.

National Education Policy-2020

Common Minimum Syllabus for all U. P. State Universities and Colleges

FOR

B.A./B.Sc. - MATHEMATICS (w.e.f. session 2021-22)

Approved by

Board of Studies

Department of Mathematics
Faculty of Science and Technology
Mahatma Gandhi Kashi Vidyapith
Varanasi

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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 Equations & Mechanics	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 (15Weeks)	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	089 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(2 Hours Each)	2x2x 15= 60	**Practical** (Practicals to be done using MATHEMATICA /MATLAB /Maple /SCILAB/Maxima/ GAP 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 (15Weeks)	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 Equations & Mechanics** **Part A: Differential Equations** **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 Spaces** **&** **Complex Analysis** **Part A: Metric Spaces** **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(2 Hours 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 outcomes 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).** 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.	**9**
II	Limit, continuity and differentiability of function of single variable, Cauchy's definition, Heine's definition, equivalence of definition of Cauchy's and Heine's, 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 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**

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, Pappu's 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 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. H. S. Dhami, Differential Calculus, New Age Publisher
7. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS
8. Course Books (text/reference) published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Integral Calculus):

9. T. M. Apostal, Calculus Vol. II, John Wiley Publication
10. Shanti Narayan & Dr. P.K. Mittal, Integral Calculus, S. Chand
11. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
12. H. S. Dhami, Integral Calculus, New Age Publisher
13. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS
14. Course Books (text/reference) published in Hindi may be prescribed by the respective universities at local level.

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/** Research Orientation assignment	**5**
4	**Assignment (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. 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 plotthe different graph andsolve the different types of equations by plottingthe 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 theconvergence 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 toplotComplex numbers and their representations, Operations like addition, substraction, Multiplication, Division, Modulus andGraphical 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 practicals to be done using R/Python/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) $\sqrt{ax+b}$, $\lvert ax+b\rvert$, $c \pm \lvert ax+b\rvert$ (ix) $\frac{\lvert x\rvert}{x}$, $\sin\left(\frac{1}{x}\right)$, $x\sin\left(\frac{1}{x}\right)$, e^{x}, e^{-x} for $x \neq 0$. (x) e^{ax+b}, $\log(ax+b)$, $\frac{1}{ax+b}$, $\sin(ax+b)$, $\cos(ax+b)$, $\lvert\sin(ax+b)\rvert$, $\lvert\cos(ax+b)\rvert$. Observe and discuss the effect of changes in the real constants aand b on the graphs. (2) By plotting the graph find thesolution 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 secondderivatives.	

	(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 representation of polar form. (9) Find numbers between two real numbers and plotting of finite and infinite subset of R. (10) Matrix Operations: Addition, Multiplication, Inverse, Transpose, Determinant, Rank, Eigenvectors, Eigenvalues, Characteristic equation and verification of the Cayley-Hamilton theorem, Solving the systems of linear equations. (11) Study the convergence of sequences through plotting. (12)Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. (13)Study the convergence/divergence of infinite series by plotting their sequences of partial sum. (14) Cauchy's root test by plotting *n*-th roots. (15) 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 12th

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, Eigenvalues 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, Echelon form of a Matrix, Normal form of a Matrix, Inverse of a Matrix by elementary operations, System of linear homogeneous and non-homogeneous equations, Theorems on consistency of a system of linear equations.	**12**
II	Eigenvalues, Eigenvectors and characteristic equation of a matrix, Cayley-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, Equation in 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, Polar equation of conics and its properties.	**12**
VI	Three-Dimensional Coordinates, Direction Cosines & Ratios, Projections, Planes (Cartesian and vector form), Straight lines in three dimensions.	**11**
VII	Sphere, Cone and Cylinder.	**11**
VIII	Central conicoids, Paraboloids, Plane section of conicoids, Generating lines, Confocal conicoids, Reduction of second degree equations.	**11**

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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. A. C. Yadav, Matrices & Linear Algebra with GAP, Educreation Publishing.
5. Suggested digital plate form: NPTEL/SWAYAM/MOOCs.
6. M. D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand Pub.
7. 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. Narayan & P. K. Mittal, 3-dimensional Geometry, S. Chand.

4. S. L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London.

5. Suggested digital plate form: NPTEL/SWAYAM/MOOCs.

6. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

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/** Research Orientation assignment	**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.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 student's 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	**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's and Euler's theorems	**11**
III	Normal subgroups, Quotient groups, Homomorphisms and isomorphisms, Fundamental theorem of homomorphism, Theorems on isomorphism.	**11**
IV	Rings, Subrings, Integral domains and fields, Characteristic of a ring, Ideal and quotient rings, Ring homomorphisms, Quotient field of an integral domain.	**11**

Part- B
Mathematical Methods

Unit	Topics	No. of Lectures
I	Limit and Continuity of functions of two variables, Differentiation of function of two variables, Necessary and sufficient condition for differentiability of functions of two variables, Schwarz's and Young's theorem, Taylor's theorem for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange's multiplier method, Jacobians.	**12**
II	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**
III	Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Fourier transforms (finite and infinite), Fourier integrals.	**11**
IV	**Calculus of variations:** Variational problems with fixed boundaries- Euler's equation for functional containing first order derivative and one independent variable, Extremals, Functional dependent on higher order derivatives, Functional dependent on more than one independent variable, Variational problems in parametric form.	**11**

Suggested Readings(Part-A Algebra):

1. J. B. Fraleigh, A first course in Abstract Algebra, Addison-Wiley.
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons.
3. J. A. Gallian, Contemporary Abstract Algebra, Fourth edition, Narosa Publishing House.
4. R. Lal, Algebra-1(Group, Rings & Fields), Infosys series of Mathematical Sciences, Springer.
5. Suggested digital plate form: NPTEL/SWAYAM/MOOCS
6. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

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 –McGraw Hill
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4. A. S. Gupta, Calculus of Variations, PHI, New Delhi.
5. Suggested digital plate form: NPTEL/SWAYAM/MOOCs
6. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

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/** Research Orientation assignment	**5**
4	**Assignment (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, 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 mechanics 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, Series solutions of differential equations, Power series method.	**12**
II	Bessel, Legendre and Hypergeometric functions and their properties, recurrence and generating relations.	**11**
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.	**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
I	Frame of reference, work energy principle, Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines and null planes.	**12**
II	Virtual work, Stable and Unstable equilibrium, Catenary, Catenary of uniform string.	**11**
III	Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other laws of forces. Elastic strings, Motion in resisting medium, Constrained motion, Motion on smooth and rough plane curves.	**11**
IV	Motion of particles of varying mass & Rocket motion, Central orbit, Kepler's laws of motion, Motion of particle in three dimensions, Rotating frame of reference, Rotating earth, Acceleration in terms of different coordinate systems.	**11**

Suggested Readings(Part-A Differential Equations):

1. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata –McGraw Hill
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 plate form: NPTEL/SWAYAM/MOOCs.
6. M. D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand Pub.
7. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

Suggested Readings(Part-B Mechanics):

1. R.C. Hibbeler, Engineering Mechanics-Statics, Prentics Hall Publishers
2. R. C. Hibbeler, Engineering Mechanics-Dynamics, Prentice Hall Publishers
3. A. Nelson, Engineering Mechanics Statics and Dynamics, Tata McGraw Hill
4. M. Ray, A text book on Dynamics, S. Chand
5. F. Charlton, A text book of Dynamics, CBS Publisher.
6. Suggested digital plate form: NPTEL/SWAYAM/MOOCs
7. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

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/** Research Orientation assignment	**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: Linear 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: 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	**Introduction to Indian ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE).** Automorphisms, inner automorphisms, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.	**10**
II	Conjugacy classes, The class equation, *p*-groups, The Sylow's theorems and its consequences, Applications of Sylow's theorems; Finite simple groups, Non-simplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications.	**10**
III	Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains (PID), Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein's criterion, Unique factorization in Z[x] (UFD).	**9**
IV	Divisibility in integral domains, Irreducible, Primes, Unique factorization domains, Euclidean domains (ED), Relation between UFD, PID & ED.	**9**

PART-B

Linear Algebra

Unit	Topics	No. of Lectures
V	Vector spaces, Subspaces, Linear independence and dependence of vectors, Basis and Dimension, Quotient space.	**10**
VI	Linear transformations, The Algebra of linear transformations, Rank & Nullity of Linear Transformations, rank-nullity theorem, Representation of Linear transformations as matrices, Effect of change of bases.	**9**
VII	Linear functionals, Dual space, characteristic values of linear transformations, 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, Bilinear and Quadratic forms.	**9**

Suggested Readings:

1. J. B. Fraleigh, A first course in Abstract Algebra, Addison-Wiley.
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons.
3. J. Rotman, Group Theory, Springer
4. J. A. Gallian, Contemporary Abstract Algebra, Fourth edition, Narosa Publishing House.
5. T. S. Blyth & Robertson, Basic Linear Algebra, Springer.
6. A. C. Yadav, Matrices and Linear Algebra with GAP, Educreation Publication.
7. Suggested digital plate form: NPTEL/SWAYAM/MOOCs
8. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

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 (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, Solving rectangular game by Simplex method, reduction of $m \times n$ game and solution of 2×2, $2 \times s$, and $r \times 2$ cases by graphical method, algebraic and linear programming solution of m×n games.	**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.ece.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.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 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, 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, Hasse diagram. **Boolean Algebra-** Basic definitions, Sum of products and products of sums, Logic gates and Karnaugh maps.	**10**
VII	**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**
VIII	**Finite Automata-** Basic concepts of automation theory, Deterministic Finite Automation (DFA), transition function, transition table, Non Deterministic Finite Automata (NDFA), Mealy and Moore machine, Minimization of finite automation.	**9**

Suggested Readings (Part-A Graph Theory):

1. N. Deo, Graph Theory with Applications to Engineering and Computer Science.
2. D. B West, Introduction to Graph Theory.
3. S. S. Ray , Graph Theory with Algorithms and Its Applications: In Applied Science and Technology.
4. A. C. Yadav, Elements of Discrete Mathematics, Golden Valley Publication.
5. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
6. Course Books published in Hindi may be prescribed by the Universities.

Suggested Readings (Part-B Discrete Mathematics):

1. C. L. Liu, Discrete Mathematics, Mc Graw Hill.
2. Trembley and Manohar, Discrete Mathematics with computer application.
3. K. H. Rosen, Discrete Mathematics and Its Applications, Mc Graw Hill.
4. R. Garnier & J. Taylor, Discrete Mathematics A new Technology, IOP Publishing, London.
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), 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 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	**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- Parametric patches on surface curve of a surface, family of surfaces (one parameter), edge of regression, rues 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, canonical geodesic 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 a covariant vector, irrotational vector, with examples.	**9**
VIII	Riemannian space, Riemannian curvatures and their properties, geodesics, geodesic curvature, geometrical interpretation of curvature tensor, 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. D. Somasundaram, Differential Geometry: A First Course, Alpha Science International.
10. Suggested digital plateform:NPTEL/SWAYAM/MOOCs
11. 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.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.

The student will be able to solve various problems based on linear programming. After successful completion of this paper will enable the students to apply the basic concepts 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

Metric Spaces

Unit	Topics	No. of Lectures
I	**Basic Concepts** Metric spaces**:** Definition and examples, Sequences in metric spaces, Cauchy sequences, Complete metric space.	**8**
II	**Topology of Metric Spaces** Open and closed balls, Neighborhoods, Open sets, Interior of a set, limit points of a set, derived sets, closed sets, closure of a set, diameter of a set, Cantor's intersection theorem, Subspaces, Dense set.	**8**
III	**Continuity & Uniform Continuity in Metric Spaces** Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphisms, Contraction mappings, Banach fixed point theorem.	**7**
IV	**Connectedness and Compactness** Connectedness, Connected subsets of a metric space, Connectedness and continuous mappings, Compactness, Compactness and boundedness, Continuous functions on compact spaces.	**7**

Part- B
Complex Analysis

Unit	Topics	No. of Lectures
V	**Analytic Functions and Cauchy-Riemann Equations** Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples. Milne-Thompson method.	**8**
VI	**Elementary Functions and Integrals** Exponential function, Logarithmic function, Branches and derivatives of logarithms, Trigonometric function. Derivatives of these functions, Definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals.	**8**
VII	**Cauchy's Theorems and Fundamental Theorem of Algebra** Anti-derivatives, Proof of Anti-derivative theorem, Cauchy-Goursat theorem, Cauchy integral formula; an extension of Cauchy integral formula, Consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.	**7**
VIII	**Series and Residues** Convergence of sequences and series, Taylor series and its examples; Laurent series and its examples, Absolute and Uniform convergence of power series, Uniqueness of series representations of power series, Zeros & types of singularities, Residues at poles and its examples, Residues, Cauchy's residue theorem, residue at infinity.	**7**

Suggested Readings (Part-A Metric Space):

1. S. Kumaresan, Topology of Metric Spaces (2nd ed.). Narosa Publishing House. New Delhi, 2014.
2. P. K. Jain & K. Ahmad, Metric Space, PHI, India.
3. Shirali, Satish & Vasudeva, H. L. (2009). Metric Spaces, Springer, First Indian Print.
4. Suggested digital plate form: NPTEL/SWAYAM/MOOCS.
5.Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

Suggested Readings (Part-B Complex Analysis):

1. Brown & Churchill , Complex variable and applications
2. S. Ponnusamy, Foundation of Complex Analysis, Narosa Publishing House.
3. T. W. Gamelin, Complex Analysis, Springer.
4. Suggested digital plate form: NPTEL/SWAYAM/MOOCS.
5. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

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 & Operations 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 linear programming. After successful completion of this paper will enable the students to apply the basic concepts 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	Solution of equations: bisection, Secant, Regula-Falsi, Newton-Raphson's method, Newton's method for multiple roots, Interpolation, Lagrange and Hermite interpolation, Difference schemes, Divided differences, Interpolation formula using differences.	**8**
II	Numerical differentiation, Numerical Quadrature: Newton Cotes Formulas, Gaussian Quadrature Formulas, 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). The Algebraic Eigenvalue problems: Jacobi's method, Givens method, Power method.	**8**
III	Numerical solution of Ordinary differential equations: Euler method, single step methods, Runge-Kutta method, Multi-step methods: Milne-Simpson method, Types of approximation: Least Square polynomial approximation, Uniform approximation, Chebyshev polynomial approximation.	**7**
IV	Difference Equations and their solutions, Shooting method and Difference equation method for solving second linear order differential equation with boundary conditions of first, second and third type.	**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.	**7**
VIII	Sensitivity analysis, Transportation problems, assignment problems.	**7**

Suggested Readings(Part-A Numerical Analysis):

1. M. K. Jain, S. R. K. Iyengar & R. K. Jain, Numerical Methods for Engineering and scientific computation, New Age Int. Publisher.
2. S. S. Sastry, Introductory methods of Numerical Analysis,
3. Suggested digital plate form: NPTEL/SWAYAM/MOOCs
4. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

Suggested Readings(Part-B Operation Research):

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

2. Gupta, Prem Kumar, Initials, " Operations Research", Chand (S) & Co Ltd, India

3. Kanti Swaroop, P. K. Gupta & Manmohan, Operations Research, S. Chand.

4. Hillier Frederick S and Lieberman Gerald J., "Operations Research", McGraw Hill Publication.

5. Winston Wayne L., "Operations Research: Applications and Algorithms", Cengage Learning, 4th Edition.

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

7. Suggested digital plate form: NPTEL/SWAYAM/MOOCs.

8. Course Books (text/reference) published in Hindi may be prescribed by the Universities at local levels.

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's to be done using computer algebra software (CAS), for example /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) 6. Fitting a Polynomial Function (up to third degree)	

	7. Solution of ordinary differential equations i) Euler method ii) Modified Euler method iii) Runge-Kutta method (order 4) (iv) 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: