Chaudhary Charan Singh University, Meerut

Syllabus of the Subject

Mathematics

For First Three Years of Under-Graduate (UG) Programme

As per guidelines of Common Minimum Syllabus by U.P. Government according to National Education Policy-2020

w.e.f. the session 2021-2022

(For both University Campus and Colleges)

Members of the Board of Studies

S. No.	Name	Signature
1	Prof. M.K. Gupta- (Dean) Science Faculty	
2	Prof. Shiv Raj Singh, Convener-I	
3	Dr (Smt.) Shashi Sharma, Convener-II	
4	Dr Kunwar Pal Singh, Internal Subject Expert	
5	Dr Rishi Kumar Agarwal, Internal Subject Expert	
6	Prof. Anil Vashistha, External Subject Expert	
7	Prof. C.K. Goel, External Subject Expert	
8	Prof. R.C. Mittal, External Subject Expert	
9	Prof. G.C. Sharma, (Retd.) Principal	
10	Dr Pramod Kumar Sahoo, Scientist	

SEMESTER WISE TITLES OF THE PAPER IN UG MATHEMATICS COURSE					
YEAR	**SEMESTER**	**COURSE CODE**	**PAPER TITLE**	**THEORY/PRACTICAL**	**CREDIT**
CERTIFICATE COURSE IN APPLIED MATHEMATICS					
FIRST YEAR	**I**	B030101T	Differential Calculus & Integral Calculus	THEORY	**4**
		B030102P	PRACTICAL	PRACTICAL	**2**
	II	B030201T	Matrices and Differential Equations & Geometry	THEORY	**6**
DIPLOMA IN MATHEMATICS					
SECOND YEAR	**III**	B030301T	Algebra & Mathematical Methods	THEORY	**6**
	IV	B030401T	Differential Equation & Mechanic	THEORY	**6**
DEGREE IN MATHEMATICS					
THIRD YEAR	**V**	B030501T	Group and Ring Theory & Linear Algebra	THEORY	**5**
		B030502T	Any One of the following (i) Number Theory & Game Theory (ii) Graph Theory & Discrete Mathematics (iii) Differential Geometry & Tensor Analysis	THEORY	**5**
	VI	B030601T	Metric Space & Complex Analysis	THEORY	**4**
		B030602T	Numerical Analysis & Operations Research	THEORY	**4**
		B030603P	PRACTICAL	PRACTICAL	**2**

PROPOSED STRUCTURE OF UG MATHEMATICS SYLLABUS AS PER NEP 2020 GUIDELINES

GENERAL OVERVIEW

B.A./B.Sc. I										
PROGRAMME	**YEAR**	**SEMESTER (15 Weeks)**	**PAPER**	**CREDIT**	**PERIODS Per Week**	**PERIODS (HOURS) Per Semester**	**PAPER TITLE**	**UNIT (Periods Per Semester)**	**PREREQUISITE**	**ELECTIVE (For Other Faculty)**
CERTIFICATE COURSE IN APPLIED MATHEMATICS	**FIRST YEAR**	**SEMESTER – I**	**Paper-1**	**4**	**4**	4x 15= 60	**Differential Calculus & Integral Calculus** **Part A: Differential Calculus** **Part B: Integral Calculus**	**Part A** Unit I (9) Unit II (7) Unit III (7) Unit IV (7) **Part B** Unit V (9) Unit VI (7) Unit VII (7) Unit VIII (7)	Mathematics in 12th	Engg. and Tech. (UG), Chemistry/Biochemistry/ Life Sciences (UG), Economics (UG/PG), Commerce (UG), BBA/BCA, B.Sc. (C.S.)
			Paper-II Practical	**2**	**2 Lab Periods (2Hours Each)**	2x2x 15= 60	**Practical** (Practicals to be done using Mathematica /MATLAB /Maple /Scilab/Maxima etc.)		Mathematics in 12th	Engg. and Tech. (UG), B.Sc.(C.S.)
		SEMESTER – II	**Paper-1**	**6**	**6**	6 x 15= 90	**Matrices and Differential Equations & Geometry** **Part A: Matrices and Differential Equations** **Part B: Geometry**	**Part A** Unit I (12) Unit II (11) Unit III (11) Unit IV (11) **Part B** Unit V (12) Unit VI (11) Unit VII (11) Unit VIII (11)	Mathematics in 12th	Engg. and Tech. (UG), B.Sc.(C.S.)

B.A./B.Sc. II

PROGRAMME	YEAR	SEMESTER (15 Weeks)	PAPER	CREDIT	PERIODS Per Week	PERIODS (HOURS) Per Semester	PAPER TITLE	UNIT (Periods Per Semester)	PREREQUISITE	ELECTIVE (For Other Faculty)
DIPLOMA IN MATHEMATICS	SECOND YEAR	SEMESTER –III	Paper-1	6	6	6 x 15= 90	**Algebra & Mathematical Methods** **Part A: Algebra** **Part B: Mathematical Methods**	**Part A** Unit I (12) Unit II (11) Unit III (11) Unit IV (11) **Part B** Unit V (12) Unit VI (11) Unit VII (11) Unit VIII (11)	Certificate Course in Applied Mathematics	Engg. and Tech. (UG), B.Sc. (C.S.)
		SEMESTER – IV	Paper-1	6	6	6 x 15= 90	**Differential Equation & Mechanics** **Part A: Differential Equation** **Part B: Mechanics**	**Part A** Unit I (12) Unit II (11) Unit III (11) Unit IV (11) **Part B** Unit V (12) Unit VI (11) Unit VII (11) Unit VIII (11)	Certificate Course in Applied Mathematics	Engg. and Tech. (UG), Economics (UG/PG), B.Sc. (C.S.) Engineering and Technology (UG), Science (Physics-UG)

B.A./B.Sc. III

PROGRAMME	YEAR	SEMESTER (15 Weeks)	PAPER	CREDIT	PERIODS Per Week	PERIODS (HOURS) Per Semester	PAPER TITLE	UNIT (Periods Per Semester)	PREREQUISITE	ELECTIVE (For Other Faculty)
DEGREE IN MATHEMATICS	THIRD YERAR	SEMESTER – V	Paper-1	5	5	5x 15= 75	**Group and Ring Theory & Linear Algebra** **Part A: Group and Ring Theory** **Part B: Linear Algebra**	**Part A** Unit I (10) Unit II (10) Unit III (9) Unit IV (9) **Part B** Unit V (10) Unit VI (9) Unit VII (9) Unit VIII (9)	Certificate Course in Applied Mathematics	Engg. and Tech. (UG), Economics (UG/PG), B.Sc. (C.S.)
			Paper-2	5	5	5x 15= 75	**(i) Number Theory & Game Theory** **Part A: Number Theory** **Part B: Game Theory**	**Part A** Unit I (10) Unit II (9) Unit III (9) Unit IV (9) **Part B** Unit V (10) Unit VI (10) Unit VII (9) Unit VIII (9)	Diploma in Mathematics	Engg. and Tech. (UG), BCA, B.Sc. (C.S.)
							(ii) Graph Theory & Discrete Mathematics **Part A: Graph Theory** **Part B: Discrete Mathematics**	**Part A** Unit I (10) Unit II (9) Unit III (9) Unit IV (9) **Part B** Unit V (10) Unit VI (10) Unit VII (9) Unit VIII (9)	Diploma in Mathematics	Engg. and Tech. (UG), B.Sc. (C.S.)
							(iii) Differential Geometry & Tensor Analysis **Part A: Differential Geometry** **Part B: Tensor Analysis**	**Part A** Unit I (10) Unit II (9) Unit III (9) Unit IV (9) **Part B** Unit V (10) Unit VI (10) Unit VII (9) Unit VIII (9)	Diploma in Mathematics	Engg. and Tech. (UG), B.Sc. (C.S.)

		SEMESTER – VI	Paper-1	**4**	**4**	4 x 15= 60	**Metric Space & Complex Analysis** **Part A: Metric Space** **Part B: Complex Analysis**	**Part A** Unit I (8) Unit II (8) Unit III (7) Unit IV (7) **Part B** Unit V (8) Unit VI (8) Unit VII (7) Unit VIII (7)	Diploma in Mathematics	Engg. and Tech. (UG), B.Sc. (C.S.)
			Paper-2	**4**	**4**	4x 15= 60	**Numerical Analysis & Operations Research** **Part A: Numerical Analysis** **Part B: Operations Research**	**Part A** Unit I (8) Unit II (8) Unit III (7) Unit IV (7) **Part B** Unit V (8) Unit VI (8) Unit VII (7) Unit VIII (7)	Diploma in Mathematics	Engg. and Tech. (UG), Economics (UG/PG),BBA/BCA, B.Sc. (C.S.)
			Paper-III Practical	**2**	**2 Lab Periods (2Hours Each)**	2x2x 15= 60	**Practical** (Practicals to be done using Mathematica /MATLAB /Maple /Scilab/Maxima etc.)		Diploma in Mathematics	Engg. and Tech. (UG), B.Sc. (C.S.)

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 develop 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.A. /B.Sc. I (MATHEMATICS)

Detailed Syllabus For

CERTIFICATE COURSE

IN

APPLIED MATHEMATICS

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

Programme: Certificate Class: B.A./B.Sc.	Year: First	Semester: First
Subject: Mathematics		
Course Code: B030101T	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 as sequence 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 / Elective
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).(Appendix) Neighborhood of a point, bounded above sets, bounded below sets, Bounded Sets, Unbounded sets, open sets/intervals, closed sets/intervals, Limit points of a set, Isolated points, Limit, continuity and differentiability of function of single variable, Cauchy's definition, Uniform continuity, boundedness theorem, Intermediate value theorem, extreme value theorem, Darboux's intermediate value theorem for derivatives and Chain rule.	9
II	Rolle's theorem, Lagrange and Cauchy Mean value theorems, 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
III	Tangent and Normal, 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
IV	Definition of a sequence, theorems on limits of sequences, bounded and monotonic sequences, Cauchy's convergence criterion, Cauchy sequence, 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.	7

Part-B
Integral Calculus

Unit	Topics	No. of Lectures
V	Concept of partition of interval, Properties of Partitions, Riemann integral, Criterion of Riemann Integrability of a function, 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., Statements of Theorems, of Gauss, Green & Stokes, only without proof, Applications of these theorems for evaluation of double and triple integrals.	7

Suggested Readings (Part- A Differential Calculus):

1. R.G. Bartle & D.R. Sherbert, **Introduction to Real Analysis**, John Wiley & Sons, 1999
2. T.M. Apostal, **Calculus Vol. I**, John Wiley & Sons Inc., 1974
3. Ajit Kumar and S. Kumaresan, **A Basic Course in Real Analysis**, CRC Press, 2019
4. S. Balachandra Rao & C. K. Shantha, **Differential Calculus**, New Age Publication. 1992
5. H. Anton, I. Birens and S. Davis, **Calculus**, John Wiley and Sons, Inc. 2007
6. G.B. Thomas and R.L. Finney, **Calculus**, Pearson Education, 2010
7. Wilson A Sutherland, **Introduction to Metric and Topological Spaces**, Oxford University Press, 2009
8. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS

Suggested Readings (Part-B Integral Calculus):

1. T.M. Apostol, **Calculus Vol. II**, John Wiley Publication, 1974
2. Withold A.J. Kosmala, **A Friendly Introduction to Analysis, Single and Multivariable**, Pearson/Prentice Hall, 2003
3. Shanti Narayan & P.K. Mittal, **Integral Calculus**, S Chand, 2005
4. Erwin Kreyszig, **Advanced Engineering Mathematics**, John Wiley & Sons. 2011
5. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS

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:

Further Suggestions:

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

Programme: Certificate **Class: B.A./B.Sc.**	**Year: First**	**Semester: First**
Subject: Mathematics		
Course 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, subtraction, 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: 25+75	**Min. Passing Marks:**

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 practical to be done using R/Python/Mathematica /MATLAB /Maple /Scilab/Maxima etc.

1. Plotting the graphs of the following functions:

- **i.** a^x
- **ii.** $[x]$ (Greatest integer function)
- **iii.** $x^{2n}; n \in \mathbb{N}$
- **iv.** $x^{2n-1}; n \in \mathbb{N}$
- **v.** $\frac{1}{x^{2n-1}}; n \in \mathbb{N}$
- **vi.** $\frac{1}{x^{2n}}; n \in \mathbb{N}$
- **vii.** $\sqrt{ax+b}$, $|ax+b|$, $c \pm |ax+b|$
- **viii.** $\frac{|x|}{x}, \sin\left(\frac{1}{x}\right), x\sin\left(\frac{1}{x}\right), e^x, e^{-x}$ for $x \neq 0$.
- **ix.** $e^{ax+b}, \log(ax+b), \frac{1}{ax+b}, \sin(ax+b), \cos(ax+b), |\sin(ax+b)|, |\cos(ax+b)|$.

2. Observe and discuss the effect of changes in the real constants a and b on the graphs.

- **i.** By plotting the graph find the solution of the equations $x = e^x$, $x^2 + 1 = e^x$, $1 - x^2 = e^x$, $x = \log_{10}(x)$, $\cos(x) = x$, $\sin(x) = x$, $\cos(y) = \cos(x)$, $\sin(y) = \sin(x)$ etc.
- **ii.** Plotting the graphs of polynomial of degree 2,3, 4 and 5, and their first and second derivatives.
- **iii.** Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid and Hypocycloid etc.

	iv. Graph of circular and hyperbolic functions. **v.** Obtaining surface of revolution of curves. **vi.** Complex numbers and their representations, Operations like addition, Multiplication, Division, Modulus. Graphical representationof polar form. **vii.** Find numbers between two real numbers and plotting of finite and infinite subset of R. **viii.** Matrix Operations: Addition, Multiplication, Inverse, Transpose, Determinant, **ix.** Study the convergence of sequences through plotting. **x.** Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. **xi.** Study the convergence/divergence of infinite series by plotting their sequences of partial sum. **xii.** Cauchy's root test by plotting n^{th} roots. **xiii.** Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.	

Suggested Readings

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**	**5**

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

Suggested equivalent online courses:

Further Suggestions:

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

Programme: Certificate **Class: B.A./B.Sc.**	**Year: First**	**Semester: Second**
Subject: Mathematics		
Course 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 / 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
Matrices and Differential Equations

Unit	Topics	No. of Lectures
I	Types of Matrices, Elementary operations on Matrices, Rank of a Matrix, System of linear homogeneous and non-homogeneous equations, Theorems on consistency of a system of linear equations. Echelon form of a Matrix, Normal form of a Matrix, Inverse of a Matrix by elementary operations.	**12**
II	Eigen values, Eigen vectors and characteristic equation of a matrix, Caley-Hamilton theorem, and its applications in finding inverse of a matrix, Diagonalization of matrices.	**11**
III	Formation of differential equations, Geometrical meaning of a differential equation, Equation of first order and first degree, Equationin in which the variables are separable, Homogeneous equations, Exact differential equations and equations reducible to the exact form, Linear differential 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, Polar equation of conics and its properties.	12
VI	Three-Dimensional Coordinates, Projection and Direction Cosine, Plane (Cartesian and vector form), Straight line in three dimensions.	11
VII	Sphere, Cone and Cylinder.	11
VIII	Central conicoid, Paraboloids, Plane section of conicoid, Generating lines, Confocal conicoid, Reduction of second degree equations.	11

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

1. Shanti Narayan, **A Textbook of Matrices**, S. Chand, 2010
2. Fuzhen Zhang, **Matrix Theory- Basic Results and Techniques**, Springer,1999
3. B. Rai, D.P. Choudhary & H. J. Freedman, **A Course in Differential Equations**, Narosa, 2002
4. William E Boyce and Richard C Di Prima, **Elementary Differential Equations and Boundary Value Problems**, John Wiley and Sons, 2009
5. D.A. Murray, **Introductory Course in Differential Equations**, Orient Longman, 1967
6. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Geometry):

1. Robert J.T Bell, **An Elementary Treatise on Coordinate Geometry of three dimensions**, Macmillan India Ltd., 1923
2. P.R. Vittal, **Analytical Geometry 2d & 3D**, Pearson, 2013
3. S.L. Loney, **The Elements of Coordinate Geometry, McMillan and Company**, London. 2018
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

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 12^{th}

Suggested equivalent online courses:

Further Suggestions:

B.A. /B.Sc. II (MATHEMATICS)

Detailed Syllabus For

DIPLOMA IN MATHEMATICS

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

Programme: Diploma **Class: B.A./B.Sc.**	**Year: Second**	**Semester: Third**
Subject: Mathematics		
Course 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 / 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
Algebra

Unit	Topics	No. of Lectures
I	Cartesian product of Sets, Functions or mappings, Binary operations, Relation, Equivalence relations and partitions, Congruence modulo n, Definition of a group with examples and simple properties, Abelian group, Finite and infinite group, Order of a finite group, General properties of groups, Composition table for finite groups	**12**
II	An Alternative set of postulates of groups, Subgroups. Permutations, Cyclic Permutations, Even and odd permutations, group of Permutations alternating group, Integral power of an element of a group, Order of an element of a group, Group homomorphism, Isomorphism on groups, the relation of isomorphism in the set of all groups Complexes and subgroup of a group, theorems on subgroups, Coset decomposition, Lagrange's theorem and its consequences, Cayley's theorem, Cyclic group, generating system of group.	**11**
III	Normal subgroups, Simple group, Conjugate elements, Normalizer of an element of a group, Class equation of a group, Centre of a group, Conjugate subgroups, Invariant subgroups, Quotient group, Homomorphism and Isomorphism on groups, Kernel of a Homomorphism and related theorems.	**11**
IV	Rings, Elementary properties of Ring, Ring with or without zero divisors, Integral domains and field, Division ring or skew field, Homomorphism and Isomorphism on rings, Subrings, Subfields, Characteristic of a ring, Ideal and quotient rings	**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 and Young theorem (Statement Only), Taylor's theorem for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange multiplier method, Jacobians.	12
VI	Existence theorems for Laplace transforms, Linearity of Laplace transform and their properties, Laplace transform of the derivatives, Initial and final value theorems and Evaluation of Integrals of a function	11
VII	Inverse Laplace transforms, Linearity of Inverse Laplace transform, Shifting theorems (first and second), Convolution theorem. Solution of the differential equations using Laplace transforms.	11
VIII	Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Fourier transforms (finite and infinite), Application of Fourier Transform in initial and boundary value problem. Fourier integral. **The topic "Indian Ancient Mathematics and Mathematicians should be covered under Continuous Internal Evaluation (CIE). (Appendix)**	11

Suggested Readings (Part-A Algebra):

1. J.B. Fraleigh, **A first course in Abstract Algebra**, Addison-wiley, 2003
2. I. N. Herstein, **Topics in Algebra**, John Wiley & Sons, 2006
3. Thomas W Hungerford, **Abstract Algebra – An Introduction**, Sauders College Publishing 1990
4. Joseph A Gallian, **Contemporary Abstract Algebra**, Brooks/Cole Cengage Learning, 2016
5. Suggested digital platform: NPTEL/SWAYAM/MOOCS

Suggested Readings (Part- B Mathematical Methods):

1. T.M. Apostol, **Mathematical Analysis**, Person, 1974
2. G.F. Simmons, **Differential Equations with Applications and Historical Notes**, Tata -Mc Graw Hill 2002
3. Erwin Kreyszig, **Advanced Engineering Mathematics**, John Wiley & Sons. 2011
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

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 12^{th}

Suggested equivalent online courses:

Further Suggestions:

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

Programme: Diploma **Class: B.A./B.Sc.**	**Year: Second**	**Semester: Fourth**
Subject: Mathematics		
Course 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, nonlinear 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: The complete Solution in terms of A known Integral, Removal of the first order Derivative (normal form), Solution by Changing the Independent Variable, variation of parameters, Method of Operational Factors.	**10**
II	Bessel and Legendre functions and their properties, Orthogonal properties, recurrence Formula and generating Function.	**10**
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, Surfaces Orthogonal to the given system of surfaces.	**9**
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.	**9**

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.	10
VI	Virtual work, Stable and Unstable equilibrium, Potential energy test, Z-test, stability of a body resting on a fixed rough surface.	9
VII	Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other law of forces.	9
VIII	Elastic strings, Motion in resisting medium, Constrained motion, Motion on smooth and rough plane curves. Central orbit. Kepler's laws of motion,	9

Suggested Readings (Part-A Differential Equations):

1. G.F. Simmons, **Differential Equations with Application and Historical Notes**, Tata –McGraw Hill 2002
2. B. Rai, D.P. Choudhary & H. J. Freedman, **A Course of Ordinary Differential Equations**, Narosa 2002
3. Ian N. Snedden, **Elements of Partial Differential Equations**, Dover Publication 2013
4. L.E. Elsgolts, **Differential Equation and Calculus of variations**, University Press of the Pacific. 1970
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Mechanics):

1. R.C. Hibbeler, **Engineering Mechanics-Statics**, Prentice Hall Publishers 2010
2. R.C. Hibbeler, **Engineering Mechanics-Dynamics**, Prentice Hall Publishers 2012
3. A. Nelson, **Engineering Mechanics Statics and Dynamics**, Tata McGraw Hill 2009
4. J.L. Synge & B.A. Griffith, **Principles of Mechanics**, Tata McGraw Hill 2018
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

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.A. /B.Sc. III (MATHEMATICS)

Detailed Syllabus For

DEGREE IN MATHEMATICS

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

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Fifth**
Subject: Mathematics		
Course 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 and some 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 / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**

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	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, Polynomial rings over commutative rings.	**9**
III	Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein Criterion of Irreducibility of polynomials over rational field.	**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 and their elementary properties Subspaces, Linear independence and dependence of vectors, Basis and Dimension, Direct sum, Quotient space.	10
VI	Linear transformations, The Algebra of linear transformations, Range and Null space of a linear Transformation	10
VII	Rank and nullity theorem, their representation as Linear Transformations and matrices, Change of Basis.	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. **The topic "Indian Ancient Mathematics and Mathematicians" should be covered under Continuous Internal Evaluation (CIE). (Appendix)**	9

Suggested Readings:

1. I. N. Herstein, **Topics in Algebra**. 2006
2. B. Dubey, **Introductory Linear Algebra**, Asian Books Pvt Ltd, 2007
3. K. Hoffman and R. Kunze**, Linear Algebra**. 2015
4. David C Lay**, Linear Algebra**, Pearson 2016
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

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

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Sixth**
Subject: Mathematics		
Course 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	**Core Compulsory / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**

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; Euler's phi-function.	**10**
II	**Congruences** Congruence modulo powers of prime; primitive roots and their existence; quadratic residues; Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.	**9**
III	**Diophantine Equations** Solutions of ax + by = c, $x^n + y^n = z^n$; properties of Pythagorean triples; sums of two, four and five 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 rectangular games.	9
VIII	Relationship between rectangular game and Linear Programming Problem, reduction of m x n game and solution of 2x2, 2 x s, and r x 2 cases by graphical method. algebraic and linear programming solution of m x n games.	9

Suggested Readings (Part-A Number Theory):

1. Niven, I., Zuckerman, H. S. and Montegomery, H. L. **An Int. to the Theory of Numbers** John Wiley and sons, 2003
2. Burton, D. M., **Elementary Number Theory** (4th edition) Universal Book Stall, 2002
3. Balakrishnan, V. K., **Schaum's Outline of Theory and Problems of Combinatorics Including Concepts of Graph Theory**, Mc Graw Hill, 1995
4. Balakrishnan, V. K., **Introductory Discrete Mathematics**, Dover Publications, 1996
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

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, 1999 (Website 1) http://www.ece.stevens-tech.edu/~ccomanic/ee800c.html
4. Allan Mac Kenzie, **Game Theory for Wireless Engineers**, Synthesis lectures on Communications, 2006
5. Suggested digital platform: NPTEL/SWAYAM/MOOCS

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

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Sixth**
Subject: Mathematics		
Course 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	**Core Compulsory / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**

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 coloring, 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, proof by 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 Algebraic system, Basic properties, Sublattices.	**10**
VII	**Boolean Algebra-** Basic definitions, Sum of products and products of sums, Boolean Functions, Disjunctive normal form, Complete Disjunctive normal form, conjugate normal form, Logic circuits, Logic networks, Design of circuits from given properties, Logic gates, and Karnaugh maps.	**9**
VIII	**Combinatorics-** 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. Narsingh Deo, **Graph Theory with Applications to Engineering and Computer Science**, Dover Publications, 2017
2. Douglas B West**, Introduction to Graph Theory**, Pearson, 2018
3. Santanu Saha Ray, **Graph Theory with Algorithms and Its Applications: In Applied Science and Technology**, Springer India, 2012
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Discrete Mathematics):

1. C. L. Liu., **Discrete Mathematics**, Tata McGraw Hill, 1986
2. Trembley and Manohar, **Discrete Mathematics with computer application**, Tata McGraw Hill, 2008
3. Kenneth H. Rosen, **Discrete Mathematics and Its Applications**, McGraw-Hill Companies, 2012
4. Suggested digital platform: NPTEL/SWAYAM/MOOCS

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

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

Course Otcomes

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	**Core Compulsory / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**
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-Tangent plane, Normal, Parametric patches on surface curve of a surface, family of surfaces (one parameter), edge of regression, rues surfaces, skew ruled surfaces and developable surfaces.	**9**
III	Metric-first fundamental form and second fundamental form and arc length, Direction coefficients, families of curves, intrinsic properties.	**9**
IV	Gauss-Bonnet theorem, curvature of curves on surfaces, Gaussian curvature, normal curvature, Meusneir's theorem, mean 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.	10
VI	Tensor Analysis: Contravariant and covariant vectors and tensors, Mixed tensors, Symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Q uotient theorem, Reciprocal tensors. Christoffel's symbols, Law of transformation of Christoffel's symbols,	10
VII	Gradient of scalars, Divergence of a contravariant vector, covariant vector and conservative vectors, Laplacian of an invariant, curl of a covariant vector.	9
VIII	Riemannian space, Riemannian curvatures and their properties, geodesics, geodesic curvature, geometrical interpretation of curvature 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. L. P. Eisenhart, **An Introduction to Differential Geometry** (with the use of tensor Calculus), Princeton University Press,1940.
8. I. S. Sokolnikoff,**Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continua**, 2nd Edition, John Wiley and Sons.,1964.
9. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Tensor Analysis):

1. Z. Ahsan, **Tensors- Mathematics of Differential Geometry,** 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 Riemannian Geometry**, Pothishala Pvt. Ltd, 1965
4. Suggested digital platform: NPTEL/SWAYAM/MOOCS

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

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Sixth**
Subject: Mathematics		
Course 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 / Elective**
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

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 and sub sequences in metric spaces, Convergent Sequences in metric spaces, Cluster point of a sequence, Cauchy sequences in a Metric space, Definition of Complete Metric space and examples and cantor's intersection theorem	**7**
IV	**Continuity & Uniform Continuity in Metric Spaces** Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity of composite functions, Homomorphism, Characterization of Homomorphism	**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	Analytic Functions Cauchy-Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples, Harmonic function Method of constructing a regular function (Milne-Thomson's method).	8
VII	Conformal mapping, necessary and sufficient condition, Inverse point, Bilinear transformation, critical point, cross ratio, fixed point.	7
VIII	Exponential function, Logarithmic function, Branches and derivatives of logarithms, Trigonometric function, Derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals.	7

Suggested Readings (Part-A Metric Space):

1. M K Singal and A R Singal , **Topics in Analysis II** 2017
2. Shirali, Satish & Vasudeva, H. L., **Metric Spaces**, Springer, First Indian Print. 2009
3. Kumaresan, S., **Topology of Metric Spaces** Narosa Publishing House, 2014
4. Simmons, G. F. **Introduction to Topology and Modern Analysis,** Tata McGraw Hill. 2004
5. Suggested digital platform: NPTEL/SWAYAM/MOOCS.

Suggested Readings (Part-B Complex Analysis):

1. Shanti Narain , Function of Complex Variable, S Chand, 2005
2. S Ponnusamy, **Functions of Complex Analysis**, Narosa, 2005
3. Brown & Churchill, **Complex variable and applications,** 2013
4. Suggested digital platform: NPTEL/SWAYAM/MOOCS

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

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Sixth**
Subject: Mathematics		
Course 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 of the 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 / Elective**
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

Numerical Analysis

Unit	**Topics**	**No. of Lectures**
I	**Errors in Computation-** Floating point representation of numbers, Significant Digits, Rounding and chopping, Absolute and relative errors, computation of errors using differentials, Truncation error. Solution of non-linear equations: bisection, Secant, Regular Falsi, Newton Raphson's method.	**8**
II	**Interpolation-**Some operators and their properties, Finite difference table, Error in approximating a function by polynomial, Newton forward and backward Difference formulae, Gauss forward and backward formulae, Stirling's and Bessel formulae, Lagrange's method, Divided differences and Newton's divided difference formula.	**8**
III	**Numerical differentiation** -Differentiation methods based on Newton's forward and backward formulae, Differentiation by central difference formula, Numerical Integration: Trapezoidal, Weddle, Simpsons Newton Cotes Formulas, Gaussian Quadrature 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	Operations research and its scope, 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.	7
VIII	Transportation problems, assignment problems.	7

Suggested Readings (Part-A Numerical Analysis):

1. MK. Jain, S.R.K. Iyengar & R.K. Jain, **Numerical Methods for Engineering and scientific computation,** New Age Publishers, 2009
2. S. S. Sastry, **Introductory methods of Numerical Analysis, PHI, 2012**
3. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Operations Research):

1.Taha, Hamdy H, **Operations Research- An Introduction**, Pearson Education. 2017

2.Hillier Frederick S and Lieberman Gerald J., **Introduction to Operations Research**, McGraw Hill Publication. 2012

3.Winston Wayne L., **Operations Research: Applications and Algorithms**, Cengage Learning, 4th Edition., 2004

4.Hira D.S. and Gupta Prem Kumar, **Problems in Operations Research**: Principles and Solutions, S Chand & Co Ltd., 1995

5.Suggested digital platform: NPTEL/SWAYAM/MOOCs.

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

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Sixth**
Subject: Mathematics		
Course 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 / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**

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 practical to be done using computer algebra software (CAS), for example R/Python/Mathematica/MATLAB/Maple/ Maxima/Scilab etc. 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. Interpolation i. Lagrange Interpolation ii. Newton's forward, backward and divided difference interpolations 4. Numerical Integration i. Trapezoidal Rule ii. Simpson's one third rule iii. Weddle's Rule iv. Gauss Quadrature 5. Method of finding Eigenvalue by Power method (up to 4 × 4) i. Runge Kutta method (order 4) ii. The method of successive approximations (Picard)	

Suggested Readings:		
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:		

Appendix (परिशिष्ट)
भारतीय प्राचीन गणित और गणितज्ञों का परिचय,
सुझाए गए पाठ्यक्रम

(Introduction to Indian ancient Mathematics and Mathematicians- Suggested syllabus)

पाठ्यक्रम - 1 प्रथम वर्ष, (FIRST YEAR)

~मित्र तथा परम मित्र अंक (Friend and Fast Friend) -
सूत्र - निखिलम् नवतश्चरमं दशतः (Nikhilam Navatascharamam Dashatah)
~संकलन तथा व्यवकलन (Addition and subtraction)
सूत्र - एकन्यूनेन पूर्वेण तथा निखिलं नवतश्चरमं दशतः (Eknunen Purvena and Nikhilam Navatascharamam Dashatah)
~गुणन (Multiplication) -
एकाधिकेन पूर्वेण विधि (Ekadhikena Method)
एकन्यूनेन पूर्वेण विधि (Eknunen Purvena Method)
विचलन विधि (Deviation Method)
ऊर्ध्वतिर्यग्भ्याम् विधि (Vertically and Crosswise Method)
~संयुक्त संक्रिया (Mixed Operations)
निम्नलिखित भारतीय गणितज्ञों का योगदान (Contribution of the following Indian Mathematician)
~वराहमिहिर (Varahmihir)
~भास्कराचार्य (Bhaskaracharya)
~नीलकंठ सोमैया (Nilakantha Somaiya)
~श्रीधराचार्य (Sridharacharya)

पाठ्यक्रम - 2 द्वितीय वर्ष (SECOND YEAR)

~ विनकुलम संख्या, परिचय, रुपांतरण तथा अनुप्रयोग (Vinakulum number, Introduction, Conversion and Application)
भाग (Division)
~निखिलं विधि (Nikhilam Method)
~परावर्त्य विधि (Paravartya Method)
~ध्वजांक विधि (Flag Method)
विभाजकता की जांच (Test of Divisibility)
~लघुतम समापवर्त्य तथा महत्तम समापवर्तक (Least Common Multiple and Highest Common Factor)

निम्नलिखित भारतीय गणितज्ञों का योगदान (Contribution of the following Indian Mathematician)
~भारती कृष्ण तीर्थ (Bharti Krishna Tirtha)
~ब्रह्मगुप्त (Brahmagupta)
~महावीराचार्य (Mahaviracharya)
~श्रीनिवास रामानुजन (Srinivas Ramanujan)

पाठ्यक्रम - 3 तृतीय वर्ष (THIRD YEAR)

~द्वंद्वयोग (Duplex)
~वर्ग (Square)
~घन (Cube)
~वर्ग मूल (Square root)
~ घन मूल (Cube root)
~मूलांक - संकलन, व्यवकलन, गुणन तथा विभाजन की जांच (Digital root - Test of Addition, Subtraction, Multiplication and Division)

निम्नलिखित भारतीय गणितज्ञों का योगदान (Contribution of the following Indian Mathematician)
सी. आर. राव (C. R. RAO)
सत्येंद्र नाथ बोस (SATYENDRA NATH BOSE)
हेमचन्द्र(HEMCHANDRA)
शकुन्तला देवी(SHAKUNTALA DEVI)
मंजुल भार्गव(Manjul bhargav)

संदर्भ-ग्रंथ-सूची :-

(1) वैदिक गणित निर्देशिका भाग -1 तथा भाग - 2 विद्या भारती अखिल भारतीय शिक्षा संस्थान, कुरुक्षेत्र
(2) वैदिक गणित - मोतीलाल बनारसीदास, नई दिल्ली
(3) वैदिक गणित विहंगम दृष्टि - 1 शिक्षा संस्कृति उत्थान न्यास दिल्ली - डॉ. कैलाश विश्वकर्मा
(4) वैदिक गणित अतीत, वर्तमान एवं भविष्य शिक्षा संस्कृति उत्थान न्यास दिल्ली, डॉ. कैलाश विश्वकर्मा
(5) Vedic Mathematics for School (Vol. - 1) Vedic Mathematics Publication, Rakesh Bhatia
(6) Vedic Mathematics, Vedic Mathematics Publication, Rakesh Bhatia & Akshay Bhatia

(Dr. Shashi Sharma) (Dr. Kunwar Pal Singh) (Dr. Rishi Kumar Agarwal) (Prof. C.K Goel)

(Prof. R.C. Mittal) (Prof. Anil Vashistha) (Dr. Pramod Kumar Sahoo) (Prof. G.C. Sharma)

(Prof. M.K. Gupta) (Prof. Shiv Raj Singh)