KUMAUN UNIVERSITY NAINITAL

Common Minimum Syllabus for State Universities and Colleges of Uttarakhand
National Education Policy- 2020

Subject: MATHEMATICS

PROPOSED STRUCTURE OF UG MATHEMATICS SYLLABUS

Effective from Academic Year 2022-23

National Education Policy-2020
Common Minimum Syllabus for all Uttarakhand State Universities/Colleges
SUBJECT: MATHEMATICS
(Approved by Board of Studies on dated 27/07/2022.)
Semester-wise Titles of the Papers in B. Sc. (Mathematics as one of the major Subject)

Year	Sem.	Course Code	Paper Title	Theory/Practical	CREDIT (L+P+T)
Certificate in Science (Mathematics as one of the major Subject)					
FIRST YEAR	**I**		**Fundamental Mathematics**	THEORY	**6 (5+0+2)**
	II		**Geometry**	THEORY	**6 (5+0+2)**
Diploma in Science (Mathematics as one of the major Subject)					
SECOND YEAR	**III**		**Calculus**	THEORY	**6 (5+0+2)**
	IV		**Differential Equations**	THEORY	**6 (5+0+2)**
Bachelor of Science (Mathematics as one of the major Subject)					
THIRD YEAR	**V**		**Abstract Algebra**	THEORY	**6 (5+0+2)**
			Linear Algebra	THEORY	**6 (5+0+2)**
	VI		**Analysis**	THEORY	**6 (5+0+2)**
			Numerical Analysis	THEORY	**6 (5+0+2)**

Purpose of the Program

The Importance of Mathematics is well known. Without the study of Mathematics, student cannot think to pursue the higher studies not only in Science subjects but also in certain subjects of humanities. The purpose of the undergraduate program at the university and college level is to prepare our students for all those fields where basic knowledge of science subjects is required including academia for careers as well as professionals in various industries and research institutions.

Program Outcomes

PO 1. Students will have a firm foundation in the fundamentals and applications of mathematics and scientific theories.

PO 2. Students will develop skills in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PO 3. Students will be able to explore new directions to pursue higher studies in science subjects.

PO 4. Students will be able to contest and qualify different competitive exams where graduation degree is one of the essential qualifications.

PO 5. Students will be able to function as a member of an interdisciplinary problem-solving team.

PROGRAM SPECIFIC OUTCOMES (PSOS)	
First Year	**Certificate in Science (Mathematics as one of the major Subject)**
	Certificate in Science will give students a basic knowledge of mathematics. Two other major subjects needed for the study of other courses in forthcoming years. It will enable students to join the diploma course (semester III and IV) in any University or College of Higher education in Uttarakhand
Second Year	**Diploma in Science (Mathematics as one of the major Subject)**
	Diploma will enable students to join the Bachelor of Science course (semester V and VI) in any University or College of Higher education in Uttarakhand
Third Year	**Bachelor of Science (Mathematics as one of the major Subject)**
	Upon completion of a degree, students will be eligible for Masters Degree in any of the major subject in any of the higher institutions of India. It will give students an ability of critical thinking and scientific study of any discipline. Students after getting Bachelors degree will be eligible for all the competitive examinations where graduation is an essential qualification.

Year	Semester	Theory Paper	Units	Practical Paper	Units	Research Project	Total Credits (L+P+T)
1st	I	**Fundamental Mathematics**	5	NIL	NIL	NIL	(5+0+2)=6
	II	**Geometry**	5	NIL	NIL	NIL	(5+0+2)=6
2nd	III	**Calculus**	5	NIL	NIL	NIL	(5+0+2)=6
	IV	**Differential equations**	5	NIL	NIL	NIL	(5+0+2)=6
3rd	V	**Abstract Algebra**	5	NIL	NIL	NIL	(5+0+2)=6
		Linear Algebra	5	NIL	NIL	NIL	(5+0+2)=6
	VI	**Analysis**	5	NIL	NIL	NIL	(5+0+2)=6
		Numerical Analysis	5	NIL	NIL	NIL	(5+0+2)=6

Subject: Mathematics							
Course	**Semester**	**Paper Title**		**Prerequisite for Paper**	**Elective for Major Subject**	**Hours per Semester**	**Total Credits**
Certificate	I	Theory-1	**Fundamental Mathematics**	12th standard with Mathematics	Yes, open for all	70-75	(5+0+2)=6
	II	Theory-1	**Geometry**	Passed Sem-I Theory Paper-1	Yes, for the students with major Economics/ Geography	70-75	(5+0+2)=6
Diploma	III	Theory-1	**Calculus**	Passed Certificate Course	Yes, for the students with major Economics/ Geography	70-75	(5+0+2)=6
	IV	Theory-1	**Differential Equations**	Passed Sem-III Theory Paper-1	Yes, for the students with major Economics/ Geography	70-75	(5+0+2)=6
Degree	V	Theory-1	**Abstract Algebra**	Passed Sem-III and Sem-IV Theory papers	Yes, for the students with major Economics/ Geography	70-75	(5+0+2)=6
		Theory-2	**Linear Algebra**	Passed Sem-III and Sem-IV Theory papers	Yes, for the students with major Economics/ Geography	70-75	(5+0+2)=6
	VI	Theory-1	**Analysis**	Passed Sem-V Theory papers	Yes, for the students with major Economics/ Geography	70-75	(5+0+2)=6
		Theory-2	**Numerical Analysis**	Passed Sem-V Theory papers Theory papers	Yes, for the students with major Economics/ Geography	70-75	(5+0+2)=6

Pattern of Examination Theory Papers

1. Theory

- *Each theory paper shall consist of two sections **A** and **B**.*
- ***Section A (Short answers type with reasoning**): 45 marks, eight questions of nine marks each, any five have to be attempted.*
- ***Section B (Long answers type):** 30 marks, two questions of fifteen marks each, and both questions are compulsory with internal choice.*

2. Internal assessment

For each theory paper internal assessment shall be conducted periodically (in the form of class tests and/or assignments/ group discussion/ oral presentation/ overall performance) during the semester period. Total marks allotted to internal assessment shall be 25. The evaluated answer sheets/assignments have to be retained by the Professor In-Charge for the period of six months and can be shown to the students if students want to see the evaluated answer sheets. The marks obtained by the students shall be submitted to the Head of concerned department/ the Principal of the College for uploading onto the University examination portal.

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Science (Mathematics as one of the major Subject)					
1	**I**		**Fundamental Mathematics**	Theory	(5+0+2)=6
1	**II**		**Geometry**	Theory	(5+0+2)=6

Semester-I
Paper-I (Theory)
Course Title: Fundamental Mathematics

Programme/Class: Certificate	**Year:** First	**Semester:** First
Paper-I Theory Subject: Mathematics		
Course Code:	**Course Title: Fundamental Mathematics**	

Course Outcomes: This paper is a fundamental course for intermediate pass students who are going to study mathematics as one of the major subject for their graduation degree. It gives basic knowledge and background to understand other courses either in mathematics or physics.

Credits:6	**Compulsory**
Max. Marks: 25+75	Minimum Passing Marks: ….

Total Number of Hours = 70-75

Unit	Content	Number of Hours
Unit I	**Preliminaries** Sets, Operations on sets, Index set and family of sets, Relations, Equivalence relations and partitions, Functions, Composition of functions, Infinite sets and cardinality, Cantor set, Principle of mathematical induction.	10-15
Unit II	**Theory of Equations** Relations between Roots and Coefficients of algebraic equations, Transformation of equations, Descartes rule of signs, Solutions of Cubic and Bi-quadratic equations.	12-15
Unit III	**Matrices** Basic concepts of matrices, Types of matrices, Transpose, trace and determinant of a matrix, Elementary operations, Row Reduced echelon form, Rank and inverse of a matrix, Normal form of a matrix, Solutions of a system of linear equations, Characteristic equation of a matrix, eigenvalues, eigenvectors, Cayley-Hamilton theorem.	10-15
Unit IV	**Trigonometry** Complex numbers with elementary properties, De-Moivre's theorem, Exponential Functions, Euler's theorem, Circular and hyperbolic functions of complex variables together with their inverses, Logarithmic Functions, Gregory's series, Summation of Trigonometric series.	10-15
Unit V	**Vector Calculus** Dot product, cross product and their geometric interpretation, Triple products, Reciprocal vectors, Ordinary differentiation of vectors, Differential operators-Del, Gradient, Divergence and Curl, Line, surface and volume integrals, Simple applications of Gauss divergence theorem, Green's theorem and Stokes' theorem.	12-15

Books Recommended:

1. C. C. MacDuffee: *Theory of Equations,* John Wiley & Sons, 1954.
2. Shanti Narayan and P. K. Mittal: A Text Book of Vector Calculus, S. Chand & Company, 1987.
3. J. G. Chakravorty and P. R. Ghosh: *Analytical Geometry and Vector Analysis,* U. N. Dhur & Sons Pvt. Ltd, 1973.
4. Murray Spiegel, Seymour Lipschutz and Dennis Spellman: *Vector Analysis,* Schaum's Outline Series, McGraw Hill Edition, 2017.
5. R. K. Sharma, S. K. Shah and A. G. Shankar: *Complex Numbers and the Theory of Equations,* Anthem Press , 2011.
6. N. Saran and S. N. Nigam*: Introduction to vector analysis,* Pothishala publication, Allahabad, 1990.

Further Readings:

1. William Snow Burnside and Arthur William Panton: *The Theory of Equations Vol. I*, Nabu Press, 2011.
2. Leonard E. Dickson: *First Course in the Theory of Equations*, Merchant Books, 2009.
3. Fuzhen Zhang: *Matrix Theory- Basic Results and Techniques*, Springer, 1999.
4. K. B. Dutta: *Matrix and Linear Algebra*, Prentice Hall of India, 2004.
5. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have studied the Mathematics of class 12^{th} standard.

Semester-II
Paper-I (Theory)
Course Title: Geometry

Programme/Class: Certificate	**Year:** First	**Semester:** Second
		Paper-I Theory Subject: Mathematics
Course Code:		**Course Title:** Geometry

Course Outcomes: This course will enhance the understanding of mathematical concepts with geometrical/graphical interpretations. After studying this course students will be able to visualize mathematical concepts geometrically.

Credits: 6	**Compulsory**	
Max. Marks: 25+75	Minimum Passing Marks: ….	
Total Number of Hours = 70-75		
Units	**Content**	**Number of Hours**
Unit I	**Introduction** Polar coordinate system, Polar equation of a conic, Chords, Tangent and Normal to a conic, Tracing of conics.	10-15
Unit II	**Direction Cosines and the Plane** Cartesian co-ordinates in 3D, Direction cosines, direction ratios and their properties, Equation of a Plane in various forms, Two sides of a plane, Length of perpendicular from a point to a plane, Angle between two planes, System of planes, Intersection of three planes, Transformation of coordinates.	12-15
Unit III	**Straight Lines and the Sphere** Equation of a line in different forms, Angle between a line and a plane, Co-planar lines, Shortest distance, Length of perpendicular from a point to a line, Intersection of three planes, Transformation of coordinates. Definition and equation of a sphere, Plane section of a sphere,	10-15

	Intersection of two spheres, Sphere through a given circle, Intersection of a sphere and a line, Power of a point, Tangent plane, Plane of contact, Polar plane and polar lines, Pole of a plane, Conjugate points and conjugate planes, Angle of Intersection of two spheres. Radical axis and centre.	
Unit IV	**Cone and Cylinder** Definition and equation of a cone with various properties, Three mutually perpendicular generators, Intersection of a line with a cone, Tangent line and tangent plane, Reciprocal cone, Right circular cone, Definition and equation of a cylinder, Right circular cylinder, Enveloping cylinder, General equation of second degree.	10-15
Unit V	**The Conicoids** Central conicoids, Tangent plane, Director sphere, Normal, Plane of contact, Polar plane, Conjugate points, conjugate planes and conjugate lines, enveloping cone, Paraboloids, Plane sections of conicoids.	12-15

Books Recommended:

1. S.L. Loney: *The Elements of Coordinate Geometry,* McMillan and Company, London, 2018.
2. Shanti Narayan and P. K. Mittal: *Analytical Solid Geometry*, S. Chand & company, 2007.
3. P. K. Jain: *A Textbook of Analytical Geometry,* New Age Publication, 2014.
4. Jyoti Das: *Analytical Geometry,* Academic Publisher, 2011.
5. J. G. Chakravorty and P. R. Ghosh: *Analytical Geometry and Vector Analysis,* U. N. Dhur & Sons Pvt. Ltd, 1973.

Further Readings:

1. Henry B. Fine and H. D. Thompson: *Coordinate Geometry,* The Macmillan company, 1909.
2. George B. Thomas and Ross L. Finney: *Calculus and Analytic Geometry*, Pearson Education, 2010.
3. Robert J. T. Bell: *An Elementary Treatise on Coordinate Geometry of three dimensions,* Macmillan India Ltd., 1923.
4. P. R. Vittal: *Analytical Geometry-2D & 3D,* Pearson Education, 2013.
5. Manicavachagom T.K. Pillay: *A Textbook of Analytical Geometry (Part:1 & 2),* Viswanathan, S., Printers & Publishers Pvt Ltd, 2009.
6. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have studied the Mathematics of class 12^{th} standard.

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Diploma in Science (Mathematics as one of the major Subject)					
2	**III**		**Calculus**	Theory	(5+0+2)=6
2	**IV**		**Differential Equations**	Theory	(5+0+2)=6

Semester-III
Paper-I (Theory)
Course Title: Calculus

Programme/Class: Diploma	**Year:** Second	**Semester:** Third
		Paper-I Theory Subject: Mathematics
Course Code:		**Course Title: Calculus**

Course Outcomes: This paper provides detailed knowledge of differentiation and integration of various classes of functions. It relates and gives an analytical aptitude for various mathematical problems. After completing this courses students will be able to understand basic concepts of calculus and able to apply these concepts in other areas of study especially physics and engineering.

Credit: 6	**Compulsory**
Max. Marks: 25+75	Minimum Passing Marks: ….

Total No. of Hours = 70-75

Unit	**Contents**	**Number of Hours**
Unit I	**Limit, Continuity and Differentiability** Functions of one variable, Limit and Continuity of a function, Properties of continuous functions, Classification of Discontinuities, Differentiability of a function, Rolle's Theorem, Mean value theorems and their geometrical interpretations, Applications of mean value theorems. Successive Differentiation, n^{th} Differential coefficient of functions, Leibnitz Theorem; Taylor's Theorem, Maclaurin's Theorem, Taylor's and Maclaurin's series expansions, Indeterminate forms.	10-15
Unit II	**Tangents, Normals, Curvature and Asymptotes:** Geometrical meaning of dy/dx, Definition and equation of Tangent and Normal, Tangent at origin, Angle of intersection of two curves, Subtangent and Subnormal, Tangents and Normals of polar curves, Angle between radius vector and tangent, Perpendicular from pole to tangent, Pedal equation of curve, Polar subtangent and polar subnormal, Intrinsic equations. Curvature, Radius of curvature; Cartesian, Polar and pedal formula for radius of curvature, Tangential polar form, Centre of curvature, Asymptotes of algebraic curves, Methods of finding asymptotes, Parallel asymptotes.	12-15
Unit III	**Partial Derivatives and Jacobians:** Partial Derivatives, Euler's Theorem for Homogeneous Functions, Jacobians and their applications, Chain rule, Taylor's expansion of functions of several variables.	10-15

	Singular Points and Curve Tracing: Existence and classification of singular points, points of inflexion, Double Points, Cusp, Node and conjugate points, Curve tracing.	
Unit IV	**Definite Integrals:** Integral as a limit of sum, Properties of Definite integrals, Summation of series by integration, Beta function, Gamma function, Recurrence formula and other relations, Relation between Beta and Gamma function, Evaluation of integrals using Beta and Gamma functions, Differentiation and integration under the integral sign.	10-15
Unit V	**Multiple Integrals:** Double integrals, Repeated integrals, Evaluation of Double integrals, Double integral in polar coordinates, Change of order of integration in Double integrals, Triple integrals, Evaluation of Triple integrals, Dirichlet's theorem and its Liouvelle's extension. **Geometrical Applications of Definite Integrals:** Area bounded by curves (quadrature), Rectification (length of curves), Volumes and Surfaces of Solids of revolution.	12-15

Books Recommended:

1. T. M. Apostol: *Calculus Vol. I***,** John Willey & Sons, 1999.
2. Gorakh Prasad: *Differential Calculus*, Pothishala publication, Allahabad, 2016.
3. Gorakh Prasad: *Integral Calculus*, Pothishala Publication, Allahabad, 2016.
4. M. Ray, H. S. Sharma and S. S. Seth: *Differential Calculus*, Shiva Lal Agarwal & Company, Agra.
5. M. Ray, H. S. Sharma and S. S. Seth: *Integral Calculus*, Shiva Lal Agarwal & Company, Agra.

Further Readings:

1. S. Lang: *A First Course in Calculus*, Springer-Verlag New York Inc.,1986.
2. H. Anton, I. Birens and S. Davis: *Calculus*, John Wiley & Sons, 2007.
3. G. B. Thomas and R. L. Finney: *Calculus*, Pearson Education, 2010.
4. S. Balachandra Rao and C. K. Shantha: *Differential Calculus*, New Age Publication, 1992.
5. Frank Ayres and Elliott Mendelson: *Calculus*, Schaum's Outline Series, McGraw Hill Edition, 2009.
6. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have studied the Mathematics of class 12^{th} standard and completed mathematics courses of I and II semesters.

Semester-IV
Paper-I (Theory)
Course Title: Differential Equations

Programme/Class: Diploma	**Year:** Second	**Semester:** Fourth
		Paper-I Theory Subject: Mathematics
Course Code:	**Course Title: Differential Equations**	

Course Outcomes: This paper provides detailed knowledge of differential equations and their solutions. This course is useful for the students to solve not only mathematical problems in daily life but also helps to understand typical problems of physics and other related areas.

Credits: 6	**Compulsory**
Max. Marks: 25+75	Minimum Passing Marks: ….

Total No. of Hours = 70-75

Unit	**Contents**	**Number of Hours**
Unit I	Order and Degree of Differential Equations, Complete primitive (general solution, particular solution and singular solutions), Existence and uniqueness of the solution dy/dx= f(x,y). Differential equations of first order and first degree, Separation of variables, Homogeneous Equations, Linear Differential Equations, Exact Differential Equations, Integrating Factor, Equation of First order but not of first degree, variation of parameters, Clairaut's form, Singular solutions, Trajectory, Orthogonal Trajectory, Self-Orthogonal family of Curves.	10-15
Unit II	**Linear Differential Equations:** Linear equations with constant coefficients, Complementary function, Particular integral, Working rule for finding solution, Homogeneous linear equations. **Miscellaneous Equations:** Simultaneous differential equations, Differential equations of the form dx/P= dy/Q= dz/R where P, Q, R are functions of x, y and z, Exact differential equations, Total differential equations, Series solutions of differential equations, Linear differential equations of second order with variable coefficients.	12-15
Unit III	**Partial Differential Equations**: Partial differential equations of first order, Charpit's method, Linear partial differential equations with constant coefficients. First-order linear, quasi-linear and non-linear partial differential equations using the method of characteristics: explicit solutions. **Partial differential equations of second order:** Classification of second order linear equations in two independent variables: hyperbolic, parabolic and elliptic types (with examples).	10-15
Unit IV	Laplace Transformation, Inverse Laplace Transformation, Applications to solve Differential equations	10-15
Unit V	Fourier Transformation, Inverse Fourier Transformation, Applications to solve Differential equations	12-15

Books Recommended:

1. G. F. Simmons: *Differential Equations with Application and Historical Notes*, McGraw Hill Edition, 2002

2. Shepley L. Ross: *Differential Equations*, John Wiley & Sons, 1984.
3. M. D. Raisinghania: *Ordinary & Partial Differential Equation*, S. Chand & Co. Ltd, 2017.
4. B. Rai, D. P. Choudhary and H. J. Freedman: *A Course of Ordinary Differential Equations*, Narosa, 2002.

Further Readings:

1. Earl A. Coddington and Norman Levinson: *Theory of Ordinary Differential Equations*, McGraw-Hill Edition, 1998.
2. Ravi P. Agarwal and Donal O'Regan: *Ordinary and Partial Differential Equations*, Springer, 2009.
3. Martin Braun: *Differential Equations and Their Applications*, Sringer, 1993.
4. Erwin Kreyszig: *Advanced Engineering Mathematics*, John Wiley & Sons, 2011.
5. Ian N. Snedden: *Elements of Partial Differential Equations*, Dover Publication, 2013.
6. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have studied the Mathematics of class 12^{th} standard and completed mathematics courses of I, II and III semesters.

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Diploma in Science (Mathematics as one of the major Subject)					
3	**V**		**Abstract Algebra**	Theory	(5+0+2)=6
			Linear Algebra	Theory	(5+0+2)=6
3	**VI**		**Analysis**	Theory	(5+0+2)=6
			Numerical Analysis	Theory	(5+0+2)=6

Semester-V
Paper-I (Theory)
Course Title: Abstract Algebra

Programme/Class: Bachelor of Science	**Year:** Third	**Semester:** Fifth
		Paper-1 Theory Subject: Mathematics
Course Code:		**Course Title: Abstract Algebra**

Course Outcomes: This course is useful to understand the concepts of algebraic structures and their properties. It will help the students for better understanding of other subjects, especially atomic structures in chemistry and certain concepts of physics.

Credits: 6	**Compulsory**
Max. Marks: 25+75	Minimum Passing Marks: ….

Total Number of Hours = 70-75

Unit	**Contents**	**Number of**

		Hours
Unit I	Groups: Binary operation and Algebraic structure, Subgroups, Permutation groups, Cyclic groups, Coset decomposition, Lagrange theorem and its consequences, Normal subgroups, Quotient group.	10-15
Unit II	Homomorphism and Isomorphism, Fundamental theorems of homomorphism, Cayley's theorem, Automorphism and inner automorphism, Automorphism groups and their computation, Normalizer and center of group, Finite groups, Commutator subgroups.	12-15
Unit III	Direct Product, Group actions, Stabilizers and orbits, Conjugacy classes, Cauchy Theorem, Simple groups, Sylow's Theorems and their applications	10-15
Unit IV	Rings, Sub rings, Integral domain, Field, Skew field, Ideals, Characteristic of a ring, Ring Homomorphism, Quotient rings, Principal ideals, Maximal ideals, Prime ideals, Principal ideal domains, Polynomial rings and irreducibility.	10-15
Unit V	Field of quotients of an integral domain, Embedding of an integral domain in a field, Factorization in an integral domain, Divisibility, Units, Associates, Prime and irreducible elements, Unique Factorization Domain, Euclidean rings.	12-15

Books recommended:

1. I. N. Herstein: *Topics in Algebra*, John Wiley & Sons, 2006.
2. Joseph A. Gallian: *Contemporary Abstract Algebr,* Narosa Publishing House, 2016.
3. David S. Dummit and Richard M. Foote: *Abstract Algebra*, John Wiley & Sons, 2011.
4. Surjeet Singh and Qazi Zameeruddin: *Modern Algebra,* Vikas Publishing House, India, 2021.

Further Readings:

1. Michael Artin: *Algebra,* Pearson Education, 2015.
2. N. Jacobson: Lectures in Abstract Algebra-*Vol. I, II & III,* Springer, 2013.
3. N. Jacobson: Basic Algebra-*Vol. I & II,* Dover Publications Inc., 2009.
4. R. S. Aggarwal: *A Textbook on Modern Algebra,* S Chand & Company, 1973.
5. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have studied mathematics courses of I, II and III semesters.

Semester-V
Paper-II (Theory)
Course Title: Linear Algebra

Programme/Class: Bachelor of Science	**Year:** Third	**Semester:** Fifth
		Paper-II Theory Subject: Mathematics
Course Code:		**Course Title: Linear Algebra**

Course Outcomes: Upon successful completion of this course, the students will be able to understand the theory used to solve the mathematical problems. It also helps to enhance the critical thinking of the students.

Credits: 6	**Compulsory**
Max. Marks: 25+75	Minimum Passing Marks: ….

Total Number of Hours = 70-75

Unit	**Contents**	**Number of Hours**
Unit I	Vector space, subspaces, Linear combinations, linear spans, Sums and direct sums, Linear dependence and independence, Bases and dimensions, Dimensions and subspaces, Coordinates and change of bases.	10-15
Unit II	Linear transformations, rank-nullity theorem, Linear operators, Invertible linear transformations, Matrix representation of a linear transformation, Transpose of a linear transformation, Similarity of Matrices, Linear functional, Dual space and dual basis, Second dual space, hyperspace.	12-15
Unit III	Eigen values and Eigen vectors, Algebraic and Geometrical Multiplicity, Characteristic and Minimal Polynomials, Annihilators, Cayley-Hamilton theorem, Similar Matrices, Diagonalizable operator.	10-15
Unit IV	Invariant Subspaces, Direct sum decomposition, Projection on a vector space, Primary decomposition theorem, Canonical Forms, Diagonal forms, Triangular forms, Jordan forms.	10-15
Unit V	Inner Product Space, Gram Schmidt orthogonalization Process, Orthogonal Complements. Quadratic Forms, Congruence of Matrices, Reduction and Classification of a real quadratic form, Canonical and Normal form of a real quadratic form, Rank, Signature and Index, Various classes of a real quadratic form.	12-15

Books Recommended:

1. K. Hoffman and R. Kunze: *Linear Algebra*, Prentice Hall of India, 1972.
2. K. B. Dutta: *Matrix and Linear Algebra*, Prentice Hall of India, 2004.
3. Seymour Lipschutz and Marc L. Lipson*: Linear Algebra*, Schaum's Outline Series, McGraw Hill Edition, 2017.
4. S. H. Friedberg, A. J. Insel and L. E. Spence: *Linear Algebra*, Pearson Education, 2015.

Further Readings:

1. G. Hadley: *Linear Algebra*, Narosa Publishing House, 2002.
2. H. Helson: *Linear Algebra*, Hindustan Book Agency, New Delhi, 1994.
3. Gilbert Strang: *Linear Algebra and its Applications*, Cengage Learning India, 2005.
4. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have studied mathematics courses of I, II and III semesters.

Semester-VI

Paper-I (Theory)
Course Title: Analysis

Programme/Class: Bachelor of Science	**Year:** Third	**Semester:** Sixth
		Paper-I Theory Subject: Mathematics
Course Code:		**Course Title: Analysis**

Course Outcomes: The core concepts of Analysis (Real and complex) have been included in this course with a view that students can understand the behavior of real/complex numbers in a critical way.

Credits: 6	**Compulsory**
Max. Marks: 25+75	Minimum Passing Marks: ….

Total Number of Hours = 70-75

Unit	**Contents**	**Number of Hours**
Unit I	**Topology of real line:** Complete ordered field, Archimedean Property, Supremum, infimum, Neighbourhood of a point, Interior of a set, open set, closed set, Derived set, Closure of a set, Bolzano-Weierstrass Theorem, Brief introduction of compactness and connectedness. **Numerical Sequence and Series:** Sequences, theorems on limit of sequences, Cauchy sequence and completeness, Infinite series, series of non-negative terms, Various tests for convergence, Alternating series, Leibnitz's theorem, Absolute convergence, Conditional convergence.	10-15
Unit II	Continuity of functions, Discontinuities, Monotonic functions, Uniform continuity, Differentiability, Taylor's theorem with various forms of remainders. **Integration:** Riemann integral-definition and properties, Integrability of continuous and monotonic functions, Fundamental theorem of Calculus, Improper integrals and their convergence. **Sequence and Series of functions:** Point wise convergence, Uniform convergence, Tests of uniform convergence, Interchange of limits.	12-15
Unit III	Algebraic Properties of Complex Numbers, Powers and roots, Regions in complex plane, The point at infinity and Stereographic projection, Elementary functions, Limit, continuity and differentiability of functions of a complex variable, Cauchy-Riemann equations, Analytic functions, Harmonic functions.	10-15
Unit IV	Line Integration, Cauchy's theorem, Cauchy's integral formula. Morera's Theorem, Liouville's Theorem, Open mapping theorem, Maximum modulus principle, Schwarz lemma, Taylor's series, Laurent's series, Power series, Radius of convergence, Poles and	10-15

	singularities, Residues, The Residue theorem, Evaluation of Improper real integrals.	
Unit V	**Metric Spaces** Examples of metric spaces, Continuity, convergence, completeness and compactness in metric spaces, Cantor's Intersection Theorem.	12-15

Books Recommended:

1. Walter Rudin: *Principle of Mathematical Analysis*, McGraw Hill Edition, 1976.
2. R. G. Bartle and D. R. Sherbert: *Introduction to Real Analysis*, John Wiley & Sons, 1999.
3. T. M. Apostol: *Mathematical Analysis*, Narosa Publishing House, New Delhi, 1985.
4. J. B. Conway*: Functions of One Complex Variable*, Narosa Publishing House, 1980.
5. R. V. Churchil and J. W. Brown and R. F. Verhey: *Complex Variables and Applications*, McGraw Hill Edition, 1976.

Further Readings:

1. L. V. Ahlfors: *Complex Analysis*, McGraw Hill Edition, 1977.
2. E. T. Copson: *Complex Variables*, Oxford University Press.
3. Richard R. Goldberg: *Methods of Real Analysis*, John Wiley & Sons, 1976.
4. D. Sarason: *Complex Function Theory*, Hindustan Book Agency, Delhi, 1994.
5. James R. Munkres: *Analysis on Manifolds*, Addison-Wesley Publishing Company, Advanced Book Program, Redwood City, CA, 1991.
6. H. L. Royden: *Real Analysis*, Macmillan Publishing Company, New York, 1988.
7. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Edition, 2011.
8. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have passed all Theory papers up to V semester.

Semester-VI
Paper-II (Theory)
Course Title: Numerical Analysis

Programme/Class: Bachelor of Science	**Year:** Third	**Semester:** Sixth
Paper-II Theory Subject: Mathematics		
Course Code:	**Course Title: Numerical Analysis**	

Course Outcomes: After completion of this course, the students will be able to understand the methods to find alternate/ approximate solutions of certain mathematical problems.

Credits: 6	**Compulsory**
Max. Marks: 25+75	Minimum Passing Marks: ….

Total Number of Hours = 70-75

Unit	**Contents**	**Number of Hours**

Unit I	**Errors in numerical Calculations:** Absolute, Relative and Percentage errors, General Error, Error in series approximation.	10-15
Unit II	**Solutions of Algebraic and Transcendental Equations:** Bisection method, False position method, Newton-Raphson Method, Picard's iteration method. Linear systems of equations: Consistency of Linear System of equations, Solutions of Linear Systems by direct method: Guassian elimination and computation of inverse of a matrix, Method of Factorization, Solutions of linear systems by iterative methods: Jacobi method, Gauss-Siedel method.	12-15
Unit III	Least square curve fitting Procedures, Fitting of a straight line, Nonlinear curve fitting, Curve fitting by a sum of exponentials.	10-15
Unit IV	**Interpolation:** Errors in Polynomial interpolation, Finite differences, Differences of a polynomial, Newton's forward and backward interpolation, Central differences, Gauss, Stirling, Bessel's and Everett's Formulae, Lagrange's Interpolation formula.	10-15
Unit V	**Numerical differentiation and integration:** Numerical differentiation, Newton-Cotes Integration formula, Numerical integration by Trapezoidal rule, Simpson'1/3, Simpson's 3/8, and Romberg Integration.	12-15

Books Recommended:

1. S. S. Sastry*: Introductory of Methods Numerical Analysis*, Prentice Hall of India, 2012.
2. J. W. Thomas: *Numerical Partial differential Equations: Finite Difference Methods*, Springer, 1998.
3. S. D. Conte and C. de Boor : *Elementary Numerical Analysis - An Algorithmic Approach,* McGraw Hill Edition, 1981.

Further Readings:

1. P. Henrici: *Elements of Numerical Analysis*, John Wiley & Sons, 1964.
2. C. F. Gerald and P. O. Wheatley: *Applied Numerical Analysis*, Addison-Wesley Publishing Company, Advanced Book Program, Redwood City, CA, , 1998.
3. C. E. Froeberg: *Numerical Mathematics- Theory and Computer Applications,* The Benjamin Cummings Pub. Co., 1985.
4. Digital Platform: NPTEL/SWAYAM/MOOCs.

Course Prerequisites: To study this course, a student must have passed all Theory papers up to V semester.

Minor in Mathematics
Paper-I (Theory)
Course Title: Mathematics-I

Programme/Class: Minor	**Year:** First	**Semester:** First/Second
		Paper-I Theory Subject: Mathematics
Course Code:		**Course Title:Mathematics-I**

Course outcomes: This paper provides basic knowledge of continuity of functions, differentiability of functions and algebra of matrices with basic knowledge of system of linear equations. After completing this courses students will be able to learn the basic concepts of continuity, differentiability and methods of finding derivatives. The students will be able to understand the concept of matrices, their algebra and how to apply matrices to obtain solution of a system of linear equations. The students will be able to apply these concepts in other areas of study like economics, geography etc.

Credit: 5	**Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Hours- = 70-75	

Unit	Contents	Number of Hours
Unit I	Limit and continuity of functions, $(\epsilon - \delta)$ definition of continuity, differentiability of functions, geometrical representation of derivative.	**6-8**
Unit II	Differentiation of polynomial functions$(a_0 + a_1x + a_2x^2 + \cdots a_nx^n)$, trigonometric functions ($sinx, cosx$, $tanx$ etc), inverse trigonometric functions ($sin^{-1}x$, $cos^{-1}x$, $tan^{-1}x$ etc.), exponential function e^x and logarithmic function $log_e x$. Derivative of a sum of functions, derivative of a product of functions. Derivative of a function of function (chain rule). Derivative of implicit functions.	**8-10**
Unit III	Concept and notation of matrix, order of a matrix, equality of matrices, operations on matrices: addition, subtraction, scalar multiplication. Transpose of a matrix, Types of matrices: null matrix, identity matrix, symmetric and skew-symmetric matrices, matrix multiplication.	**8-10**
Unit IV	Square matrices, determinant, adjoint and inverse of a matrix, system of linear equations.	**8-10**

Books Recommended:

1. T. M. Apostol: *Calculus Vol. I***,** John Willey & Sons, 1999.
2. S. Lang: *A First Course in Calculus*, Springer-Verlag New York Inc.,1986.
3. Gorakh Prasad: *Differential Calculus*, Pothishala publication, Allahabad, 2016.
4. M. Ray, H. S. Sharma and S. S. Seth: *Differential Calculus*, Shiva Lal Agarwal & Company, Agra.
5. Fuzhen Zhang: Matrix Theory- Basic Results and Techniques, Springer, 1999.

Minor in Mathematics
Paper-II (Theory)
Course Title: Mathematics-II

Programme/Class: Minor	**Year:** Second	**Semester:** Third/Fourth
Paper-II Theory Subject: Mathematics		
Course Code:	**Course Title:Mathematics-II**	

Course outcomes: This paper provides basic knowledge of integration of functions and concept of differential equations along with their solutions. After completing this courses students will be able to learn the basic concepts of integrability, methods of finding integration, formation and solution of differential equations.

Credit: 5	**Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Hours- = 70-75	

Unit	Contents	Number of Hours
Unit I	Integration as inverse process of differentiation, Indefinite integrals, integration of standard functions like polynomials, trigonometric and inverse-trigonometric functions, exponential functions etc.,	**8-10**
Unit II	Integration by substitution, integration by parts, definite integrals, properties of definite integrals.	**8-10**

Unit III	Introduction, order and degree, solution of differential equations, general and particular integral, equation of first order and first degree $\left(\frac{dy}{dx} = f(x,y)\right)$, variable separable method, homogeneous linear equations,	**8-10**
Unit IV	Linear differential equation $\left(\frac{dy}{dx} + py = q\right)$, exact differential equation $(Mdx + Ndy = 0)$, integrating factors.	**8-10**

Books Recommended:

1. T. M. Apostol: *Calculus Vol. I***,** John Willey & Sons, 1999.
2. S. Lang: *A First Course in Calculus*, Springer-Verlag New York Inc.,1986.
3. Gorakh Prasad: *Integral Calculus*, Pothishala Publication, Allahabad, 2016.
4. M. Ray, H. S. Sharma and S. S. Seth: *Integral Calculus*, Shiva Lal Agarwal & Company, Agra.
5. Martin Braun: Differential Equations and Their Applications, Sringer, 1993.
6. M. D. Raisinghania: Ordinary & Partial Differential Equation, S. Chand & Co. Ltd, 2017.
7. B. Rai, D. P. Choudhary and H. J. Freedman: A Course of Ordinary Differential Equations, Narosa, 2002.