamiltonian of mechanical systems and use these functions to obtain the solutions of even complicated mechanical systems with ease.
CO6. To identify the conserved quantities, if any, associated with the mechanical system.
CO7. To apply fundamental conservation principles to analyze mechanical systems.
CO8. To use advanced theoretical techniques to solve mechanical problems like use of canonical transformations, variational principles, Hamilton Jacobi theory.
CO9. To use Poisson's Brackets and Lagrange's Brackets to solve mechanical problems.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction to the system of particles, Conservation laws for the system of particles, generalized coordinates, Virtual displacements, Constraints and constrained motion, classification of constraints: Holonomic versus non-holonomic systems, Scleronomic versus rheonomic systems, Degree of Freedom, generalized velocity, generalized acceleration, generalized potential, generalized momentum (Conjugate momentum), Generalized force. Lagrangian Mechanics: Physics in configuration space with generalized coordinates as independent variable, Definition of the Lagrangian, Euler-Lagrange equations of motion, Derivation of Euler-Lagrange equations from differential principle i.e., by D' Alembert's principle, Simple applications of the Lagrangian formulation to systems with holonomic and non-holonomic constraints	15
II	Hamiltonian mechanics: physics in phase space with generalized coordinates and momenta treated as independent variables. Definition of the Hamiltonian (through Legendre's transformation) and its relation to the energy, Hamilton's canonical equations in cylindrical and spherical coordinates as well, Hamilton's principle, Derivation of Hamilton's equations by integral principle i.e. by Hamilton's principle, Derivation of Hamilton's principle by differential principle i. e. by D' Alembert's principle, Derivation of Lagrange's equations from integral principle i.e. Hamilton's principle, Simple applications of Hamilton's equations of motion. Cyclic (ignorable) coordinates and conservation laws. Routhian Mechanics: Definition of Routhian. Routh's equations of motion and energy function Principle of least action.	15
III	Variational Calculus and its Application to Mechanics: Euler's equation for functions of one dependent variable and its generalization to (i) "n" dependent variables (ii) higher order derivatives, Applications of calculus of variation: Shortest distance between two points on a plane, Minimum surface of revolution, Brachistochrone problem, Isoperimetric problem, Geodesic, Lagrange's multiplier method.	15
IV	Hamilton Jacobi theory: Hamilton Jacobi equation, Jacobi theorem, Method of separation of variables in Hamilton Jacobi equation and its simple applications.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Gelfand ,I.M., Fomin ,S.V. and Silverman ,R.A.:** Calculus of Variations, Prentice Hall,2000
2. **Goldstein, H.:** Classical Mechanics (3rd Edition), Pearson New International Edition, 2014, ISBN 13: 9780201657029/ ISBN 10: 0201657023
1. **Rana, N.C. and Joag, P.S.:** Classical Mechanics, Tata McGraw Hill, New Delhi, 1991. ISBN-10: 0074603159/ ISBN-13: 9780074603154

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core- Elective (Group - 1) COURSE- II : Financial Mathematics

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820325	Course Title: Financial Mathematics	Theory

Course Objectives: The objectives are to introduce the basic mathematical concepts and techniques used in finance and business. This also highlights the inter-relationships of the mathematics and problem-solving skills with a particular emphasis on financial and business applications.

Course outcomes:

CO1: Demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization.
CO2. Demonstrate understanding of concepts relating to functions and annuities.
CO3. Employ methods related to these concepts in a variety of financial applications
CO4. Apply logical thinking to problem solving in context.
CO5. Use appropriate technology to aid problem solving.
CO6. Demonstrate skills in writing mathematics

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 75 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Some Basic Definitions and Terminology, Basic option theory: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CCR) model, Black Scholes formula for potion pricing as a limit of CCR model.	15
II	Brownian ad Geometric Brownian Motion, Theory of Martingales, Stochastic Calculus, Stochastic differential Equations.	15
III	Ito"s formula to solve SDE"s, FeymannKac theorem, Application of stochastic calculus in option pricing, Black Scholes partial differential equations and Black Scholes formula.	15
IV	Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM), Interest rates and interest rate derivatives:	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Parikh, J.C.**, Stochastic Process and Financial Markets, Alpha Science International, 2003.
1. **Roman,S.** An Introduction the Mathematics of Finance, Springer, 1st Edition, 2000
1. **Ross,S.** An Introduction to Mathematical Finance, Cambridge University press,3rd Edition, 2011.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective (Group-1) Course – III : FLUID DYNAMICS

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820326	Course Title: FLUID DYNAMICS	Theory

Course Objectives: Almost everything on this planet, either is a fluid or moves within or near a fluid. Fluid Mechanics is an important subject that is particularly open to cross fertilization with other sciences and disciplines of engineering. The main objective of the course is to develop fundamental knowledge and understanding of the mechanics of fluid at rest and in motion to develop the ability to demonstrate and formulate physical problems encountered in different branches of engineering in mathematical form and arrive at useful solutions

CO1. To know, understand and apply the basic concepts of Fluid Mechanics .
CO2. To describe the physical properties of a fluid.
CO3. To convert physical laws of conservation of mass, momentum, moment of momentum and energy into mathematical equations and apply them to describe the fluid motion.
CO4. To frame and describe the flow through potential function and stream function.
CO5. To describe the motion of ideal and real fluids with different techniques including complex variable technique.
CO6. To understand stress-strain relationship in Newtonian fluids.
CO7. To apply Bernoulli equations in their domain of validity for fluid flow rate measurement.
CO8. To understand the singularities of the flow field.
CO9. To make dimensional analysis and use it to derive the dimensionless numbers
CO10. To link flow behavior with non-dimensional parameters
CO11. To apply the similitude concept and set up the relation between a model and a prototype.
CO12. To define, describe and apply the basic flow equations, such as the Navier-Stokes equations to evaluate velocity, pressure drop in simple geometries like laminar flows between parallel plates, axial and transverse flows in pipes and flows in annular region produced.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minim Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Introduction: fluid characteristics, continuum concept and basic properties of fluids, Newtonian law of viscosity, Kinematics of fluids: Eulerian vs. Lagrangian descriptions of fluid motion, Equivalence of Lagrangian and Eulerian methods, General motion of a fluid element: Translation (Acceleration of a fluid particle in a velocity field), Rotation (angular deformation) and Deformation (volumetric or extensional strain/ shear strain), Flow lines: Stream lines, Path lines, Streak lines, Boundary conditions and boundary surface.	15
II	General theory of stress in a real fluid: Normal stress, Shearing stress, Transformation of stress components from one coordinate system to another coordinate system, Symmetry of stress tensor, Plane stresses, Principal directions and Principal values of stress tensor, Constitutive equation for Newtonian fluid, Conservation laws by the Control Volume approach: Mass conservation equation in rectangular cartesian, cylindrical and spherical coordinate systems, Equivalence of the mass conservation equations derived by Lagrangian method and Eulerian method, Equation of conservation of momentum (NavierStokes Equation and Euler Equation), Equation of conservation of moment of momentum, Equation of conservation of energy, Simple and direct applications of conservation equations.	15
III	Vorticity and circulation, Elementary properties of vortex motion, Stream function for two-dimensional incompressible Flow, Stream function and potential flow theory, Theorems about rotational and irrotational flows of inviscid and incompressible flows – Stokes' theorem, Kelvin's minimum energy theorem, Gauss theorem, Kelvin's circulation theorem, Uniqueness of irrotational flows, Bernoulli's equation for incompressible and inviscid flows: Integration of Euler's equation along a streamline for steady and unsteady flows, Applications of Bernoulli's equation for irrotational flows: Flow through an orifice, Motion of a jet through atmosphere, Pitot tube, Venturi meter.	15
IV	Two-dimensional irrotational incompressible flows (Complex variable technique and its applications): Blasius theorem, Milne's circle theorem, Flow field singularities: Sources, Sinks and Doublets in two dimensions, Images of a source/ sink/ doublet with respect to a line and with respect to a circle, Simple applications of source, sink and doublet. Dimensional analysis, Buckingham Pi theorem, Dimensionless numbers (Reynold number, Pressure coefficient, Mach number, Froude number, Prandtl number) and their properties Basic introduction to Newtonian and non-Newtonian rheologies	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Batchelor, G.K.** An Introduction of Fluid Mechanics, Oxford University Books, NewDelhi, 2000.
2. **Charlton, F.:** Text Book of Fluid Dynamics, CBS Publishers, Delhi, 2004.
3. **Raisinghania, M.D.:** Fluid Dynamics: with Complete Hydrodynamics and Boundary Layer Theory, S. Chand Publishing, 2014, ISBN 13: 9788121908696.
4. **Rathy, R.K.:** An Introduction of Fluid Dynamics, Oxford and IBH Publishing Co.,New Delhi, 1903.
5. **Yuan, S.W.:** Foundations of Fluid Mechanics, Prentice Hall of India Private Limited.New-Delhi, 1988., ISBN10: 0133298132/ ISBN-13: 978-0133298130.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG Level..

Suggested equivalent online courses: There are online courses on the channels such as Swayam, Swayam Prabha, and NPTEL. e-contents from different online libraires.

Further Suggestions:.....

Core-Elective (Group-2) COURSE-I : Linear Algebra

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820327	**Course Title: Linear Algebra**	**Theory**

Course Objectives:
The main objective of this course is to develop theoretical as well as working knowledge of the central ideas of linear algebra like linear transformations, invertibility & isomorphisms, eigenvalues, eigenvectors, the minimal polynomial, diagonalization, canonical forms, rational & Jordan forms, bilinear forms and their classification.
Linear algebra finds applications in coding theory, cryptography, graph theory and linear programming. Thus, after completing this course, students shall bear a good insight to study general plus advanced contents of the above-mentioned courses.

Course outcomes:
CO1: Understand the notion of a vector space and linear transformation and to determine basis and dimension of a vector space.
CO2: Understand the concept of linear transformation and to find the range space and null space of the linear transformation
CO3: Find the eigenvectors and Eigen-value of a square matrix and to know diagonalization of the matrix
CO4: Compute an orthogonal basis using the Gram-Schmidt process.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40
	Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester	
Unit	**Course Topic**	**No. of Lectures Hours**
I	Linear transformations, Isomorphism, Range and null space, The matrix representation of linear transformations, Linear functional, Double dual.	15
II	Invertibility and Isomorphisms, The change of coordinate matrix, The transpose of a linear transformations, Polynomial ideals, Prime factorization of polynomials, Inner product spaces, Bessel's inequality, Normal and unitary operators.	15
III	Elementary canonical forms: Annihilating polynomials, The minimal polynomial, Invariant subspaces,Simultaneous triangulation, Simultaneous diagonalization, Direct-sum decomposition, Invariant direct sums, The primary decomposition theorem.	15
IV	Orthogonal and unitary reduction of quadratic and Hermitian form, Positive definite quadratic forms, simultaneous reduction. Bilinear forms, Matrix of a bilinear form, Classification of bilinear forms: Symmetric bilinear forms, Skew-symmetric bilinear forms	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **David C.Lay, Steven R.Lay and Judi J.MC Donald**; Linear Algebra and Its Applications, 6th Edition Pearson Education 2021.
2. **Hoffman, K., Kunze R.**: Linear Algebra (2nd Edition), Pearson, 2017.
3. **Friedberg, S.H., Insel ,A.J., Spence, L.E.**: Linear Algebra Pearson Education India,2015.
4. **Strang, G.** Linear Algebra and its Applications (4th Edition), Cengage Learning, 2007.
5. **Sahai, V. and Bist, V.**: Linear Algebra (2nd Edition), Narosa Publishing House, 2013.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective (Group-2) COURSE-II : Data Structure with C

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820328	Course Title: Data Structure with C	Theory

Course Objectives:

1. A prominent purpose of programming languages is to provide instructions to a computer.
2. Programming languages differ from most other forms of human expression in that they require a greater degree of precision and completeness.
3. Studying programming languages will help the students be better at their job, make more money, and be a happier, more fulfilled and more informed citizen, because they will learn to: Choose the most appropriate language for a given task.
1. A programming language lets the students to express computational tasks in certain ways.
2. Programming languages often produce more efficient code through optimization for specific system architecture.

Course outcomes:

CO1. Understanding a functional hierarchical code organization.
CO2. Ability to define and manage data structures based on problem subject domain.
CO3. Ability to work with textual information, characters and strings.
CO4. Students will be able to develop logics which will help them to create programs, applications in C.
CO5. Also, by learning the basic programming constructs they can easily switch over to any other Language in future.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	**Introduction to the C Language:** Writing a Simple C Program: Learning the format of a C program, declaring variables, designing program flow and control, defining and using functions, data types, using standard terminal I/O functions.	15
II	**Conditional Program Execution:** Applying if and switch statements, nesting if and else, restrictions on switch values, use of break and default with switch. Program Loops and Iteration: Uses of while, do and for loops, multiple loop variables, assignment operators, using break and continue. **Modular Programming, Arrays and Structures** Passing arguments by value, scope rules and global variables, separate compilation, and linkage, building your own modules. Array notation and representation, manipulating array elements, using multidimensional arrays, arrays of unknown or varying size.	15
III	**Structures:** Purpose and usage of structures, declaring structures, assigning of structures. Unions: Components in overlapping memory, declaring and using unions. .h vs. private .c files, hiding private variables and functions	15
IV	**Functions and Pointers to Objects:** Simple C-functions, passing arguments to functions, returning values from functions, reference arguments, overloaded functions, recursion, inline functions, default arguments, scope and storage class, returning by reference, Constant function arguments, runtime memory management. Pointer and address arithmetic, pointer operations and declarations, using pointers as function arguments, Dynamic memory allocation	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1.**Budd,**"Object Oriented Programming ", Addison Wesley
2.**Balaguruswamy,** "Programming in ANSI C," TMH
3.**Kanetkar ,Yashwant** "Pointers in C"
4.**Schield, Herbert,** Complete Reference in C," TMH
1. **Yashwant Kanetkar,"** Let us C", BPB

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions: .....

Core-Elective (Group-2) Course – III: Dynamical System

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820329	Course Title: Dynamical Systems	Theory

Course Objectives: Dynamical systems describe the time evolution of systems which arise from mathematics, physics, biology, chemistry and other areas. As mathematical objects they are ordinary differential equations, usually nonlinear and therefore not usually able to explicitly solved. The aim of the course is to see how to make a qualitative analysis of a dynamical system using many different analytic tools. Course outcomes:

CO1. To introduce students to the basic mathematical skills for the qualitative solving of low dimensional systems of ordinary differential equations in continuous time, including dimensionless forms, phase portraits, and bifurcations.

CO2. To provide a brief introduction to the way ordinary differential equation can be used to model, explain and interpret real world problems.

CO3. To provide a brief introduction to the theory and concepts that under pin the field of dynamical systems.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	The orbit of a map, fixed point, equilibrium point, periodic point, circular map, configuration space and phase space.	15
II	Origin of bifurcation. Stability of a fixed point, equilibrium point. Concept of limit cycle and torus. Hyperbolicity. Quadratic map. Feigenbaum's universal constant.	15
III	Turning point, trans critical, pitch work. Hopf bifurtation. Period doubling phenomena. Nonlinear OscillatorsConservative system. Hamiltonian system. Various Type of oscillators in nonlinear system. Solutions of nonlinear differential equations.	15
IV	Phenomena of losing stability. Quasiperiodic motion. Topological study of nonlinear differential equations. Poincare map.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Arnold. V.I, Dynamical Systems. Cambridge University Press, 1993.
2. Arrowsmith. D.K., Introduction to Dynamical Systems, Cambridge University Press, 1990.
3. Robert L.Davaney. An Introduction to Chaotic Dynamical Systems, Addison-Wesley Publishing Co. 1989.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraires.

Further Suggestions:.....

Maa Shakumbhari University, Saharanpur

Syllabus- B.Sc.(Mathematics) Honours with Research

Programme Outcome/ Programme Specific Outcome
Programme Outcome: **PO1:** It is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for the same. **PO2:** It is to develope enhanced quantitative skills and pursuing higher mathematics and research as well. **PO3:** Students will be able to develop solution oriented approach towards various issues related to their environment. **PO4:** Students will become employable in various govt. and private sectors **PO5:** Scientific temper in general and mathematical temper in particular will be developed in students. **Programme Specific Outcome:** **PSO1:** Student should be able to possess recall basic idea about mathematics which can be displayed by them. **PSO2:** Student should have adequate exposure to many aspects of mathematical sciences. **PSO3:** Student is equipped with mathematical modeling ability, critical mathematical thinking, and problem solving skills etc. **PSO4:** Student should be able to apply their skills and knowledge in various fields of studies including, science, engineering, commerce and management etc.

B.Sc.(Mathematics)-I Year
Certificate in Mathematics

B.Sc. I (SEMESTER-I) PAPER-I Differential Calculus & Integral Calculus

Programme: Certificate Class: B.Sc.	Year: First	Semester: First
Subject: Mathematics		
NEP Code: B030101T Course Code: 0120301	Course Title: Differential Calculus & Integral Calculus	

Course outcomes:

CO1: The programme outcome is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for developing enhanced quantitative skills and pursuing higher mathematics and research as well.

CO2: By the time students complete the course they will have wide ranging application of the subject and have the knowledge of real valued functions such assequence and series. They will also be able to know about convergence of sequence and series. Also, they have knowledge about curvature, envelope and evolutes and trace curve in polar, Cartesian as well as parametric curves.

CO3: The main objective of the course is to equip the student with necessary analytic and technical skills. By applying the principles of integral he learns to solve a variety of practical problems in science and engineering.

CO4: The student is equipped with standard concepts and tools at an intermediate to advance level that will serve him well towards taking more advance level

course in mathematics.

Credits: 4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Part- A Differential Calculus

Unit	Topics	No. of Lectures
I	**Introduction to Indian Ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE).** Definition of a sequence, theorems on limits of sequences, bounded and monotonic sequences, Cauchy's convergence criterion, Cauchysequence, limit superior and limit inferior of a sequence, subsequence, Series of non-negative terms, convergence and divergence, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic test, de Morgan and Bertrand's tests, alternating series, Leibnitz's theorem, absolute and conditional convergence.	9
II	Limit, continuity and differentiability of function of single variable, Cauchy's definition, Heine's definition, equivalence of definition of Cauchy and Heine, Uniform continuity, Borel's theorem, boundedness theorem, Bolzano's theorem, Intermediate value theorem, extreme value theorem, Darboux's intermediate value theorem for derivatives, Chain rule., indeterminate forms.	7
III	Rolle's theorem, Lagrange and Cauchy Mean value theorems, mean value theorems of higher order, Taylor's theorem with various forms of remainders, Successive differentiation, Leibnitz theorem, Maclaurin's and Taylor's series, Partial differentiation, Euler's theorem on homogeneous function.	7
IV	Tangent and normals, Asymptotes, Curvature, Envelops and evolutes, Tests for concavity and convexity, Points of inflexion, Multiple points, Parametric representation of curves and tracing of parametric curves, Tracing of curves in Cartesian and Polar forms.	7

Part-B. Integral Calculus

Unit	Topics	No. of Lectures
V	Definite integrals as limit of the sum, Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Differentiation under the sign of Integration.	9
VI	Improper integrals, their classification and convergence, Comparison test, μ-test, Abel's test, Dirichlet's test, quotient test, Beta and Gamma functions.	7
VII	Rectification, Volumes and Surfaces of Solid of revolution, Pappus theorem, Multiple integrals, change of order of double integration, Dirichlet's theorem, Liouville's theorem for multiple integrals.	7
VIII	Vector Differentiation, Gradient, Divergence and Curl, Normal on a surface, Directional Derivative, Vector Integration, Theorems of Gauss, Green, Stokes (without proof) and related problems.	7

Suggested Readings (Part- A Differential Calculus):

1. R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons
2. T.M. Apostal, Calculus Vol. I, John Wiley & Sons Inc.
3. S. Balachandra Rao & C. K. Shantha, Differential Calculus, New Age Publication.
4. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc., 2002.
5. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2007.
6. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS
7. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Integral Calculus):

1. T.M. Apostal, Calculus Vol. II, John Wiley Publication
2. Shanti Narayan & Dr. P.K. Mittal, Integral Calculus, S.Chand
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Chemistry/Biochemistry/Life Sciences(UG),

Economics(UG/PG), Commerce(UG), BBA/BCA, B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment (Introduction to Indian ancient Mathematics and Mathematicians).	5

Course prerequisites: To study this course, a student must have subject Mathematics in class 12th

Suggested equivalent online courses:

B.Sc. I (SEMESTER-I) Paper-II Practical

Programme: Certificate Class: B.Sc.	Year: First	Semester: First
Subject: Mathematics		
Course Code: 0120380 NEP Code: B030102P	Course Title: Practical	

Course outcomes:

CO1: The main objective of the course is to equip the student to plot the different graph and solve the different types of equations by plotting the graph using different computer software such as Mathematica /MATLAB /Maple /Scilab/Maxima etc.

CO2. After completion of this course student would be able to know the convergence of sequences through plotting, verify Bolzano-Weierstrass theorem through plotting the sequence, Cauchy's root test by plotting n^{th} roots and Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

CO3. Student would be able to plot Complex numbers and their representations, Operations like addition, substraction, Multiplication, Division, Modulus and Graphical representation of polar form.

CO4: Student would be able to perform following task of matrix as Addition, Multiplication, Inverse, Transpose, Determinant, Rank, Eigenvectors, Eigenvalues, Characteristic equation and verification of the Cayley-Hamilton theorem, Solving the systems of linear equations.

Credits: 2	Core Compulsory / Elective
Max. Marks: 100	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4

Unit	Topics	No. of Lectures
	Practical / Lab work to be performed in Computer Lab. List of the practicals to be done using Mathematica /MATLAB /Maple /Scilab/Maxima etc. 1. Plotting the graphs of the following functions: (i) ax (ii) [x] (greatest integer function) (iii) x^{2n} ; $n \in N$ (iv) x^{2n-1} ; $n \in N$ (v) $\frac{1}{x^{2n-1}}$; $n \in N$ (vi) $\frac{1}{x^{2n}}$; $n \in N$ (vii) $\sqrt{ax+b}$, $|ax+b|$, $c \pm \|ax+b\|$ (ix) $\frac{1}{x}$, $\sin\frac{1}{x}$, $x\sin\frac{1}{x}$, e^x, e^{-x} for $x \neq 0$. (x) e^{ax+b}, $\log(ax+b)$, $\frac{1}{ax+b}$, $\sin(ax+b), \cos(ax+b), \|\sin(ax+b)\|, \|\cos(ax+b)\|$.	

	Observe and discuss the effect of changes in the real constants a and b on the graphs. (2) By plotting the graph find the solution of the equation $x = e^x$, $x^2 + 1 = e^x$, $1 - x^2 = e^x$, $x = \log_{10}(x)$, $\cos(x) = x$, $\sin(x) = x$, $\cos(y) = \cos(x)$, $\sin(y) = \sin(x)$ etc (3) Plotting the graphs of polynomial of degree 2,3, 4 and 5, and their first and second derivatives. (4) Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid and Hypocycloid etc. (5) Tracing of conic in Cartesian coordinates. (6) Graph of circular and hyperbolic functions. (7) Obtaining surface of revolution of curves. (8) Complex numbers and their representations, Operations like addition, Multiplication, Division, Modulus. Graphical representationof polar form. (9) Matrix Operations: Addition, Multiplication, Inverse, Transpose, Determinant, Rank.	
Suggested Readings		

B.Sc. I (SEMESTER-II) PAPER-I Matrices and Differential Equations & Geometry

Programme: Certificate Class: B.Sc.	Year: First	Semester: Second
Subject: Mathematics		
Course Code: 0220301 NEP Code: B0302017	Course Title: Matrices and Differential Equations & Geometry	

Course outcomes:

CO1: The subjects of the course are designed in such a way that they focus on developing mathematical skills in algebra, calculus and analysis and give in depth knowledge of geometry, calculus, algebra and other theories.

CO2: The student will be able to find the rank, eigen values of matrices and study the linear homogeneous and non-homogeneous equations. The course in differential equation intends to develop problem solving skills for solving various types of differential equation and geometrical meaning of differential equation.

CO3: The subjects learn and visualize the fundamental ideas about coordinate geometry and learn to describe some of the surface by using analytical geometry.

CO4: On successful completion of the course students have gained knowledge about regular geometrical figures and their properties. They have the foundation for higher course in Geometry.

Credits: 6	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0	

PART-A. Matrices and Differential Equations

Unit	Topics	No. of Lectures
I	Types of Matrices, Elementary operations on Matrices, Rank of a Matrix, Echelon form of a Matrix, Normal form of a Matrix, Inverseof a Matrix by elementary operations, System of linear homogeneous and non-homogeneous equations, Theorems on consistency of a system of linear equations.	12
II	Eigen values, Eigen vectors and characteristic equation of a matrix, Caley-Hamilton theorem and its use in finding inverse of a matrix.Complex functions and separation into real and imaginary parts, Exponential and Logarithmic functions Inverse trigonometric and hyperbolic functions.	11
III	Formation of differential equations, Geometrical meaning of a differential equation, Equation of first order and first degree, Equationin which the variables are separable, Homogeneous equations, Exact differential equations and equations reducible to the exact form, Linear equations.	11
IV	First order higher degree equations solvable for x, y, p, Clairaut's equation and singular solutions, orthogonal trajectories, Linear differential equation of order greater than one with constant coefficients, Cauchy- Euler form.	11

PART-B. Geometry

Unit	Topics	No. of Lectures
V	General equation of second degree, System of conics, Tracing of conics, Confocal conics in two dimentional geometry.	12
VI	Three-Dimensional Coordinates, Projection and Direction Cosine, Plane (Cartesian and vector form), Straight line in three dimension.	11
VII	Sphere and Cone with related problems	11
VIII	Cylinder, Definition only: Central conicoids, Paraboloids, Plane section of conicoids, Generating lines, Confocal conicoids.	11

Suggested Readings (PART-A Matrices and Differential Equations):

1. Stephen H. Friedberg, A.J Insel & L.E. Spence, Linear Algebra, Person
2. B. Rai, D.P. Choudhary & H. J. Freedman, A Course in Differential Equations, Narosa
3. D.A. Murray, Introductory Course in Differential Equations, Orient Longman
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
5. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Geometry):

1. Robert J.T Bell, Elementary Treatise on Coordinate Geometry of three dimensions, Macmillan India Ltd.
2. P.R. Vittal, Analytical Geometry 2d & 3D, Pearson.
3. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London.
4. R.J.T. Bill, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan India Ltd., 1994.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Economics(UG/PG), Commerce(UG), BBA/ BCA,

B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have subject Mathematics in class 12th

Suggested equivalent online courses:

Further Suggestions:

B.Sc.(Mathematics)-II Year
Diploma in Mathematics

B.Sc.II (SEMESTER-III) PAPER-I Algebra & Mathematical Methods

Programme: Diploma Class: B.Sc.	Year: Second Semester: Third
Subject: Mathematics	
Course Code: 0320301 NEP Code: B030301T	Course Title: Algebra & Mathematical Methods

Course outcomes:

CO1: Group theory is one of the building blocks of modern algebra. Objective of this course is to introduce students to basic concepts of Group, Ring theory and their properties.

CO2: A student learning this course gets a concept of Group, Ring, Integral Domain and their properties. This course will lead the student to basic course in advanced mathematics and Algebra.

CO3: The course gives emphasis to enhance students' knowledge of functions of two variables, Laplace Transforms, Fourier Series.

CO4: On successful completion of the course students should have knowledge about higher different mathematical methods and will help him in going for higher studies and research.

Credits: 6	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0	

Part- A. Algebra

Unit	Topics	No. of Lectures
I	Introduction to Indian ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE). Equivalence relations and partitions, Congruence modulo n, Definition of a group with examples and simple properties, Subgroups, Generators of a group, Cyclic groups.	12
II	Permutation groups, Even and odd permutations, The alternating group, Cayley's theorem, Direct products, Coset decomposition, Lagrange's theorem and its consequences, Fermat and Euler theorems	11
III	Normal subgroups, Quotient groups, Homomorphism and isomorphism, Fundamental theorem of homomorphism, Theorems on isomorphism.	11
IV	Rings, Subrings, Integral domains and fields, Characteristic of a ring, Ideal and quotient rings, Ring homomorphism, Field of quotient of an integral domain.	11

Part- B
Mathematical Methods

Unit	Topics	No. of Lectures
V	Limit and Continuity of functions of two variables, Differentiation of function of two variables, Necessary and sufficient condition for differentiability of functions two variables, Schwarz's, Young theorem, Taylor's theorem (Statements only) for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange multiplier method(without proof), Jacobians.	12
VI	Existence theorems for Laplace transforms, Linearity of Laplace transform and their properties, Laplace transform of the derivatives and integrals of a function, Convolution theorem, inverse Laplace transforms, Solution of the differential equations using Laplace transforms.	11
VII	Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Fourier transforms (finite and infinite).	11
VIII	Calculus of variations-Variational problems with fixed boundaries- Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives.	11

Suggested Readings(Part-A Algebra):

1. J.B. Fraleigh, A first course in Abstract Algebra, Addison-weley
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons
3. Suggested digital plateform: NPTEL/SWAYAM/MOOCS
4. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part- B Mathematical Methods):

1. T.M. Apostal, Mathematical Analysis, Person
2. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata -McGrawHill
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4. Suggested digital plateform: NPTEL/SWAYAM/MOOCs
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment (Introduction to Indian ancient Mathematics and Mathematicians)	5

Course prerequisites: To study this course, a student must have subject Mathematics in class 12th

Suggested equivalent online courses:

Further Suggestions:

B.Sc. II (SEMESTER-IV) PAPER-I Differential Equations & Mechanics

Programme: Diploma Class: B.Sc.	Year: Second	Semester: Fourth
Subject: Mathematics		
Course Code: 0420301 NEP Code: B030401T	Course Title: Differential Equations & Mechanics	

Course outcomes:

CO1: The objective of this course is to familiarize the students with various methods of solving differential equations, partial differential equations of first order and second order and to have qualitative applications.

CO2: A student doing this course is able to solve differential equations and is able to model problems in nature using ordinary differential equations. After completing this course, a student will be able to take more courses on wave equation, heat equation, diffusion equation, gas dynamics, non linear evolution equation etc. These entire courses are important in engineering and industrial applications for solving boundary value problem.

CO3: The object of the paper is to give students knowledge of basic mechanics such as simple harmonic motion, motion under other laws and forces.

CO4: The student, after completing the course can go for higher problems in mechanic such as hydrodynamics, this will be helpful in getting employment in industry.

Credits: 6	Core Compulsory / Elective
Max. Marks: 25+75	Min. Passing Marks:
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0	

Part- A

Differential Equations

Unit	Topics	No. of Lectures
I	Second order linear differential equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters.	11
II	Elementary idea of Power series solutions of second order ordinary differential equations(ODE); Bessels and Legender functions and their properties	12
III	Origin of first order partial differential equations. Partial differential equations of the first order and degree one, Lagrange's solution, Partial differential equation of first order and degree greater than one. Charpit's method of solution,	11
IV	Origin of second order PDE, Solution of partial differential equations of the second and higher order with constant coefficients, Classification of linear partial differential equations of second order, Solution of second order partial differential equations with variable coefficients, Monge's method of solution.	11

Part- B

Mechanics

Unit	Topics	No. of Lectures
V	Frame of reference, work energy principle, Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines and planes.	11
VI	Virtual work, Stable and Unstable equilibrium.	11
VII	Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other law of forces. Elastic strings, Motion in resisting medium,	11
VIII	Constrained motion, Motion on smooth and rough plane curves. Central orbit, Kepler's laws of motion, Motion of particle in three dimensions	12

Suggested Readings(Part-A Differential Equations):

1. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata –McGrawHill
2. B. Rai, D.P. Choudhary & H. J. Freedman, A Course of Ordinary Differential Equations, Narosa
3. Ian N. Snedden, Elements of Partial Differential Equations, Dover Publication
4. L.E. Elsgolts, Differential Equation and Calculus of variations, University Press of the Pacific.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings(Part-B Mechanics):

1. R.C. Hibbeler, Engineering Mechanics-Statics, Prentics Hall Publishers
2. R.C. Hibbeler, Engineering Mechanics-Dynamics, Prentics Hall Publishers
3. A. Nelson, Engineering Mechanics Statics and Dynamics, Tata McGraw Hill
4. J.L. Synge & B.A. Griffith, Principles of Mechanics, Tata McGraw Hill
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Economics(UG/PG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Certificate Course in Applied Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc.(Mathematics)-III Year
Degree in Mathematics

B.Sc. III (SEMESTER-V) PAPER-I Group and Ring Theory & Linear Algebra

Programme: Degree Class: B.Sc.	Year: Third	Semester: Fifth
Subject: Mathematics		
Course Code: 0520301 NEP Code: B030501T	Course Title: Group and Ring Theory & Linear Algebra	

Course outcomes:

CO1: Liner algebra is a basic course in almost all branches of science. The objective of this course is to introduce a student to the basics of linear algebra andsome of its applications.
CO2: Students will be able to know the concepts of group, ring and other related properties which will prepare the students to take up further applications in the relevant fields.
CO3: The student will use this knowledge in computer science, finance mathematics, industrial mathematics and bio mathematics. After completion of this course students appreciate its interdisciplinary nature.

Credits: 5	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0

PART-A

Group and Ring Theory

Unit	Topics	No. of Lectures
I	**Introduction to Indian ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE).** Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups.	10
II	Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.	10
III	Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion.	9
IV	Divisibility in integral domains, Irreducibles, Primes, Unique factorization domains, Euclidean domains.	9

PART-B

Linear Algebra

Unit	Topics	No. of Lectures
V	Vector spaces, Subspaces, Linear independence and dependence of vectors, Basis and Dimension, direct sum and Quotient space.	10
VI	Linear transformations, The Algebra of linear transformations, rank and null space.	9
VII	Rank nullity theorem, their representation as matrices., Change of basis, Characteristic values, Cayley Hamilton Theorem.	9
VIII	Inner product spaces and norms, Cauchy-Schwarz inequality, Orthogonal vectors, Orthonormal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process.	9

Suggested Readings:

1. Topics in Algebra by I. N. Herstein.
2. Linear Algebra by K. Hoffman and R. Kunze.
3. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
4. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), BCA, B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment (Introduction to Indian ancient Mathematics and Mathematicians)	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-V) PAPER-II (i) Number Theory & Game Theory

Programme: Degree	Year: Third	Semester: Sixth
Class: B.Sc.		
Subject: Mathematics		
Course Code: 0520302 Code: B030502T	Course Title: Number Theory & Game Theory	

Course outcomes:

CO1: Upon successful completion, students will have the knowledge and skills to solve problems in elementary number theory and also apply elementary

number theory to cryptography.

CO2: This course provides an introduction to Game Theory. Game Theory is a mathematical framework which makes possible the analysis of the decision making process of interdependent subjects. It is aimed at explaining and predicting how individuals behave in a specific strategic situation, and therefore help improve decision making.

CO3: A situation is strategic if the outcome of a decision problem depends on the choices of more than one person. Most decision problems in real life are strategic.

CO4: To illustrate the concepts, real-world examples, case studies, and classroom experiments might be used.

Credits: 5	Elective
Max. Marks: 25+75	Min. Passing Marks: 33
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0	

Part- A

Number Theory

Unit	Topics	No. of Lectures
I	**Theory of Numbers** Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem.	10
II	**Congruences** Congruence modulo powers of prime; primitive roots and their existence; quadratic residues; Legendre symbol, Jacobi symbol, Mobious Function and Euler's phi Function.	9
III	**Diophantine Equations** Solutions of $ax + by = c$, $x^n + y^n = z^n$; properties of Pythagorean triples; sums of two and four squares; assorted examples of diophantine equations.	9
IV	**Generating Functions and Recurrence Relations** Generating Function Models, Calculating coefficient of generating functions, Partitions, Exponential Generating Functions, A Summation Method. Recurrence Relations: Recurrence Relation Models, Divide and conquer Relations, Solution of Linear, Recurrence Relations, Solution of Inhomogeneous Recurrence Relations, Solutions with Generating Functions.	9

Part- B
Game Theory

Unit	Topics	No. of Lectures
V	Introduction, overview, uses of game theory, some applications and examples, and formal definitions of: the normal form, payoffs, strategies, pure strategy Nash equilibrium.	10
VI	Introduction, characteristic of game theory, Two- person zero-sum game, Pure and Mixed strategies, Saddle point and its existence.	10
VII	Fundamental Theorem of Rectangular games, Concept of Dominance, Dominance and Graphical method of solving Rectangulargames.	9
VIII	Relationship between rectangular game and Linear Programming Problem, Solving rectangular game by Simplex method, reduction ofm x n game and solution of 2x2, 2 x s, and r x 2 cases by graphical method.	9

Suggested Readings (Part-A Number Theory):

1. Niven, I., Zuckerman, H. S. and Montegomery, H. L. (2003) An Int. to the Theory of Numbers (6th edition) John Wiley and sons, Inc., New York.
2. Burton, D. M. (2002) Elementary Number Theory (4th edition) Universal Book Stall, New Delhi.
3. Balakrishnan, V. K. (1994) Schaum's Outline of Theory and Problems of Combinatorics Including Concepts of Graph Theory, Schaum's Outline.
4. Balakrishnan,V. K. (1996) Introductory Discrete Mathematics, Dover Publications.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Game Theory):

1. Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003
2. Vijay Krishna, Game Theory, Academic Press.
3. Prajit Dutta, Strategies and Games, MIT Press, (Website 1) http://www.ecc.stevens-tech.edu/~ecomanic/ee800c.html
5. Allan MacKenzie, Game Theory for Wireless Engineers, Synthesis lectures on Communications, 2006
6. Suggested digital plateform:NPTEL/SWAYAM/MOOCS
7. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-V) PAPER-II (ii) Graph Theory & Discrete Mathematics

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0520303 NEP Code: B030502T	Course Title: Graph Theory & Discrete Mathematics	

Course outcomes:

CO1: Upon successful completion, students will have the knowledge of various types of graphs, their terminology and applications.

CO2: After Successful completion of this course students will be able to understand the isomorphism and homomorphism of graphs. This course covers the basic concepts of graphs used in computer science and other disciplines. The topics include path, circuits, adjacency matrix, tree, coloring.. After successful completion of this course the student will have the knowledge graph coloring, color problem, vertex coloring.

CO3: After successful completion, students will have the knowledge of Logic gates, Karnaugh maps and skills to proof by using truth tables. After Successful completion of this course students will be able to apply the basics of the automation theory, transition function and table.

CO4: This course covers the basic concepts of discrete mathematics used in computer science and other disciplines that involve formal reasoning. The topics include logic, counting, relations, hasse diagram and Boolean algebra. After successful completion of this course the student will have the knowledge in

Mathematical reasoning, combinatorial analysis, discrete structures and Applications.

Credits: 5	Elective
Max. Marks: 25+75	Min. Passing Marks: 33
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0	

Part- A

Graph Theory

Unit	Topics	No. of Lectures
I	Introduction to graphs, basic properties of graphs, Simple graph, multi graph, graph terminology, representation of graphs, Bipartite,regular, planar and connected graphs, connected components in a graph, Euler graphs, Directed, Undirected, multi-graph, mixed graph.	10
II	Walk and unilateral components, unicursal graph, Hamiltonian path and circuits, Graph colouring, chromatics number, isomorphism and homomorphism of graphs, Incidence relation and degree of the graph.	9
III	Operation of graph circuit, Path and circuits, Eulerian circuits, Hamiltonian path and cycles, Adjacency matrix, Weighted graph,Travelling salesman problem, Shortest path, Dijkstra's algorithm.	9
IV	Tree, Binary and Spanning trees, Coloring, Color problems, Vertex coloring and important properties.	9

Part- B
Discrete Mathematics

Unit	Topics	No. of Lectures
V	**Propositional Logic-** Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification, proofby implication, converse, inverse contrapositive, contradiction, direct proof by using truth table.	10
VI	**Relation-** Definition, types of relation, domain and range of a relation, pictorial representation of relation, properties of relation, partial ordering relation, Representation of Posets using Hasse Diagram, Chains, Maximal and Minimal Point, Glb, Lub, Lattices and its basic properties	10
VII	**Boolean Algebra-** Basic definitions, Sum of products and products of sums, Logic gates Switching Circuits and Karnaugh maps	9
VIII	**Combinatories-** Inclusion- exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relations using G.F. solution of combinatorial problem using G.F.)	9

Suggested Readings (Part-A Graph Theory):

1. "Graph Theory with Applications to Engineering and Computer Science" by Narsingh Deo
2. "Introduction to Graph Theory" by Douglas B West
3. "Graph Theory with Algorithms and Its Applications: In Applied Science and Technology" by Santanu Saha Ray
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
5. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Discrete Mathematics):

1. Discrete Mathematics by C. L.Liu.
2. Discrete Mathematics with computer application by Trembley and Manohar. 3.Discrete Mathematics and Its Applications by Kenneth H. Rosen
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCS
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-V) PAPER-II (iii) Differential Geometry & Tensor Analysis

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0520304 NEP Code: B030502T	Course Title: Differential Geometry & Tensor Analysis	

Course outcomes:

CO1: After Successful completion of this course, students should be able to determine and calculate curvature of curves in different coordinate systems.
CO2: This course covers the Local theory of Curves, Local theory of surfaces, Geodesics, Geodesics curvature, Geodesic polars, Curvature of curves on surfaces, Gaussian curvature, Normal curvature etc.

CO3: After Successful completion of this course, students should have the knowledge of tensor algebra, different types of tensors, Riemannian space, Ricci tensor, Einstein space and Einstein tensor etc.

Credits: 5	Elective
Max. Marks: 25+75	Min. Passing Marks: 33
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0	

Part- A

Differential Geometry

Unit	Topics	No. of Lectures
I	Local theory of curves-Space curves, Examples, Plane Curves, tangent and normal and binormal, Osculating Plane, normal plane and rectifying plane, Osculating circle, osculating sphere Helices, Serret-Frenet apparatus, contact between curve and surfaces, tangent surfaces, involutes and evolutes of curves, Bertrand curves, Intrinsic equations, fundamental existence theorem for space curves.	10
II	Local Theory of Surfaces- Parametric patches on surface curve of a surface, family of surfaces (one parameter), edge of regression,ruled surfaces, skew ruled surfaces and developable surfaces, surfaces of revolution, Helicoids.	9
III	Metric-first fundamental form and arc length, Direction coefficients, families of curves, intrinsic properties, geodesics, canonicalgeodesic equations, normal properties of geodesics, geodesics curvature, Geodesic polars.	9
IV	Gauss-Bonnet theorem, curvature of curves on surfaces, Gaussian curvature, normal curvature, Meusneir's theorem, mean curvature,Gaussian curvature, umbilic points, lines of curvature, Rodrigue's formula, Euler's theorem.	9

Part- B
Tensor Analysis

Unit	Topics	No. of Lectures
V	Tensor algebra: Vector spaces, the dual spaces, tensor product of vector spaces, transformation formulae, contraction, special tensors-symmetric tensor, inner product, associated tensor with examples.	10
VI	Tensor Analysis: Contravariant and covariant vectors and tensors, Mixed tensors, Symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Quotient theorem, Reciprocal tensors, Christoffel's symbols, Law of transformation of Christoffel's symbols, Covariant differentiation, non- commutativity of Covariant derivative.	10
VII	Gradient of scalars, Divergence of a contravariant vector, covariant vector and conservative vectors, Laplacian of an invariant, curl of acovariant vector, irrotational vector, with examples.	9
VIII	Riemannian space, Riemannian curvatures and their properties, geodesics, geodesic curvature, geometrical interpretation of curvaturetensor, Ricci tensor, scalar curvature, Einstein space and Einstein tensor.	9

Suggested Readings (Part-A Differential Geometry):

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
3. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
4. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
5. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
6. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003.
7. An Introduction to Differential Geometry (with the use of tensor Calculus), L. P. Eisenhart, Princeton University Press, 1940.
8. Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continua, 2nd Edition, I. S. Sokolnikoff, John Wiley and Sons., 1964.
9. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
10. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Tensor Analysis):

1. Tensors- Mathematics of Differential Geometry by Z. Ahsan, PHI,2015
2. David C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill 1988.
3. R. S, Mishra, A Course in Tensors with Applications to Reimannian Geometry, Pothishala Pvt. Ltd, Allahabad.
4. Suggested digital plateform:NPTEL/SWAYAM/MOOCS
5. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

Sn	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-VI) PAPER-I METRIC SPACES & COMPLEX ANALYSIS

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0620301 NEP Code: B030601T	Course Title: METRIC SPACES & COMPLEX ANALYSIS	

Course outcomes:

CO1: The course is aimed at exposing the students to foundations of analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics.

CO2: After completion of this course the student will have rigorous and deeper understanding of fundamental concepts in Mathematics. This will be helpful to the student in understanding pure mathematics and in research.

CO3: Students will be able to know the concepts of metric space, basic concepts and developments of complex analysis which will prepare the students to take up further applications in the relevant fields.

Credits: 4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Part- A. Metric Spaces

Unit	Topics	No. of Lectures
I	**Basic Concepts** Metric spaces: Definition and examples, diameters in Metric Space. Bounded and Unbounded Metric Space.	8
II	**Topology of Metric Spaces** Open and closed ball, Neighborhood, Open set, Interior of a set, limit point of a set, derived set, closed set, closure of a set.Subspaces, Dense set.	8
III	**Completeness in Metric Spaces** Sequences in metric spaces, Cauchy sequences, Complete metric space with Examples, Cantor intersection Theorem	7
IV	**Continuity & Uniform Continuity in Metric Spaces** Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mapping, Banach fixed point theorem	7

Part- B
Complex Analysis

Unit	Topics	No. of Lectures
V	Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae,	8
VI	Cauchy-Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples, Harmonic Function, method of construction of a regular function(Milne-Thomson's Method..	8
VII	Conformal Mapping, necc. & suff. Condition; inverse point, bilinear transformation, critical point, cross ratio, fixed point.	7
VIII	Exponential functions, Logarithmic functions, branches and derivative of logarithmic function, Trigonometric functions, Derivative of functions. Definite integral of functions, contours, contour integrals and its examples, upper bound for moduli of contour integrals	7

Suggested Readings (Part-A Metric Space):

1. Mathematical Analysis by Shanti Narain.
2. Shirali, Satish & Vasudeva, H. L. (2009). Metric Spaces, Springer, First Indian Print.
3. Kumaresan, S. (2014). Topology of Metric Spaces (2nd ed.). Narosa Publishing House. New Delhi.
4. Simmons, G. F. (2004). Introduction to Topology and Modern Analysis.Tata McGraw Hill. New Delhi.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCS.
6. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Complex Analysis):

1. Function of Complex Variable by Shanti Narain.
2. Complex variable and applications by Brown & Churchill.
3. Suggested digital plateform:NPTEL/SWAYAM/MOOCS.
4. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-VI) PAPER-II Numerical Analysis & Operation Research

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0620302 NEP Code: B030602T	Course Title: Numerical Analysis & Operations Research	

Course outcomes:

CO1: The aim of this course is to teach the student the application of various numerical technique for variety of problems occurring in daily life. At the end ofthe course the student will be able to understand the basic concept of Numerical Analysis and to solve algebraic and differential equation.

CO2: The main outcome will be that students will be able to handle problems and finding approximated solution. Later he can opt for advance course in Numerical Analysis in higher Mathematics.

CO3: The student will be able to solve various problems based on convex sets and linear programming. After successful completion of this paper will enable the students to apply the basic concepts of transportation problems and its related problems to apply in further concepts and application of operations research.

Credits: 4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

PART-A

Numerical Analysis

Unit	Topics	No. of Lectures
I	Errors in computations, floating point representation of numbers, significant digits, rounding and chopping errors, absolute and relative errors, computation of errors using differentials, truncation errors. Solution of algebraic and transcendental equations; bisection, Secant, Regular Falsi, Newton Raphson's method, Newton's method for multiple roots.	8
II	Caculus of finite differences, Interpolation,Lagrange and Hermite interpolation, Newton's Divided difference formula, Interpolation formula using differences.	8
III	Numerical differentiation using Newton's forwarded and backward formula, differentiation by central and divided difference formula. Numerical Integration: Trapezoidal, Weddle, Simpsons Newton Cotes Formulas, Gaussian Quadratic Formulas.	7
IV	System of Linear equations: Direct method for solving systems of linear equations (Gauss elimination, LU Decomposition, Cholesky Decomposition),Iterative methods (Jacobi, Gauss Seidel, Relaxation methods).	7

PART-B. Operations Research

Unit	Topics	No. of Lectures
V	Introduction, Linear programming problems, statement and formation of general linear programming problems, graphical method, slack and surplus variables, standard and matrix forms of linear programming problem, basic feasible solution.	8
VI	Convex sets, fundamental theorem of linear programming, basic solution, Simplex method, introduction to artificial variables, two phase method Big-M method and their comparison.	8
VII	Resolution of degeneracy, duality in linear programming problems, primal dual relationships, revised simplex method, sensitivity analysis.	7
VIII	Transportation problems, assignment problems.	7

Suggested Readings(Part-A Numerical Analysis):

1. Numerical Methods for Engineering and scientific computation by M. K. Jain, S.R.K. Iyengar & R.K. Jain.
2. Introductory methods of Numerical Analysis by S. S. Sastry
3. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
4. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings(Part-B Operation Research):

1.Taha, Hamdy H, "Opearations Research- An Introduction ", Pearson Education.
2.Kanti Swarup , P. K. Gupta , Man Mohan Operations research, Sultan Chand & Sons
3.Hillier Frederick S and Lieberman Gerald J., "Operations Research", McGraw Hill Publication.
4.Winston Wayne L., "Operations Research: Applications and Algorithms", Cengage Learning, 4th Edition.
5.Hira D.S. and Gupta Prem Kumar, "Problems in Operations Research: Principles and Solutions", S Chand & Co Ltd.
6. Kalavathy S., "Operations Research", S Chand.
7. Suggested digital plateform:NPTEL/SWAYAM/MOOCs.
8. Course Books published in Hindi may be prescribed by the Universities.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Economics(UG/PG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

SN	Assessment Type	Max. Marks
1	Class Tests	10
2	Online Quizzes/ Objective Tests	5
3	Presentation	5
4	Assignment	5

Course prerequisites: To study this course, a student must have Certificate Course in Applied Mathematics

Suggested equivalent online courses:

Further Suggestions:

B.Sc. III (SEMESTER-VI) PAPER-III Practical

Programme: Degree Class: B.Sc.	Year: Third	Semester: Sixth
Subject: Mathematics		
Course Code: 0620380 NEP Code: B030603P	Course Title: Practical	

Course outcomes: The main objective of the course is to equip the student to solve the transcendental and algebraic equations, system of linear equations, ordinary differential equations, Interpolation, Numerical Integration, Method of finding Eigenvalue by Power method (up to 4 × 4), Fitting a Polynomial Function (up to third degree).

Credits: 2	Core Compulsory
Max. Marks: 100	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4

Unit	Topics	No. of Lectures
	Practical / Lab work to be performed in Computer Lab. List of the practicals to be done using computer algebra software (CAS), for example Mathematica/MATLAB/Maple/ Maxima/ Scilabetc 1. Solution of transcendental and algebraic equations by i) Bisection method ii) Newton Raphson method (Simple root, multiple roots, complex roots). iii)Secant method. iv)Regula Falsi method. 2. Solution of system of linear equations i) LU decomposition method ii) Gaussian elimination method iii)Gauss-Jacobi method iv)Gauss-Seidel method 3. Numerical Integration (i) Trapezoidal (ii) Simpson's 1/3 (iii) Simpson's 3/8 (iv) Weddle, Newton Cotes Formulae	

Suggested Readings:

B.Sc.(MATHEMATICS) Honours with Research

Or

Graduate in Mathematics Honours with Research

COURSE-I : Abstract Algebra

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720321	Course Title: Abstract Algebra	Theory

Course Objectives: Acquiring ability for defining algebraic structures, constructing substructures, analyzing a given structure, developing new structures based on given structures, and comparing structures.

Course Outcomes (CO's):

CO1. Ability to solve non-trivial problems based on various concepts in the course.

CO2. Determining the connection and transit amid formerly studied mathematics (discrete mathematics) and advanced mathematics (advanced abstract mathematics).

CO3. Ability to apply abstract algebra to solve problems in other branches of mathematics and also in other disciplines.

CO4. Describing relationship between Abstract Algebra and other courses in mathematics.

CO5. Understanding the dependency of results based on earlier results, and thereby developing a correct approach towards life realizing the deep connection among past, present and future. For example, in ring theory, the ring of polynomials over a field is a gift of the division algorithm.

CO6. Possessing pre-requisites for pursuing research in Cryptography

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4--0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definitions of a group, Subgroups, Cyclic group, Permutation group, Even and odd permutation; statement of Cayley's theorem, Lagrange's theorem; definitions of Normal subgroup, Quotient group, Ring, Subrings, Integral domain and field, Ideal and quotient ring, automorphism, inner automorphism, Polynomial ring over commutative ring, definition of division algorithm, principal ideal domain, Reducibility tests, Irreducibility tests, Eisenstein criterion. Unique factorization domains, Euclidean domain	15
II	Cauchy's theorem for finite abelian group, Cauchy's theorem for an arbitrary finite group, Fundamental theorem on homomorphism of groups, Second and third law of isomorphism of groups, Maximal subgroup, Composition series, Jordon Holder's theorem, Subnormal and normal series, Solvable groups, Characteristic property of solvable groups	15
III	Direct products, External Direct products, Internal Direct products, Sylow p-subgroups, Sylow's first theorem, Double cosets, Sylow's second and third theorem, Applications of Sylow's theorem.	15
IV	The fundamental theorem on finite abelian groups, Invariants of finite abelian groups, Isomorphic abelian groups of order , non-isomorphic abelian groups of order, Decomposable groups. Imbedding of rings, Field of quotients of an integral domain, Maximal Ideal,. Field extensions, Finite field extensions, Simple field extensions, Algebraic and transcendental extensions, Minimal polynomial, Remainder theorem, Factor theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **David S. Dummit & Richard M. Foote:** Abstract Algebra, Wiley, 3rd Edition, 2011
2. **Joseph A. Gallian:** Contemporary Abstract Algebra 9th Edition, 2019.
3. **Khanna, Vijay K & Bhambri, S K** A Course in Abstract Algebra, S Chand and Company Ltd; Fifth edition (2022)
4. **Herstein, I.N.: Topics in Algebra**, Wiley, 2nd Edition, 2006.
5. **Bhattacharya, P.B., Nagpaul, S.K.** Basic Abstract Algebra (2nd Edition) Cambridge University Press, Indian Edition, 1997.
6. **Lang, S.:** Algebra, Pearson Education 3rd Edition, 1992
7. **J. B. Fraleigh** : A first course in Abstract Algebra.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-II : Real Analysis

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720322	Course Title: Real Analysis	Theory

Course Objectives:
This course puts forward some basic concepts of real-valued functions and its applications. The purpose of this course is to provide a foundation for understanding the different branches of mathematics.

Course outcomes:
CO1. To provide a topological study of real-valued functions.
CO2. To study the concepts of convergence and uniform convergence of series and sequence of real-valued functions and their applications.
CO3. To provide the methods for finding the maxima and minima values of multivariate real-valued functions with their applications.
CO4. To study the concept of integrability of real-valued functions over the closed and bounded interval and their applications in different areas, such as quantum physics.
CO5. This course gives a wide study of different concepts of functions of serval variables, such as limit and continuity, differentiability, partial differentiability and integrability.
CO6. This course lays a foundation to study other important courses such as functional analysis, complex analysis and differential equations. This course plays a central role to get the employment for the students because it is available with a great importance in the syllabi of different competitive exams

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definition and existence of Riemann-Stieltjes integral. Properties of the integral, integration and differentiation. The fundamental theorem of calculus, and Integration of vector-valued functions.	15
II	Sequences and series of functions. Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Uniform convergence and continuity, Uniform convergence and Riemann-Stieltjes integration, Uniform convergence and differentiation, Weierstrass Approximation Theorem.	15
III	Power series, Algebra of power series, Uniqueness theorem for power series. Abel's and Tauber's theorems.	15
IV	Functions of several variables, Linear transformation. Derivatives in an open subset of R^n. Chain rule, Partial derivatives, Interchange of the order of differentiation.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Apostol, T. M.: Mathematical Analysis, Narosa Publishing, New Delhi, 1985
2. Brown. W., Churchill ,R.V., Fourier Series and Boundary Value Problems, 8th 3rd Edition, 2015, McGraw Hill Education, New Delhi
3. Royden, H. L.: Real Analysis, (4th Edition), Macmillan Publishing Co. Inc. New York, 1993.
4. Rudin, W.: Principles of Mathematical Analysis, (3rd edition) McGraw-Hill, Kogaku Sha, 1903, International student edition.
1. White, J.: Real Analysis, An Introduction, Addison-Wesley Publishing, Co. Inc., 1968.

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:
There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-III : Advanced Differential Equation

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720323	Course Title: Advanced Differential Equation	Theory

Course Objectives:

1. To explore the basic ideas of Differential Equations combined with some real-life problems
2. Differential equations are very important in the mathematical modeling of physical systems.
3. Many fundamental laws of physics and chemistry can be formulated as differential equations.
4. In biology and economics, differential equations are used to model the behavior of complex systems
5. Ordinary Differential Equations are used to calculate the movement or flow of electricity, motion of an object to and fro like a pendulum, to explain thermodynamics concepts.

Course outcomes:

CO1. The use of the differential equation theory is to solve various types of Mathematical modeling problems.
CO2. The use of the differential equation theory is to solve many problems presented in different sciences such as Biology, Chemical sciences and Physics.
CO3. The use of this theory is to solve many real-life based problems such as population problem, control problems and networking security problems etc.
CO4. This theory can solve many engineering problems such as the exact trajectory path of a rocket or a missile.
CO5. Students will be able to formulate and solve differential equations arising from changes in physical world.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4–0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Ordinary Differential Equations (ODEs), General theory of homogenous and non-homogeneous linear ODEs, System of first order ODEs, The method of variation of parameters, Wronskian, Sturm-liouville boundary value problem, Picard's method of successive approximation, Picard's Theorem.	15
II	Ordinary points, Singularities, Regular and Irregular singular points, Series solutions about ordinary points, Frobenius series solution Green function.	15
IV	Origin of first order Partial Differential Equations (PDEs), Lagrange method for solving first order PDEs, Integral surfaces passing through a given curve, Surface orthogonal to a given system of surface, Non-linear PDEs of the first order, Charpit's method for first order PDEs, Jacobi Mathod, Cauchy problem for first order PDEs, Origin of second order partial differential equation and their classification, linear PDEs with constant and variable coefficients.	15
V	General solution of higher order PDEs with constant coefficient, Diffusion, Wave and Laplace equations by the method of separation of variables, Reduction of second order partial differential equation into its canonical form, Non-linear partial differential equations of second order.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/assignments, etc

Suggested Readings:

1. **Coddington, Earl A. & Levinson, Norman:** Theory of Ordinary Differential equations, Tata McGraw-Hill Publication.
2. **Rai,B., Chaudhary ,D.P. and Freedman, H.I.:** A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi 2013.
3. **Simmons, G.F.:** Differential Equations with Applications and Historical Notes, Second Edition, Tata Mcgraw-Hill Publishing Company Ltd. New Delhi (2017).
4. **Sneddon, Ian:** Elements of Partial Differential Equation, McGraw-Hill Book Company.
5. **Wirkus Stephen A, & Swift , Randall J.:** A Course in Ordinary Differential Equations 1st Edition, CRC Press, Taylor & Francis Group, 2015.
6. **Ross. S. L.:** Differential Equations, 3rd Edition, Wiley. (1980)

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:
There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-IV : Metric Space

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Seventh
Course Code: 0720324	Course Title: Metric Space	Theory

Course Objectives:

The beauty of the subject is to gain proficiency in dealing with abstract concepts, with emphasis on clear explanations of such concepts to others; to introduce the theory of metric and topological spaces; to show how the theory and concepts grow naturally from idea of distance; to be able to give examples which show that metric spaces are more general than Euclidean spaces; to be able to work with continuous functions, and to recognize whether spaces are connected, compact or complete. Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

Course outcomes:

CO1: To show how the theory and concepts grow naturally from idea of distance

CO2: Differentiate between functions that define a metric on a set and those that do not.

CO3: Use the Banach fixed point theorem to demonstrate the existence and uniqueness of solutions to differential equations

CO4: Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty

CO5: Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

CO6: Understand sequentially compact spaces, Countable compactness, BWP and compactness and explain the relation between the three types of compactness in metric spaces.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4–0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Metric Space: Metric on a set, pseudo-metrics and metrics Distance between two sets. Equivalent metrics. Limit points and closure: closed sets, Derived set of a set. Adherent points and closure of a set, Dense subsets, Interior of a set and its properties, Subspaces, Product spaces, Structure of Open balls in a product space. Closures and interiors in a product space, Finite product of metric spaces.	15
II	Convergent sequences. Cauchy sequences. Characterization of adherent points and limit points in terms of convergent sequences. Convergence in products. Convergence in Euclidean spaces. Cluster points of a sequence. Subsequences. Cluster points and convergent subsequences. Algebra of convergent real sequences. Spaces of sequences.	15
III	Continuity at a point. Continuity over a space. Continuity of composite, graph and projection maps. Algebra of real valued continuous functions in a metric space. Homeomorphisms. Isometries. Relation between isometries and Homeomorphism. Uniform continuity. Complete metric spaces. Completeness and Continuous mappings. Completeness and subspaces. Cantor's Intersection Theorem. Contraction Mapping Principle. Connectedness: Connected metric spaces. Connected sets. Characterization of connected subsets of the real line. Properties of Connectedness	15
IV	Compact spaces and Compact subsets. Compact subsets of the real line. Sequential compactness and its characterization. Countable compactness, Bolzano-Weierstrass property. Sequential characterization of BWP. Equivalence of BWP and sequential compactness. Covering characterization of the BWP. Bolzano-Weierstrass Property and Total boundedness. BolzanoWeierstrass Property and compactness. Lebesgue covering lemma. Compactness and completeness, Compactness and uniform continuity. Boundedness of continuous real-valued functions on compact metric spaces	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Copson, E.T:** Metric Spaces, Cambridge tracts, 2010.
2. **Dieudonne ,J.:** Foundation of Modern Analysis, Academic Press, New York, 1960.
3. **Kasriel ,R. H.:** Metric Spaces, Dover Publications, New York, 2009.
4. **Kumaresan S.** Topology of Metric Spaces, 2nd Edition, Narosa (2011).

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COMPULSORY COURSE- I : Topology

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820321	Course Title: Topology	Theory

Course Objectives:

The beauty of the subject is to gain proficiency in dealing with abstract concepts, with emphasis on clear explanations of such concepts to others; to introduce the theory of metric and topological spaces; to show how the theory and concepts grow naturally from idea of distance; to be able to give examples which show that metric spaces are more general than Euclidean spaces; to be able to work with continuous functions, and to recognize whether spaces are connected, compact or complete.Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

Course outcomes:

CO1: To show how the theory and concepts grow naturally from idea of distance

CO2: Differentiate between functions that define a metric on a set and those that do not.

CO3: Use the Banach fixed point theorem to demonstrate the existence and uniqueness of solutions to differential equations

CO4: Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty

CO5: Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

CO6: Understand sequentially compact spaces, Countable compactness, BWP and compactness and explain the relation between the three types of compactness in metric spaces

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definition and examples of topological space, Closed sets, Closure, Dense subset, Neighborhoods, interior, exterior, boundary and accumulation points, Derived sets, Bases and sub-bases. Subspaces, product spaces and relative topology.	15
II	Continuous functions, homeomorphisms, the pasting lemma, Connected and disconnected sets, connectedness on the real line, components, locally connected spaces.	15
III	Countability axioms – First and second countable spaces, Lindelof's theorems, Separable spaces, second countability and separability. Separation axioms – T0, T1, T2, T3, T3½, T4, their characterizations and basic properties. Urysohn's lemma and Teitze extension theorem, Statement of Urysohn's metrization theorem.	15
IV	Compactness – Continuous functions and compact sets, basic properties of compactness, compactness and finite intersection property, sequentially and countably compact sets, local compactness and one point compactification. Statements of Tychonoff's Product theorem and Stone-cech compactification theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Simmons, G. F: Introduction to Topology and Modern Analysis, Tata McGraw Hill, India,2016
2. Dieudonne ,J.: Foundation of Modern Analysis, Academic Press, New York, 1960.
3. Munkres. James.: Topology, 2nd Edition, Pearson Education, 2021.
2. Kumaresan S. Topology of Metric Spaces, 2nd Edition, Narosa (2011).

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL, E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COMPULSORY COURSE-II : Advanced Complex Analysis

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820322	Course Title: Advanced Complex Analysis	Theory

Course Objectives:
This course aims to provide an understanding of the basic facts of complex analysis, in particular the nice properties enjoyed by the derivatives and integrals of functions of a complex variable, and to show how complex analysis can be used to evaluate complicated real integrals via residue calculus

Course outcomes:

CO1. Know the fundamental concepts of complex analysis.

CO2. Prove the Cauchy-Riemann equations and apply them to complex functions in order to determine whether a given continuous function is complex differentiable.

CO3. Extend their knowledge to pursue research in this field

CO4.Solve the problems using complex analysis techniques applied to different situations in engineering and other mathematical contexts.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Complex integration, Regular Arc, Contour, Cauchy-Goursat theorem, Simply connected domains, Multiply connected domains, Cauchy's integral formula, An extension of the Cauchy's integral formula, Significance of Cauchy's integral formula, Morera's Theorem, Cauchy's inequality, Liouville's theorem and its applications, The fundamental theorem of Algebra, Maximum modulus principle.	15
II	Properties and classifications of bilinear transformations, Bilinear transformation as conformal mappings, Riemann- Mapping Theorem, Examples of conformal mappings, Meromorphic functions, Entire functions, Taylor's theorem and its applications, Laurent's Theorem and its applications.	15
III	Singularities, Categorization of Singularities using Laurent's series, Isolated singularities, Residues, Cauchy's residue theorem, Evaluation of integrals, Many valued functions, branch points, branch cuts and branches of many valued functions, and with special reference to arg z, log z and z^a, The argument principle, Rouche's theorem, Analytic continuation, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation.	15
IV	Canonical products, Jensen's formula, Poisson-Jensen formula, Hadamard's three circles theorem, Order of an entire function, Exponent of convergence, Borel's theorem, Hadamard's factorization Theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Ahlfors, L.V.:** Complex Analysis, McGraw Hill Education; 3rd Edition, 2017.
2. **Brown, J., Churchill, R.V.:** Complex Variable and Applications, McGraw-Hill Education; 9th Edition, 2013.
3. **Conway, J. B.:** Functions of One Complex Variable, Springer-Verlag, International student Edition, 2nd Edition, 1996.
1. **Priestly, H. A.:** Introduction to Complex Analysis, Oxford University Press, 2008.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Compulsory Course – III : Number Theory

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0821U323	Course Title: Number Theory	Theory

Course Objectives:
The aim of the course is to acquaint students with almost all basic concepts of number theory and to demonstrate applications of number theory. It will help students to grasp rigorous and tricky proofs of many important results that have been used by them from quiet long time. The students will learn the use of Chinese remainder theorem, Fermat's Theorem, Wilson's theorem, Lagrange theorem, Quadratic reciprocity, etc. It will supply methods to solve linear Diophantine equations, linear congruences, system of linear congruences, quadratic congruences, etc. Students will be able to detect the primality of a large integer. It will show how various number theoretic concepts and theorems are applicable in cryptography.

Course outcomes:
CO1.Identify the challenging problems in modern mathematics and find their appropriate solutions.
CO2. Formulate and prove conjectures about numeric patterns, and produce rigorous arguments centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.
CO3. Apply the knowledge of Number theory and Cryptography to attain a good mathematical maturity and enables to build mathematical thinking and skill.
CO4. Design, analyse and implement the concepts of Diophantine equations for solving different types of problems, for example, sum of two and four squares

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total) = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	The division algorithm, Definition and theory of the GCD, Euclid's Lemma, Definition and theory of the LCM, the extended Euclidean algorithm, Distribution of primes, the fundamental theorem of arithmetic, The Sieve of Eratosthenes, The Goldbach conjecture, Consequences of Dirichlet theorem, Statement of Prime Number theorem, Solutions of word problems using the theory of linear Diophantine equation, Solution of simultaneous system of linear congruences.	15
II	Number Theoretic Functions: The number (), sum (), and product of the divisors, Multiplicative function, Mobius function, Morten's Lemma, The Mobius inversion formula and its applications, The greatest integer function, Legendre formula and its application.	15
III	The order of an integer modulo n and order of higher powers of the integer modulo n , Primitive roots for primes, Finding all primitive roots of a prime, Composite numbers having primitive roots, The theory of indices, Properties of index, Solutions of non-linear congruences, Euler's criterion, Solutions of quadratic congruences with prime moduli	15
IV	Pseudoprimes and absolute pseudoprimes, Perfect numbers, even perfect numbers, The Fibonacci sequence and its properties, Continued fractions: representation of rational number as a finite simple continued fraction, Solution of linear Diophantine equation by means of simple continued fractions	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:
1. Burton, David M.: Elementary Number Theory (7th Edition), McGraw Hill Education, 2017.
2. Dudley U.: Elementary Number Theory (2nd edition) Dover Publications, 2008.
3. E. George. Andrews: Number Theory, Dover Publications, 1994.

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests, quizzes and Presentation.
Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.

FurtherSuggestions: .....

Core-Elective (Group - 1) COURSE-I : Mechanics

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820324	**Course Title: Mechanics**	**Theory**

Course Objectives:
Mechanics is the oldest branch of the Physics discipline and is as well important in the discipline of Mathematics. It is actually an intermediate course in classical mechanics intended for mathematics majors. The core is the new formulation of mechanics and the substantial range of new techniques in the applications.

Course outcomes:

CO1. To distinguish between inertia frame of reference and non-inertial frame of reference.
CO2. To frame the mathematical constraints on the bases of physical restrictions imposed on a system, which simplifies the process of solution of a physical problem.
CO3. To understand the mechanics of a system of particles falling under classical mechanics.
CO4. To differentiate between Newtonian, Lagrangian, Hamiltonian and Routhian approach of solving a mechanical problem.
CO5. To determine the Lagrangian and Hamiltonian of mechanical systems and use these functions to obtain the solutions of even complicated mechanical systems with ease.
CO6. To identify the conserved quantities, if any, associated with the mechanical system.
CO7. To apply fundamental conservation principles to analyze mechanical systems.
CO8. To use advanced theoretical techniques to solve mechanical problems like use of canonical transformations, variational principles, Hamilton Jacobi theory.
CO9. To use Poisson's Brackets and Lagrange's Brackets to solve mechanical problems.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction to the system of particles, Conservation laws for the system of particles, generalized coordinates, Virtual displacements, Constraints and constrained motion, classification of constraints: Holonomic versus non-holonomic systems, Scleronomic versus rheonomic systems, Degree of Freedom, generalized velocity, generalized acceleration, generalized potential, generalized momentum (Conjugate momentum), Generalized force Lagrangian Mechanics: Physics in configuration space with generalized coordinates as independent variable, Definition of the Lagrangian, Euler-Lagrange equations of motion, Derivation of Euler-Lagrange equations from differential principle i.e., by D' Alembert's principle, Simple applications of the Lagrangian formulation to systems with holonomic and non-holonomic constraints	15
II	Hamiltonian mechanics: physics in phase space with generalized coordinates and momenta treated as independent variables. Definition of the Hamiltonian (through Legendre's transformation) and its relation to the energy, Hamilton's canonical equations in cylindrical and spherical coordinates as well, Hamilton's principle, Derivation of Hamilton's equations by integral principle i.e. by Hamilton's principle, Derivation of Hamilton's principle by differential principle i. e. by D' Alembert's principle, Derivation of Lagrange's equations from integral principle i.e. Hamilton's principle, Simple applications of Hamilton's equations of motion. Cyclic (ignorable) coordinates and conservation laws Routhian Mechanics: Definition of Routhian. Routh's equations of motion and energy function Principle of least action.	15
III	Variational Calculus and its Application to Mechanics: Euler's equation for functions of one dependent variable and its generalization to (i) "n" dependent variables (ii) higher order derivatives, Applications of calculus of variation: Shortest distance between two points on a plane, Minimum surface of revolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Lagrange's multiplier method.	15
IV	Hamilton Jacobi theory: Hamilton Jacobi equation, Jacobi theorem, Method of separation of variables in Hamilton Jacobi equation and its simple applications.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Gelfand ,I.M., Fomin ,S.V. and Silverman ,R.A.: Calculus of Variations, Prentice Hall,2000
2. Goldstein, H.: Classical Mechanics (3rd Edition), Pearson New International Edition, 2014, ISBN 13: 9780201657029/ ISBN 10: 0201657023
1. Rana, N.C. and Joag, P.S.: Classical Mechanics, Tata McGraw Hill, New Delhi, 1991. ISBN-10: 0074603159/ ISBN-13: 9780074603154

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core- Elective (Group - 1) COURSE- II : Financial Mathematics

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820325	Course Title: Financial Mathematics	Theory

Course Objectives: The objectives are to introduce the basic mathematical concepts and techniques used in finance and business. This also highlights the inter-relationships of the mathematics and problem-solving skills with a particular emphasis on financial and business applications.

Course outcomes:

CO1: Demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization

CO2. Demonstrate understanding of concepts relating to functions and annuities.

CO3. Employ methods related to these concepts in a variety of financial applications

CO4. Apply logical thinking to problem solving in context.

CO5. Use appropriate technology to aid problem solving.

CO6. Demonstrate skills in writing mathematics

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 75 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Some Basic Definitions and Terminology, Basic option theory: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CCR) model, Black Scholes formula for potion pricing as a limit of CCR model.	15
II	Brownian ad Geometric Brownian Motion, Theory of Martingales, Stochastic Calculus, Stochastic differential Equations.	15
III	Ito"s formula to solve SDE"s, FeymannKac theorem, Application of stochastic calculus in option pricing. Black Scholes partial differential equations and Black Scholes formula.	15
IV	Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM), Interest rates and interest rate derivatives:	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

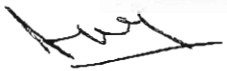
Suggested Readings:

1. **Parikh, J.C.,** Stochastic Process and Financial Markets, Alpha Science International, 2003.
1. **Roman,S.** An Introduction the Mathematics of Finance, Springer, 1st Edition, 2000
1. **Ross,S.** An Introduction to Mathematical Finance, Cambridge University press,3rd Edition, 2011.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....



Core-Elective (Group-1) Course – III : FLUID DYNAMICS

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820326	Course Title: FLUID DYNAMICS	Theory

Course Objectives: Almost everything on this planet, either is a fluid or moves within or near a fluid. Fluid Mechanics is an important subject that is particularly open to cross fertilization with other sciences and disciplines of engineering. The main objective of the course is to develop fundamental knowledge and understanding of the mechanics of fluid at rest and in motion to develop the ability to demonstrate and formulate physical problems encountered in different branches of engineering in mathematical form and arrive at useful solutions

CO1. To know, understand and apply the basic concepts of Fluid Mechanics .
CO2. To describe the physical properties of a fluid.
CO3. To convert physical laws of conservation of mass, momentum, moment of momentum and energy into mathematical equations and apply them to describe the fluid motion.
CO4. To frame and describe the flow through potential function and stream function.
CO5. To describe the motion of ideal and real fluids with different techniques including complex variable technique.
CO6. To understand stress-strain relationship in Newtonian fluids.
CO7. To apply Bernoulli equations in their domain of validity for fluid flow rate measurement.
CO8. To understand the singularities of the flow field.
CO9. To make dimensional analysis and use it to derive the dimensionless numbers.
CO10. To link flow behavior with non-dimensional parameters
CO11. To apply the similitude concept and set up the relation between a model and a prototype.
CO12. To define, describe and apply the basic flow equations, such as the Navier-Stokes equations to evaluate velocity, pressure drop in simple geometries like laminar flows between parallel plates, axial and transverse flows in pipes and flows in annular region produced.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minim Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Introduction: fluid characteristics, continuum concept and basic properties of fluids, Newtonian law of viscosity, Kinematics of fluids: Eulerian vs. Lagrangian descriptions of fluid motion, Equivalence of Lagrangian and Eulerian methods, General motion of a fluid element: Translation (Acceleration of a fluid particle in a velocity field), Rotation (angular deformation) and Deformation (volumetric or extensional strain/ shear strain), Flow lines: Stream lines, Path lines, Streak lines, Boundary conditions and boundary surface.	15
II	General theory of stress in a real fluid: Normal stress, Shearing stress, Transformation of stress components from one coordinate system to another coordinate system, Symmetry of stress tensor, Plane stresses, Principal directions and Principal values of stress tensor, Constitutive equation for Newtonian fluid, Conservation laws by the Control Volume approach: Mass conservation equation in rectangular cartesian, cylindrical and spherical coordinate systems, Equivalence of the mass conservation equations derived by Lagrangian method and Eulerian method, Equation of conservation of momentum (NavierStokes Equation and Euler Equation), Equation of conservation of moment of momentum, Equation of conservation of energy, Simple and direct applications of conservation equations.	15
III	Vorticity and circulation, Elementary properties of vortex motion, Stream function for two-dimensional incompressible Flow, Stream function and potential flow theory, Theorems about rotational and irrotational flows of inviscid and incompressible flows - Stokes' theorem, Kelvin's minimum energy theorem, Gauss theorem, Kelvin's circulation theorem, Uniqueness of irrotational flows. Bernoulli's equation for incompressible and inviscid flows: Integration of Euler's equation along a streamline for steady and unsteady flows, Applications of Bernoulli's equation for irrotational flows: Flow through an orifice, Motion of a jet through atmosphere, Pitot tube, Venturi meter.	15
IV	Two-dimensional irrotational incompressible flows (Complex variable technique and its applications): Blasius theorem, Milne's circle theorem, Flow field singularities: Sources, Sinks and Doublets in two dimensions, Images of a source/ sink/ doublet with respect to a line and with respect to a circle, Simple applications of source, sink and doublet. Dimensional analysis, Buckingham Pi theorem, Dimensionless numbers (Reynold number, Pressure coefficient, Mach number, Froude number, Prandtl number) and their properties Basic introduction to Newtonian and non-Newtonian rheologies	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. Batchelor, G.K. An Introduction of Fluid Mechanics, Oxford University Books, NewDelhi, 2000.
2. Charlton, F.: Text Book of Fluid Dynamics, CBS Publishers, Delhi, 2004.
3. Raisinghania, M.D.: Fluid Dynamics: with Complete Hydrodynamics and Boundary Layer Theory, S. Chand Publishing, 2014, ISBN 13: 9788121908696.
4. Rathy, R.K.: An Introduction of Fluid Dynamics, Oxford and IBH Publishing Co.,New Delhi, 1903.
5. Yuan, S.W.: Foundations of Fluid Mechanics, Prentice Hall of India Private Limited,New-Delhi, 1988., ISBN10: 0133298132/ ISBN-13: 978-0133298130.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG Level..

Suggested equivalent online courses: There are online courses on the channels such as Swayam, Swayam Prabha, and NPTEL e-contents from different online libraires.

Further Suggestions:.....

Core-Elective (Group-2) COURSE-I : Linear Algebra

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820327	Course Title: Linear Algebra	Theory

Course Objectives:
The main objective of this course is to develop theoretical as well as working knowledge of the central ideas of linear algebra like linear transformations, invertibility & isomorphisms, eigenvalues, eigenvectors, the minimal polynomial, diagonalization, canonical forms, rational & Jordan forms, bilinear forms and their classification.
Linear algebra finds applications in coding theory, cryptography, graph theory and linear programming. Thus, after completing this course, students shall bear a good insight to study general plus advanced contents of the above-mentioned courses.

Course outcomes:
CO1: Understand the notion of a vector space and linear transformation and to determine basis and dimension of a vector space.
CO2: Understand the concept of linear transformation and to find the range space and null space of the linear transformation
CO3: Find the eigenvectors and Eigen-value of a square matrix and to know diagonalization of the matrix
CO4: Compute an orthogonal basis using the Gram-Schmidt process.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Linear transformations, Isomorphism, Range and null space, The matrix representation of linear transformations, Linear functional, Double dual.	15
II	Invertibility and Isomorphisms, The change of coordinate matrix, The transpose of a linear transformations, Polynomial ideals, Prime factorization of polynomials, Inner product spaces, Bessel's inequality, Normal and unitary operators.	15
III	Elementary canonical forms: Annihilating polynomials, The minimal polynomial, Invariant subspaces.Simultaneous triangulation, Simultaneous diagonalization, Direct-sum decomposition, Invariant direct sums, The primary decomposition theorem.	15
IV	Orthogonal and unitary reduction of quadratic and Hermitian form, Positive definite quadratic forms, simultaneous reduction. Bilinear forms, Matrix of a bilinear form, Classification of bilinear forms: Symmetric bilinear forms, Skew-symmetric bilinear forms	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **David C.Lay, Steven R.Lay and Judi J.MC Donald;** Linear Algebra and Its Applications, 6th Edition Pearson Education 2021.
2. **Hoffman, K., Kunze R.:** Linear Algebra (2nd Edition), Pearson, 2017.
3. **Friedberg, S.H., Insel ,A.J., Spence, L.E.:** Linear Algebra Pearson Education India,2015.
4. **Strang, G.** Linear Algebra and its Applications (4th Edition), Cengage Learning, 2007.
5. **Sahai, V. and Bist, V.:** Linear Algebra (2nd Edition), Narosa Publishing House, 2013.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective (Group-2) COURSE-II : Data Structure with C

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820328	Course Title: Data Structure with C	Theory

Course Objectives:

1. A prominent purpose of programming languages is to provide instructions to a computer
2. Programming languages differ from most other forms of human expression in that they require a greater degree of precision and completeness.
3. Studying programming languages will help the students be better at their job, make more money, and be a happier, more fulfilled and more informed citizen, because they will learn to: Choose the most appropriate language for a given task.
1. A programming language lets the students to express computational tasks in certain ways.
2. Programming languages often produce more efficient code through optimization for specific system architecture.

Course outcomes:

CO1. Understanding a functional hierarchical code organization.
CO2. Ability to define and manage data structures based on problem subject domain.
CO3. Ability to work with textual information, characters and strings.
CO4. Students will be able to develop logics which will help them to create programs, applications in C.
CO5. Also, by learning the basic programming constructs they can easily switch over to any other Language in future.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	**Introduction to the C Language:** Writing a Simple C Program: Learning the format of a C program, declaring variables, designing program flow and control, defining and using functions, data types, using standard terminal I/O functions.	15
II	**Conditional Program Execution:** Applying if and switch statements, nesting if and else, restrictions on switch values, use of break and default with switch. Program Loops and Iteration: Uses of while, do and for loops, multiple loop variables, assignment operators, using break and continue. **Modular Programming, Arrays and Structures** Passing arguments by value, scope rules and global variables, separate compilation, and linkage, building your own modules. Array notation and representation, manipulating array elements, using multidimensional arrays, arrays of unknown or varying size.	15
III	**Structures:** Purpose and usage of structures, declaring structures, assigning of structures. Unions: Components in overlapping memory, declaring and using unions. .h vs. private .c files, hiding private variables and functions	15
IV	**Functions and Pointers to Objects:** Simple C-functions, passing arguments to functions, returning values from functions, reference arguments, overloaded functions, recursion, inline functions, default arguments, scope and storage class, returning by reference, Constant function arguments, runtime memory management. Pointer and address arithmetic, pointer operations and declarations, using pointers as function arguments, Dynamic memory allocation	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1.**Budd,**"Object Oriented Programming", Addison Wesley
2.**Balaguruswamy,** "Programming in ANSI C," TMH
3.**Kanetkar ,Yashwant** "Pointers in C"
4.**Schield, Herbert,** Complete Reference in C," TMH
1. **Yashwant Kanetkar,**" Let us C", BPB

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions: .....

Core-Elective (Group-2) Course – III: Dynamical System

Programme/Class: B.Sc.	Year: B.Sc. Mathematics Honours	Semester: Eight
Course Code: 0820329	Course Title: Dynamical Systems	Theory

Course Objectives: Dynamical systems describe the time evolution of systems which arise from mathematics, physics, biology, chemistry and other areas. As mathematical objects they are ordinary differential equations, usually nonlinear and therefore not usually able to explicitly solved. The aim of the course is to see how to make a qualitative analysis of a dynamical system using many different analytic tools. Course outcomes:

CO1. To introduce students to the basic mathematical skills for the qualitative solving of low dimensional systems of ordinary differential equations in continuous time, including dimensionless forms, phase portraits, and bifurcations.

CO2. To provide a brief introduction to the way ordinary differential equation can be used to model, explain and interpret real world problems.

CO3. To provide a brief introduction to the theory and concepts that under pin the field of dynamical systems.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	The orbit of a map, fixed point, equilibrium point, periodic point, circular map, configuration space and phase space.	15
II	Origin of bifurcation. Stability of a fixed point, equilibrium point. Concept of limit cycle and torus. Hyperbolicity. Quadratic map. Feigenbaum's universal constant.	15
III	Turning point, trans critical, pitch work. Hopf bifurcation. Period doubling phenomena. Nonlinear OscillatorsConservative system. Hamiltonian system. Various Type of oscillaters in nonlinear system. Solutions of nonlinear differential equations.	15
IV	Phenomena of losing stability. Quasiperiodic motion. Topological study of nonlinear differential equations. Poincare map.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Arnold, V.I, Dynamical Systems, Cambridge University Press, 1993.
2. Arrowosmith, D.K., Introduction to Dynamical Systems, Cambridge University Press, 1990.
3. Robert L.Davaney. An Introduction to Chaotic Dynamical Systems, Addison-Wesley Publishing Co. 1989.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraires.

Further Suggestions:.....