SYLLABUS(2022-23 Batch)
DEPARTMENT OF MATHEMATICS

(Recommended by B.O.S. in Mathematics, M.D.U. in its meeting held on 26.07.2024)

MADHABD EVUNIVERSITY
2024

Graduate Attributes in Mathematics

The graduate attributes in mathematics are the summation of the expected course learning outcomes mentioned in the beginning of each course. Some of them are stated below.

- Disciplinary knowledge:

Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an undergraduate programme of study.

- Communications skills:

  i. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
  ii. Ability to use mathematics as a precise language of communication in other branches of human knowledge.
  iii. Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization.
  iv. Ability to explain the development of mathematics in the civilizational context and its role as queen of all sciences.

- Critical thinking and analytical reasoning:

  i. Ability to employ critical thinking in understanding the concepts in every area of mathematics.
  ii. Ability to analyze the results and apply the various problems appearing in different branches of mathematics.

- Problem solving:

  i. Capability to solve various models such as growth and decay models,radioactive decay model, drug assimilation.
  ii. Ability to solve linear system of equations, linear programming problems and network flow problems.
  iii. Ability to provide new solutions using the domain knowledge of mathematics acquired during this programme.

- Research-related skills:

  i. Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
  ii. To know about the advances in various branches of mathematics.

- Information/digital literacy:

  i. Capability to use appropriate softwares to solve system of equations and differential equations.
  ii. Capability to understand and apply the computer programming concepts to mathematical investigations and problem solving.

- Self-directed learning:

  Ability to work independently and do in-depth study of various notions of mathematics.

- Moral and ethical awareness/reasoning:

  Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

- Life long learning:

  Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.

Programme Learning Outcomes of UG (Hons) Mathematics

UG in mathematics is the culmination of in-depth knowledge of algebra, calculus, Real Analysis, Linear Algebra, Geometry, Differential Equations and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.

1. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.

2. Students undergoing this programme learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems.

They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

3. Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.

4. Completion of this programme will also enable the learners to join teaching profession in higher, primary and secondary schools.

5. This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

Course learning outcomes

Course learning outcomes of each course of Mathematics have been enshrined in the beginning of course contents of each course.

Curriculum Framework of Four Year Under Graduate Programme (FYUGP), Madhabdev University

Academic Level	Semester	Major(60/80)	Minor (24/32)	MDC(9)	AEC(8)	VAC(7)	SEC(10)	Internship/Project(4/12)	Total Credit
	I	Major1(4)	Minor1(4)	MDC1(3)	Lifeskills(4)	Introduction to Yoga/NSS &Youth development/Sports & Physical Education (2)	Library&Information source/Computer operating system/ Introduction to communications(3)		20
	II	Major2(4)(4)	Minor2(4)	MDC2(3)	MIL/ Alternative English(4)/ Madhabdevstudies	Primary skills Rover&Ranger/Basic Yoga /NSS	Library and digital resources/ Scriptwriting/Digital literacy (3)		20
Level5	**Exit-1**	**UG Certificate Programme**							**40**
	III	Major3(4)	Minor3(4)	MDC3(3)		Environmental Studies (3)	CyberSecurity(4)		22
		Major4(4)							
	IV	Major5(4)	Minor4(4)					Community Engagement/ Internship(2)	22
		Major6(4)							
		Major7(4)							
		Major8(4)							
Level6	**Exit-2**	**UG Diploma Programme**							**84**
	V	Major9(4)	Minor5(4)						22
		Major10(4)						Internship(2)	
		Major11(4)							
		Major12(4)							
	VI	Major13(4)	Minor6 (4)						22
		Major14(4)					classical	ResearchProject(2)	
		Major15(4)							
		Major16(4)							
Level7	**Exit-3**	**UG Degree Programme**							**128**
	VII	Major17(4)	Minor7(4)				ResearchMethodology(4)	Seminar/Presentation/Internship/ ResearchProject(2)	22
		Major18(4)							
		Major19(4)							
	VIII	Major20(4)	Minor8(4)						24
		Major21(4)							

		Major22(4)						Project/Dissertation(8)	
Level8	**Exit-4**	**UG Degree Honours/ Research Programme**							**174**

2022-23 Batch

DRAFT STRUCTURE OF FOUR YEAR UNDER GRADUATE PROGRAMMES (FYUGP) AS PER NEP-2020 GUIDELINES

IN MATHEMATICS FOR MADHABDEV UNIVERSITY

First Semester			
Course Type	**Title of the Paper**	**Paper Code**	**Credit**
CORE MAJOR	Algebra I and Calculus -I	MATM 101	4
CORE MINOR		MATN 101	4
CORE MAJOR	Algebra I and Calculus -I (Practical)	MATM 102	2
CORE MINOR		MATN 102	
OPEN ELECTIVE	Mathematics I	MATO 101	3
Total Credit			
Second Semester			
CORE MAJOR	Algebra II and Calculus -II	MATM 201	4
CORE MINOR		MATN 201	4
CORE MAJOR	Algebra II and Calculus –II(Practical)	MATM 202	2
CORE MINOR		MATN 202	
OPEN ELECTIVE	Mathematics II	MATO 201	3
Total Credit			
Third Semester			
CORE MAJOR	Real Analysis	MATM 301	4
CORE MAJOR	Differential Equations	MATM 302	4
CORE MINOR	Differential Equations	MATN 301	4
MDC 3			3
VAC 3	Environmental Studies		3
SEC – 3	Cyber Security		4
	Total Credit		**22**
Fourth Semester			
CORE MAJOR	Theory of Real Functions	MATM 401	4
CORE MAJOR	PDE and System of ODE	MATM 402	4
CORE MAJOR	Numerical Methods	MATM 403	4
CORE MAJOR	Ring Theory I and Linear Algebra I	MATM 404	4
CORE MINOR	Real Analysis	MATN 401	4
Community Engagement/ Internship			2
	Total Credit		**22**

Fifth Semester			
CORE MAJOR	Introduction to Probability	MATM 501	4

CORE MAJOR	Multivariable Calculus	MATM 502	4
CORE MAJOR	Abstract Algebra II	MATM 503	4
CORE MAJOR	Mathematical Method	MATM 504	4
CORE MINOR	Numerical Analysis	MATN 501	4
Internship			2
	Total Credit		**22**
Sixth Semester			
CORE MAJOR	Riemann Integration and Series of Functions	MATM 601	4
CORE MAJOR	Complex Analysis	MATM 602	4
CORE MAJOR	Introduction to Probability	MATM 603	4
CORE MAJOR	Linear Programming	MATM 604	4
CORE MINOR	Linear Programming	MATN 601	4
Research Project			2
	Total Credit		**22**

Seven Semester			
CORE MAJOR	Topology	MATM 701	4
CORE MAJOR	Number Theory	MATM 702	4
CORE MAJOR	Abstract Algebra -III	MATM 703	4
CORE MINOR	PDE	MATN 701	4
Research Project			2
	Total Credit		**22**
Eight Semester			
CORE MAJOR	Functional Analysis	MATM 801	4
CORE MAJOR	Calculus of Variations	MATM 802	4
CORE MAJOR	Graph Theory	MATM 803	4
CORE MINOR	Introduction to Probability	MATN 801	4
Research Project			2
	Total Credit		**22**

B.A/B.SC. IN MATHEMATICS PROGRAMME(NEP)

Title of the Course	**Algebra I and Calculus I**
Course Code	**MATM/MATN 101**
Nature of Course	**Major/Minor**
Total Credits	**04(L=4,T=0,P=0)**
Distribution of Marks	**60(TH)+40(IA)**

Course Learning Outcomes: The course will enable the students to:

- Recognize consistent and inconsistent systems of linear equations by the row echelonform of the Augmented matrix, using rank.
- Find Eigenvalues and corresponding Eigenvectors for a square matrix.
- Learn conceptual variations while advancing from one variable to several variables calculus.
- Calculate the limit and examine the continuity, differentiability of a function at a point.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Recapitulation of Symmetric and Skew Symmetric matrices, Algebra of Matrices; Row and column reduction to Echelon form. Rank of a matrix; Finding rank of a matrix by reducing to row reduced echelon form and normal form; Solution of systemof linear equations; Criteria for existence of non-trivial solutions of homogeneous systemof linear equations. Solution of non-homogeneous system of linear equations. Eigen values and Eigenvectors of square matrices, standard properties; Cayley- Hamilton theorem(With Proof), inverse of matrices by Cayley- Hamilton theorem, finding A^2, A^3, A^{-1}, A^{-2}	25	0	0	25	25
II	Limits, Continuity, Differentiability and properties. Properties of continuous functions. nth Derivatives of Standard functions $e^{ax+b}, (ax+b)^n, log(ax+b), sin(ax+b), cos(ax+b),$ $e^{ax}sin(bx+c), e^{ax}cos(bx+c)$. Leibnitz theorem and its applications. .	08	0	0	08	10
III	Intermediate value theorem, Rolle's Theorem, Lagrange's Mean Value theorem, Cauchy's Mean value theorem and examples. Taylor's theorem, Maclaurin's series, Indeterminate forms and evaluation of limits using L'Hospital's rule.	08	0	0	08	10
IV	Functions of two or more variables-explicit and implicit functions, partial derivatives. Homogeneous functions- Euler's theorem, total derivatives, differentiation of implicit and composite functions, Jacobians and standard properties andillustrative examples. Taylor's and Maclaurin's series for functions of two variables, Maxima-Minima of functions of two variables.	19	0	0	19	15
	Total	**60**	**0**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Calculus- G.B.Thomas & R. L. Finney, PearsonEducation,2007
2. Linear Algebra and Its Application- David C Lay, S. R. Lay & J. J. McDonald,Pearson,2015
3. Abstract Algebra- V.K. Khanna & S. K.Bhambri, Vikash Publishing,2017

Reference Books:

1. Differential Calculus–S. Arumugam, A. Samasundaram and A. Isacc Thangapandi, CBS Publishers & Distributors private ltd., 2021.
2. Differential and Integral Calculus- A. G. Greenhill, Alpha Edition,2020.
3. Schaum's Outline of Calculus-Frank Ayres and Elliott Mendelson,5th ed.USA:Mc.Graw.
4. Linear Algebra Done Right-Axler Sheldron, Springer.

B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)

1st SEMESTER

Title of the Course	**Algebra I and Calculus-I (Practical)**
Course Code	**MATM/MATN 102**
Nature of Course	**Major/Minor**
Total Credits	**02(L=0,T=0,P=2)**
Distribution of Marks	**60(TH)+40(IA)**

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open Source Software (FOSS) tools for computer programming .
- Solve problem on algebra and calculus theory studied in MATM 101 by usingFOSS
- Solve problem on algebra and calculus theory studied in MATM 101 by using FOSS Software's
- Acquire knowledge of applications of algebra and calculus through FOSS

List of Practicals

Suggested Software's: Maxima/Scilab/Maple/MatLab/Mathematica/Python/R. Introduction to the software and commands related to the topic.

1. Basics of software with simple examples.
2. Basics of software with simple examples.
3. Matrices–Algebra of Matrices with problems.
4. Computation of rank of a matrix.
5. Solving the system of homogeneous and non- homogeneous linear equations.
6. Computation of inverse of a matrix.
7. Finding the nth derivatives of functions without Leibnitz theorem.
8. Finding the nth derivatives of functions with Leibnitz's theorem.
9. Partial Differentiation of some standard functions and Jacobians.
10. Verification of Euler's theorem with examples.
11. Finding the Taylor's and Maclaurin's expansion of the given function.
12. Indeterminate forms and evaluation of limits using L-Hospital's rule.

Note: Each problem given in the Lab-manual has to be solved manually.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

Title of the Course	**Algebra II and Calculus II**
Course Code	**MATM/MATN-201**
Nature of the Course	**MAJOR/MINOR**
Total Credits	**04 (L=4, T=0, P=0)**
Distribution of Marks	**60(TH)+40(IA)=100**

Course Learning Outcomes: The course will enable the students:

- To recognize the mathematical objects called Groups.
- To link the fundamental concepts of groups and symmetries of geometrical objects.
- To explain the significance of the notions of cosets, normal subgroups and factor groups.
- To demonstrate the quotient groups, concepts of homomorphism, isomorphism.
- To explain the center of curvature, asymptotes, evolutes and envelops of the given curve.
- To explain to find length of an arc, area of plane curves and surface area, volume of revolution.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Groups-I-Definition o f a group with examples and properties, congruence, problems. Subgroups, center of groups, order of an element of a group and its related theorems, cyclic groups, Coset decomposition, Factor groups, Lagrange's theorem and itsconsequences. Fermat's theorem and Euler's ϕ function.	13	0	0	13	13
II	Groups-II-Normal Subgroups-Examples & Problems – Quotient group- Homomorphism & Isomorphism of groups – kernel & image of a homomorphism – Normality of the kernel –Fundamental theorem of homomorphism – Properties related to isomorphism – Permutation group – Cayley's Theorem.	14	0		14	15
III	Polar coordinates, angle between the radius vector and tangent. Angle of intersection of two curves (polar forms), length of perpendicular from pole to the tangent, pedal equations. Derivative of an arc in Cartesian, parametric and polar forms, curvature of plane curve-radius of curvature formula in Cartesian, parametric and polar and pedal forms-center of curvature, asymptotes, evolutes and envelops.	20	0		20	20
IV	Reduction formulae $\int sin^n xdx$, $\int cos^n xdx$, $\int cos^n xsin^n xdx, \int_0^{\frac{\pi}{2}} sin^n xdx, \int_0^{\frac{\pi}{2}} cos^n xdx, \int_0^{\frac{\pi}{2}} sin^n xcos^n xdx$ Computation of length of an arc, Area of Plane curves, Surface are and volume of revolution.	13	0	0	13	12
	Total	**60**	**0**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. Contemporary Abstract Algebra- J. A. Gallian, 4th Ed., Narosa Publishing House, New Delhi,1999.
2. Differential Calculus- B. C Das, B. N Mukherjee, U. N Dhur and Sons. Pvt Ltd.
3. Integral Calculus- S. Narayan, P. K Mittal, S. Chand Publishing.

Reference Books:

1. A First Course in Abstract Algebra- J. B. Fraleigh, 7th Ed., Pearson, 2002.
2. Abstract Algebra, M. Artin, 2nd Ed., Pearson, 2011.
3. Differential and Integral Calculus with applications- A. G. Greenhill, Alpha Ed., 2020.
4. Calculus- G. B Thomas and R. L Finney, 9^{th} Ed., Pearson Education, Delhi, 2005

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

Title of the Course	**Algebra II and Calculus II(PRACTICAL)**
Course Code	**MATM/MATN-202**
Nature of the Course	**MAJOR/MINOR**
Total Credits	**02 (L=0, T=0, P=2)**
Distribution of Marks	**60(TH)+40(IA)=100**

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculusthrough FOSS Practical/Lab Work to be performed in Computer Lab.

List of Practicals

Suggested Software's: Maxima/Scilab/Maple/MatLab/Mathematica/Python/R. Introduction to the software and commands related to the topic.

1. Program to construct Cayley's table and test commutatively for a given finite set.
2. Program to find all possible cosets of the given finite group.
3. Program to find generators and corresponding possible subgroups of a cyclic group.
4. Program to verify Lagrange's theorem with suitable examples.
5. Program to verify Euler's φ Function for a given finite group.
6. Program to verify the given function is homomorphism and isomorphism.
7. Program to solve problems using reduction formulae.
8. Program to compute surface area.
9. Program to compute volume of revolution.
10. Finding the radius of curvature of the given curve.

Note: Each problem given in the Lab-manual has to be solved manually.

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B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)

Title of the Course	**Real Analysis**
Course Code	**MATM 301**
Nature of the Course	**MAJOR**
Total Credits	**04(L=4,T=0,P=0)**
Distribution of Marks	**60(TH)+40(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Understand many properties of the real line $\mathbb{R}$.
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
- Apply different tests for convergence.
- Familiarize with relations, equivalence relations and partitions.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Review of Algebraic and Order Properties of R,-neighborhood of a point in R, Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of R, The Archimedean Property, Density of Rational (and Irrational)numbers in R, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.	20	0	-	20	20
II	Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion. Statements of Infinite series, convergence and divergence of infinite series, Cauchy Criterion.	20	0	-	20	20
III	Functions of two or more variables-explicit and implicit functions, partial derivatives. Homogeneous functions- Euler's theorem, total derivatives, differentiation of implicit and composite functions, Jacobians and standard properties and illustrative examples. Taylor's and Maclaurin's series for functions of one and two variables, Maxima-Minima of functions of two variables.	20	0	-	20	20
	Total	**60**	**0**		**60**	**60**

Where, L: Lectures T: Tutorials P:Practical

Recommended Text Books:

1. Introduction to Real Analysis - R. G. Bartle& D.R. Sherbert, 3rd Ed., John Wiley and Sons(Asia) Pvt. Ltd., Singapore, 2002.
2. A Basic Course in Real Analysis-A. Kumar &S. Kumarasen,CRC Press, Reprint2021.
3. An Introduction to Analysis- Gerald G. Bilodeau, R., Thie Paul, & G.E. Keough,2ndEd.,Jones & Bartlett,2010.

Reference Books:

1. Elementary Real Analysis- Brian S. Thomson, Andrew M. Bruckner & Judith B. Bruckner, Prentice Hall, 2001.
2. A First Course in Real Analysis- S.K. Berberian, Springer Verlag, New York,1994.
3. Higher Algebra -Hall & Night, Arihant Publishers, 2013.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

Title of the Course	**Differential Equations**
Course Code	**MATM 302**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=0,P=1)**
Distribution of Marks	**45(TH)+15(PR)+40(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Use the techniques to solve differential equations.
- Apply these techniques in various mathematical models used in real life problems.
- Develop the concept of Differential Equations, and develop the skill to solve differential equation of different order.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.	15	0	10	25	12
II	Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.	15	0	10	25	17
III	General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.	15	0	10	25	16
	Total	**45**	**0**	**30**	**75**	**45**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Differential Equations- S.L. Ross, 3rd Ed., John Wiley and Sons,1984.
2. Elements of Partial Differential Equations- I. N. Sneddon, McGraw-Hill, International Edition,1967.
3. Ordinary and Partial Differential Equations- M. D. Raisinghania,19th Ed., S.Chand and Company, 2020.

Reference Books:

1. Differential Equations and Boundary Value problems Computing and Modeling-C. H. Edwards and D. E. Penny, Pearson Education India, 2005.
2. Differential Equations with MATHEMATICA, M. L. Abell, J. P. Braselton, 3rd Ed., Elsevier Academic Press, 2004.

List of Practical (using any software) Marks: , Contact hrs: 30

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. 8. Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two prey one predator).
9. Plotting of recursive sequences.
10. Study the convergence of sequences through plotting.
11. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent
12. Sub-sequences 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 nth roots.
15. Ratio test by plotting the ratio of nth and (n+1) th term.

B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)

Title of the Course	**Differential Equations**
Course Code	**MATN 301**
Nature of the Course	**MINOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60(TH)+40(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Understand the concept of Differential Equations.
- Explain solution technique of ordinary and partial differential equations.

UNITS	CONTENTS	L	T	P	Total Hours	
I	First order exact differential equations. Integrating factors, rules to find an integrating factor.	05	03	-	08	05
II	First order higher degree equations solvable for x, y, p .Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.	12	03	-	15	15
III	Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.	12	03	-	15	15
IV	Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.	12	03		15	15
V	Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.	04	03		07	05
	Total	**45**	**15**	**-**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. Differential Equations- S.L. Ross, 3rd Ed., John Wiley and Sons,1984.
2. Elements of Partial Differential Equations- I. N. Sneddon, McGraw-Hill, International Edition,1967.
3. Ordinary and Partial Differential Equations- M. D. Raisinghania,19th Ed., S. Chand and Company, 2020.

Reference Books

1. Differential Equations and Boundary Value problems Computing and Modeling-C. H. Edwards and D. E. Penny, Pearson Education India, 2005.
2. Differential Equations with MATHEMATICA, M. L. Abell, J. P. Braselton, 3rd Ed., Elsevier Academic Press, 2004.

B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)

Title of the Course	**Theory of Real Functions**
Course Code	**MATM 401**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60(TH)+40 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Discuss limit, continuity and differentiability of real valued functions
- Expand functions in series and different form of remainders

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Limits of functions (approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem	15	5	0	20	20
II	Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem, Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Taylor's theorem to inequalities.	15	5	0	20	20
III	Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $ln(1 + x), 1/ax + b$ and $(1 + x)^n$	15	5	0	20	20
	Total	**45**	**15**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Introduction to Real Analysis-R. Bartle and D. R. Sherbert, John Wiley and Sons, 2003.
2. A Course in Calculus and Real Analysis- S.R. Ghorpade and B.V. Limaye, Springer, 2006.
3. Elementary Analysis: The Theory of Calculus- K. A. Ross, Springer, 2004.

Reference Books:

1. Introduction to Analysis- A. Mattuck, Prentice Hall,1999.
2. Advanced Calculus-P. Fitzpatrick, AMS, 2009.

B.A/B.SC. IN MATHEMATICS PROGRAMME(NEP)

Title of the Course	**PDE and System of ODE**
Course Code	**MATM 402**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=0,P=1)**
Distribution of Marks	**45 (TH) +15(PR)+ 40(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Make mathematical formulations and their solutions of various physical problems;
- Design mathematical models used in heat, wave, Laplace equation and their solutions.
- Apply numerical techniques for solving differential equations..

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. First- Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Non-linear partial differential equations, Charpit's method & Jacobi's method Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.	15	0	10	20	15
II	Classifications of second order linear equations as hyperbolic, parabolic or elliptic. Derivations of Heat equation, Wave equation and Laplace equation and their solutions Reduction of second order Linear Equations to canonical forms.	15	0	10	20	15
III	Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions, The method of successive approximations, the Euler method, the modified Euler method, The Runge-Kutta method upto fourth order approximation.	15		10	20	15
	Total	**45**	**0**	**30**	**75**	**45**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Differential equations-S. L. Ross, 3rd Ed., John Wiley and Sons, India,2004.
2. Elements of Partial Differential Equations- I. N. Sneddon, Dover Publications, 2006.
3. Ordinary and Partial Differential Equations- M.D. Raisinghania,19th Ed., S. Chand and Company,2020.
4. Introductory Methods of Numerical Analysis- S. S. Sastry, Asoke K. Ghosh publication, 5th Ed. 2012.

Reference Books:

1. Linear Partial Differential Equations for Scientists and Engineers-T. Myint-U and L. Debnath, 4th Ed., Springer, Indian reprint,2006.
2. Differential equations with MATHEMATICA- M. L Abell, J. P Braselton, 3rd Ed., Elsevier

Academic Press,2004.
3. Applied Numerical Analysis- Sudhir Kumar Pundir, CDS Publishers and Distributors, 2019.

List of Practicals (using any software) Marks: 15 Contact hrs. 30

1. Solution of Cauchy problem for first order PDE.
2. Finding the characteristics for the first order PDE
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of wave equation $\frac{\partial u}{\partial t} - k^2 \frac{\partial^2 u}{\partial t^2} = 0$ for the following associate conditions
5. $u(x,0) = \psi(x), u(0,t) = a, u(l,t) = b, 0 < x < l, t > 0$
6. $u(x,0) = \psi(x), x \in \mathbb{R}, T > t > 0$
7. $u(x,0) = \psi(x), u(0,t) = a, x \in (0,\infty), t \geq 0$
8. Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/N.
9. Bisection Method.
10. Newton Raphson Method.
11. Secant Method.
12. Regula Falsi Method.
13. LU decomposition Method.
14. Gauss-Jacobi Method.
15. SOR Method or Gauss-Siedel Method.
16. Lagrange Interpolation or Newton Interpolation.
17. Simpson's rule.

B.A/B.SC. IN MATHEMATICS PROGRAMME(NEP)

4th SEMESTER

Title of the Course	**Numerical Methods**
Course Code	**MATM 403**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Discuss various numerical methods and interpolation formulae
- Apply numerical techniques for Integration.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.	15	4	0	19	20
II	System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.	12	4	0	16	15
III	Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation..	12	4	0	16	15
IV	Numerical Integration: Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule	06	3	0	09	10
	Total	**45**	**15**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. A Friendly Introduction to Numerical Analysis- Brian Bradie, Pearson, 2006.
2. Applied Numerical Analysis, C. F. Gerald & P. O. Wheatley, 7th Edition, Pearson Education, India, 2008.
3. Applied Numerical Analysis- Sudhir Kumar Pundir, CDS Publishers and Distributors, 2019.

Reference Books:

1. Introduction to Numerical Analysis, F. B. Hildebrand, 2nd Edition, Dover Publications, 2013
2. Numerical Methods for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar & R. K. Jain, 6th Edition, New Age International Publishers, 2012.

B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)

4th SEMESTER

Title of the Course	**Ring Theory I and Linear Algebra I**
Course Code	**MATM 404**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Describe various ring structures on sets.
- Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
- Relate matrices and linear transformations.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.	11	3	0	20	18
II	Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients.	10	4	0	10	10
III	Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.	12	4	0	15	16
IV	Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.	12	4	0	15	16
	Total	**45**	**15**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Contemporary Abstract Algebra- J. A. Gallian, Narosa Publishing House, New Delhi,1999.
2. Linear Algebra and its Applications -G. Strang, Thomson, 2007.
3. Linear Algebra – A Geometric Approach, Prentice Hall of India, 1999.

Reference Books

1. Linear Algebra- A Geometric Approach-S. Kumaresan, Prentice Hall ofIndia,1999.
2. Linear Algebra Done Right-Axler Sheldron, Springer.
3. Linear Algebra- P. K. Saikia, 2nd edition, Pearson.
4. A First Course in Abstract Algebra-J. B. Fraleigh, 7th Ed., Pearson, 2002.

B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)
4th SEMESTER

Title of the Course	**Real Analysis**
Course Code	**MATN 401**
Nature of the Course	**MINOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Develop a deep understanding of real line R and of important terms to prove the results aboutconvergence and divergence of sequences and series of real numbers.
- Study different types of infinite series and their convergency test.

	CONTENTS	L	T	P	Total Hours	Marks
I	Finite and infinite sets, examples of countable and uncountable sets, Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.	13	03	0	16	16
II	Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences, Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).	15	05	0	20	20
III	Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, convergence of p-series, alternating series,	09	03	0	12	12
IV	Comparison test, Root test, Ratio test, Leibnitz's test(Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.	08	04	0	12	12
	Total	**45**	**15**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. A Basic Course in Real Analysis- A Kumar& S. Kumarasen,CRC Press, Reprint,2021.
2. Introduction to Real Analysis- R. G. Bartle, D. R. Sherbert,3rd Ed.,John Wiley and Sons(Asia) Pvt. Ltd., Singapore, 2002.

Reference Books:

1. Intermediate Real Analysis, Fischer E.,Springer Verlag,1983.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)
5th SEMESTER

Title of the Course	**Introduction to Probability**
Course Code	**MATM 501**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the foundational principles of probability theory.
- Demonstrate the use of discrete random variables and their probability distributions.
- Apply the concepts of probability mass functions (PMFs) and cumulative distribution functions (CDFs).
- Define and distinguish between continuous random variables and their probability distributions.
- Explain the concept of joint probability distributions for two or more random variables.

Overview:
The lectures should integrate simulations using mathematical software/languages such as R/ Python/ Matlab. Chapters 12 and 13 of [Pishro-Nik] provide an introduction to simulation using Matlab and R. [Huber] gives many examples of using R in teaching probability.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Basic Concepts** Interpretations of probability, random experiments, probability measure, discrete and continuous probability models, conditional probability, independent events, total probability, Bayes' rule, conditional independence, sampling with or without replacement, ordered and unordered sampling. [Pishro-Nik, Ch 1 and 2]	9	3		12	12
II	**Discrete Random Variables** Discrete random variables, probability mass function, independence, standard distributions (Bernoulli, geometric, binomial, negative binomial, hyper-geometric, Poisson), cumulative distribution function, expectation, functions of random variables, variance. [Pishro-Nik, Ch 3]	9	3		12	12
III	**Continuous Random Variables** Continuous random variables, probability density function, expectation, functions of random variables, variance, standard distributions (uniform, exponential, normal, gamma). [Pishro-Nik, Ch 4 except 4.3]	9	3		12	12
IV	**Joint Distributions** Jointly distributed discrete random variables, joint probability mass function, jointly distributed continuous random variables, joint probability density function, joint cumulative distribution function, conditioning and independence, functions of two random variables, conditional expectation and variance, covariance and correlation, binormal distribution, multiple jointly distributed random variables. [Pishro-Nik, Ch 5 and	9	3		12	12

	6.1.1, 6.1.2]					
V	**Limit Theorems** Markov and Chebyshev inequalities, sample mean, (Weak) law of large numbers, Central Limit Theorem (with applications but without proof). [Pishro-Nik, 6.2.0 to 6.2.2 and 7.1.0, 7.1.1]	9	3		12	12
	Total	**45**	**15**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbooks:

1. H. Pishro-Nik, *Introduction to Probability, Statistics, and Random Processes*, Kappa Research LLC, 2014. https://www.probabilitycourse.com .
2. Mark Huber, *Probability: Lectures and Labs*. https://www.markhuberdatascience.org/book.

Reference Books:

1. George Casella, Roger L. Berger, *Statistical Inference*, Cengage, 2007.
2. John A. Rice, *Mathematical Statistics and Data Analysis*, 3rd edition, Cengage, 2013.
3. Sheldon Ross, *A First Course in Probability*, 9th edition, Pearson Education India, 2013.

Online Resources:

1. Dimitri P. Bertsekas and John N. Tsitsiklis, *Introduction to Probability*, MIT OCW. https://ocw.mit.edu/courses/res-6-012-introduction-to-probability-spring-2018/
2. Department of Statistics at Penn State, *STAT414: Introduction to Probability Theory.* https://online.stat.psu.edu/stat414/

BA/BSC IN MATHEMATICS PROGRAMME(NEP)

5th SEMESTER

Title of the Course	**Multivariable Calculus**
Course Code	**MATM 502**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcome: Students will be able to

- Explain the concepts of functions of several variables, related theorems and properties.
- Apply line, double and triple integrals in present scenarios, utilize key theorems in vector calculus.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Functions of several variables, limit and continuity of functions of two variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl.	12	4	0	16	18
II	Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates.	10	4	0	14	12
III	Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path.	12	4	0	16	18
IV	Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.	11	3	0	14	12
	Total	**45**	**15**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G. B. Thomas and R.L. Finney, *Calculus*, 9th Ed.,Pearson Education, Delhi, 2005.
2. J. Stewart, *Multivariable Calculus, Concepts and Contexts*, 2ndEd.,Brooks/Cole, Thomson Learning,USA,2001.

Reference Books:

1. M. J. Strauss, G. L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley(India)Pvt. Ltd.(Pearson Education), Delhi,2007.

BA/BSC IN MATHEMATICS PROGRAMME(NEP)
5th SEMESTER

Title of the Course	**Abstract Algebra II**
Course Code	**MATM 503**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain and demonstrate the structure-preserving maps between groups and their consequences.
- Demonstrate and define Constructible Numbers, Trisection of angles, Squaring a circle and Doubling a cube.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Groups Actions** Group Actions, Orbits, Isotropy subgroups, Class equations, Transitive actions, Characterisation of transitive actions, Sylow theorems, Simple groups, Solvable and Nilpotent groups. Dihedral groups. [Fraleigh;Ch.3 and Ch.7]	12	04	0	16	15
II	**Polynomials** Divisibility properties of Polynomials. Division algorithm and consequences, Irreducible and prime polynomials. Theorem of Gauss. Eisenstein's Irreducibility Criterion. Linear and Polynomial congruences. Zeroes of Polynomials. Symmetric polynomials, Fundamental theorem of algebra. [Jacobson;Ch.16 and Ch.17]	10	04	0	14	15
III	**Field Extensions** Finite field extensions, Zeros of an irreducible polynomial, Kronecker's theorem, Algebraically closed fields, Construction of an algebraic closure, Construction of Finite fields. Automorphisms of field extensions. Examples, Roots of unity, Cyclotomic field extensions. [Fraleigh ; Ch. 6 and Ch.10]	15	03	0	18	20
IV	**Historical Discussion of Geometric Constructions** Constructible Numbers, Trisection of angles, Squaring a circle and Doubling a cube. *(Constructible regular polygons, Gauss-Wantzel Theorem (Statement only.))* [Gallian; Ch. 22]	8	04	0	12	10
	Total	**45**	**15**	**0**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., 2014, Pearson Education Limited, Edinburgh, England.
2. Joseph A. Gallian, *Contemporary Abstract Algebra*, 7th Ed., 2010, Brooks/Cole, Cengage Learning, Belmont, CA, USA .
3. N. Jacobson, *Basic Algebra*, Vols. I & II, Hindustan Pub. Co., 1984.

ReferenceBooks:

1. Joseph . Rotmann, *Galois Theory*, 2nd Ed. 1998, Universitext Springer Verlag.

BA/BSC IN MATHEMATICS PROGRAMME(NEP)
5th SEMESTER

Title of the Course	**Mathematical Methods**
Course Code	**MATM 504**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Apply and demonstrate solution techniques to solve real-world problems using the studied theories.
- Explain the Fourier transform, its definition, properties, and applications.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Fourier Series: Fourier Series, Dirichlet conditions, Fourier series for even and odd functions Half range Fourier series.	12	03	-	15	15
II	Laplace Transform: Definition of Laplace transform, Existence theorem for Laplace transform. Linearity property of Laplace transform, Laplace transform of some elementary functions. (algebraic functions, trigonometric functions, exponential functions, hyperbolic functions). First Shifting theorem, Second shifting theorem, Change of scale property, Laplace transform of derivatives, Laplace transform of Integrals.	13	04	-	17	18
III	Inverse Laplace Transform: Definition of Inverse Laplace Transform, Linearity property, first and second shifting theorems, change of scale, Convolution theorem.	10	03	-	13	12
IV	Fourier Transform, and Inverse Fourier transform: Dirichlet conditions, Definition of Fourier transform, Inverse theorem for Fourier transform, Fourier Sine and Fourier cosine transforms and their inversion formula, Linearity property, change of scale property, shifting property, modulation theorem, convolution theorem.	10	05	-	15	15
	Total	**45**	**15**	**-**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. S. Sreennadh, S. Ranganatham,M. N. Prasad,V Ramesh, *Fourier series and Integral transform*, S. Chand, New Delhi, 2008.
2. M.R. Spigel, *Theory and Problems of Laplace Transform*, Schaum Outline Series. 2018.
3. M. D Raisinghania, *Advanced Differential Equation*- S. Chand, 20th Ed.

Reference Books:

1. R. N. Bracewell, *The Fourier Transform and Its Applications*, McGraw-Hill international Editions.
2. Y. H. Gangadharaiah, N. Sandeep, *Engineering Applications of Laplace Transform*, Cambridge Scholars Publishing, 2021.

BA/BSC IN MATHEMATICS PROGRAMME(NEP)
5th SEMESTER

Title of the Course	**Numerical Analysis**
Course Code	**MATN 501**
Nature of the Course	**MINOR**
Total Credits	**04(L=3,T=0,P=1)**
Distribution of Marks	**45 (TH)+15(PR)+40 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the principles behind solving nonlinear equations and apply methods such as Bisection, Newton-Raphson, and Secant methods; analyze the convergence and stability of these methods.
- Demonstrate strong problem-solving and analytical skills specific to numerical analysis.
- Apply software and programming languages (e.g., MATLAB, Python) to implement numerical methods effectively.

Overview: An introduction to Numerical Methods that focuses on Solutions to Nonlinear, Systems of Linear and Nonlinear Equations, Interpolation, Approximation, Numerical Differentiation, and Integration, with an emphasis on Approximation Techniques. The course will also take up applications to topics in Chemical, Physical, Environmental, Electronics, Economics, and Diverse Areas of Engineering.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Error Analysis** Introduction to Error Analysis and computer arithmetic(Douglas: Ch 1)	5	0	0	5	5
II	**Solutions of Nonlinear Equations in One Variable** The Bisection Method, The Method of False Position, Fixed-Point Iteration, Newton's Method, Secant Method. Applications: Ideal and Nonideal Gas Laws, Greenhouse Gases and Rainwater, and Design of an Electric Circuit. (Douglas: Ch 1,2: Chapra: Ch 8)	10	0	8	18	10
III	**Interpolation** Lagrange's Formula, Newton's Divided Difference Formula, Newton's Forward and Backward Difference Formula and Stirling's Formula. Applications: Temperature at Various Points on a Heated Plate, and Sea level Concentration of Dissolved Oxygen for Fresh Water. (Douglas: Ch 3: Chapra: Ch 18)	10	0	8	18	10
IV	**Approximation** Linear Least Square Approximation, Polynomial Least Square Approximation, Pade Approximation, and the Power Method. Applications: Linear Regression and Population Models, Tensile Strength of Plastic at a time t, and The Volume of Super-Heated Steam at Various Temperatures. (Douglas: Ch 8,9: Chapra: Ch 20)	10	0	6	16	08
V	**Numerical Differentiation and Integration** Three Point Formula, Five Point Formula, Second Derivative Midpoint Formula, Trapezoidal Rule, Simpson's 1/3 & 3/8 Rule, Romberg Integration. Applications: Velocity and Acceleration of a Jet fighter's position on an Aircraft, Integration to Determine the Total Quantity of Heat, and	10	0	8	18	12

	Effective Force on the Mast of a Racing Sailboat. (Douglas: Ch 4: Chapra: Ch 24)					
	Total	**45**	**0**	**30**	**75**	**45**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook(s):

1. Richard L. Burden, J. Douglas Faires, *Numerical Analysis*, Ninth edition, Cengage Learning, 2010. https://faculty.ksu.edu.sa/sites/default/files/numerical_analysis_9th.pdf
2. Steven C. Chapra, Raymond P. Canale, J. Douglas Faires, *Numerical Methods for Engineers*, Seventh edition, McGraw-Hill Education, 2015. https://www.gdcboysang.ac.in/About/Droid/uploads/Numerical%20Methods.pdf
3. Mathews and Fink, Numerical Methods using MatLab

Reference Books:

1. S. D. Conte, C. de Boor, *Elementary Numerical Analysis-An Algorithmic Approach*, McGraw-Hill.
2. Laurene V. Fausett, *Applied Numerical Analysis using MATLAB*, Pearson Education.
3. S.S. Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd.

List of Practicals (using any software) Marks: 15 Contact hrs. 30

1. Find the root of an equation using Bisection Method.
2. Find the root of an equation using Newton Raphson Method.
3. Find the root of an equation using Secant Method.
4. Find the root of an equation using Regula Falsi Method.
5. Solve a system of equation using LU decomposition Method.
6. Solve a system of equation using Gauss-Jacobi Method.
7. Solve a system of equation using SOR Method or Gauss-Siedel Method.
8. Interpolate the data using Lagrange Interpolation or Newton Interpolation.
9. Apply Numerical integration by Simpson's rule.
10. Apply Numerical integration by Trapezoidal rule.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)
6th SEMESTER

Title of the Course	**Riemann Integration and Series of Functions**
Course Code	**MATM 601**
Nature of the course	**Major**
Total Credit	**4(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)**

Course Learning Outcomes: This course will enable the students to:

- Apply the concepts of Riemann integration to evaluate integrals and analyze their properties.
- Distinguish between different types of series of functions and demonstrate their convergence properties.
- Explain the concept of improper integrals and their convergence criteria.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability.	9	3		12	12
II	Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus.	10	3		13	14
III	Improper integrals; Convergence of Beta and Gamma functions.	8	3		11	10
IV	Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.	8	3		11	12
V	Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem.	8	3		11	12
	Total	45	15	0	60	60

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons,2003.
2. S.R. Ghorpade and B.V. Limaye,*A Course in Calculus and Real Analysis*, Springer, 2006.
3. Kumar & S. Kumaresan, *A Basic Course in Analysis*, CRC Press, 2014

Reference Books:

1. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

BA/BSC IN MATHEMATICS PROGRAMME(NEP)

6th SEMESTER

Title of the Course	**Complex Analysis**
Course Code	**MATM 602**
Nature of the course	**Major**
Total Credit	**4(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning outcomes: After going through this course the students will be able to describe:

- Explain the importance of differentiability and analyticity of complex functions and how they lead to the derivation of the Cauchy-Riemann equations.
- Apply Taylor and Laurent series expansions of analytic functions; classify the nature of singularities, poles, and residues, and utilize the Cauchy Residue theorem.
- Utilize problem-solving skills using the Residue theorem.
- Explain and analyze the properties of path integrals.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Field of Complex numbers** Polar form of a complex number. Metric properties; Topological notions; continuity, Non-existence of a continuous argument on C* (Lemma 4.3.7). convergence of sequences of series of complex numbers etc. A quick review (Chapters 1 and 2 of SK.) **Functions from R to C** Differentiation and integration of complex value functions of real variables; (Sections 5.1 and 6.1 of SK.)	9	3	-	12	12
II	**Holomorphic functions properties** Cauchy-Riemann equations, Sufficiency part of characterization of holomorphic functions in terms of CR equations. (Sections 5.3, 5.4 (only as much as required),5.5, and 5.7 of SK) **Power series** A quick review of infinite series, definition of a power series, radius of convergence, continuity and (term-wise) differentiability of a power series function in its disk of convergence. Definition of an analytic function. (Sections: 2.2. 2.3 and 5.5 of SK)	9	3	-	12	12
III	**Path Integrals properties** ML-Inequality, and its uses. Fundamental theorem of path integrals and its relation to existence of primitives (Sections 6.1, 6.2 and 6.3 of SK) **Cauchy Theory** Cauchy-Goursat theorem for triangles, Cauchy's theorem for star-shaped domains and their extensions. (Sections 7.1 and 7.3 of SK)	9	3	-	12	12
IV	**Cauchy Integral Formula and Properties of Holomorphic Functions** Winding Numbers (Section 10.1 of SK), Cauchy integral formula and its consequences: Holomorphic iff analytic, Cauchy estimates, Liouville's theorem. Fundamental theorem of algebra, Uniqueness theorem, maximum modulus and minimum modulus principles and open mapping theorem. (Chapter 8 of SK) **Isolated singularities via the limits** Cauchy integral formula for an annulus, Laurent series, characterization of singularities in terms of Laurent series.	9	3	-	12	12

V	**Extended Complex Plane** Point at infinity, Riemann sphere, behaviour of functions at infinity, Fractional linear transformations. (Section 11.1 to 11.3 of SK) **Residue Theory** Residues and the residue theorem (Section 11.1). **Computation of real integrals using residue theorem:** One example in each of the types (Sections 15.1 and 15.2 of SK) Argument principle and Rouche's theorem.	9	3		12	12
	Total	45	15	-	60	60

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. S Kumaresan, *A Pathway to Complex Analysis*, Techno world, 2021.
2. J. Conway, *Functions of One Complex variable*, 2nd Edition, Springer International Edition, 1973

Reference Books:

1. J Bak and D.J. Newman, *Complex Analysis*, 2nd Edition, Springer-International Edition 1997
2. T.W. Gamelin, *Complex Analysis*, Springer-International Edition 2004. Videos: https:/youtube.com/kumarhcu, Playlist=Complex Analysis.

BA/BSC IN MATHEMATICS PROGRAMME(NEP)

6th SEMESTER

Title of the Course	**Introduction to Statistics**
Course Code	**MATM 603**
Nature of the course	**Major**
Total Credit	**4(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Explain sampling distributions and their relation to population distributions.
- Define point estimation and evaluate properties of point estimators such as unbiasedness, consistency, and efficiency.
- Apply interval estimation techniques and interpret confidence intervals in real-world data.
- Interpret hypothesis test results and make informed decisions based on statistical evidence.
- Utilize mathematical software/languages (R, Python, MATLAB) for calculations and simulations.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Sampling Distributions** Moments, moment generating function (mgf), mgf's of standard distributions, mgf technique, random sample, sample mean, sample variance, standard error of the mean, large sample approximations, sampling from finite populations, chi-square distribution, t distribution, F distribution. ([1] 4.3, 4.5, 8.1 to 8.6)	9	03	-	12	12
II	**Point Estimation** Point estimator, bias, efficiency, consistency, sufficiency, method of moments, maximum likelihood estimation. ([1] 10.1 to 10.8)	9	03	-	12	12
III	**Interval Estimation** Confidence intervals, degree of confidence, one-sided confidence intervals, estimation of means, difference of means, proportions, difference of proportions, variance and ratio of variances. ([1] 11.1 to 11.7)	9	03	-	12	12
IV	**Hypothesis Testing** Null and alternative hypotheses, acceptance and rejection regions, Type I and II errors, power of a test, Neyman-Pearson lemma, power function of a test, likelihood ratio tests, tests concerning means, tests concerning difference of means, tests concerning variances, contingency tables, goodness of fit. ([1] 12.1 to 12.6, 13.1 to 13.4)	9	03	-	12	12

V	**Regression** Bivariate regression, linear regression, method of least squares, normal regression analysis, normal correlation analysis, multiple linear regression, multicollinearity. ([1] Ch 14)	9	03		12	12
	Total	**45**	**15**	**-**	**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. Irwin Miller and Marylees Miller, *John E. Freund's Mathematical Statistics with Applications*, 8th edition, Pearson Education India, 2013.
2. David Freedman, Robert Pisani and Roger Purves, *Statistics*, 4th edition, Viva-Norton Student Edition, 2009.
3. Mark Huber, *Statistical Inference: Lectures and Labs*. https://www.markhuberdatascience.org/book

Reference Books:

1. George Casella, Roger L. Berger, *Statistical Inference*, Cengage, 2007.
2. Morris H. De Groot and Mark J. Schervish, *Probability and Statistics*, 4th edition, Pearson Education India, 2016.

Online Resources:

1. Department of Statistics at Penn State, *STAT415: Introduction to Mathematical Statistics.* https://online.stat.psu.edu/stat415/
2. Jeremy Balka, *Making Statistics Make Sense*, https://www.jbstatistics.com/ (Videos available on the YouTube channel @jbstatistics)

BA/BSC IN MATHEMATICS PROGRAMME(NEP)

6th SEMESTER

Title of the Course	**Linear Programming**
Course Code	**MATM 604**
Nature of the course	**Major**
Total Credits	**4(L=3,T=1,P=0)**
Distribution of Marks	**60 (TH)+40 (IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Demonstrate the theoretical basics of linear programming,
- Formulate practical problems as linear programming problems,
- Implement a linear programming model using tools.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	15	05	-	20	20
II	Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation,	15	05	-	20	20
III	Hungarian method for solving assignment problem. Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.	15	05	-	20	20
	Total	**45**	**15**		**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network*

Flows, 2nd Ed., John Wiley and Sons, India, 2004.

Reference Books:

1. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
2. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)
6th SEMESTER

Title of the Course	**Linear Programming**
Course Code	**MATN-601**
Nature of the Course	**MINOR**
Total Credits	**04(L=3, T=1,P=0)**
Distribution of Marks	**60(TH)+ 40(IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Demonstrate the theoretical basics of linear programming,
- Formulate practical problems as linear programming problems,
- Implement a linear programming model using tools.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	15	05	-	20	20
II	Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation,	15	05	-	20	20
III	Hungarian method for solving assignment problem. Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.	15	05	-	20	20
	Total	**45**	**15**		**60**	**60**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 2nd Ed., John Wiley and Sons, India, 2004.

Reference Books:

1. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
2. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.

B.A/B.SC. IN MATHEMATICS PROGRAMME(NEP)

Title of the Course	**Mathematics I**
Course Code	**MATO 101**
Nature of Course	**Open Elective**
Total Credits	**03(L=3,T=0,P=0)**
Distribution of Marks	**60(TH)+40(IA)**

Course Learning Outcomes: The course will enable the students to:

- Recognize consistent and inconsistent systems of linear equations by the row echelonform of the Augmented matrix, using rank.
- Find Eigenvalues and corresponding Eigenvectors for a square matrix.
- Calculate the limit and examine the continuity, differentiability of a function at a point.
- Find out arc length, surface area, volume of revolution.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Recapitulation of Symmetric and Skew Symmetric matrices, Algebra of Matrices; Row and column reduction to Echelon form. Rank of a matrix; Finding rank of a matrix by reducing to row reduced echelon form and normal form; Solution of systemof linear equations; Criteria for existence of non-trivial solutions of homogeneous systemof linear equations. Solution of non-homogeneous system of linear equations. Eigen values and Eigenvectors of square matrices, standard properties; Cayley- Hamilton theorem(With Proof), inverse of matrices by Cayley- Hamilton theorem, finding A^2, A^3, A^{-1}, A^{-2}	20	0	0	20	25
II	Limits, Continuity, Differentiability and properties. Intermediate value theorem (statement only with examples), Rolle's Theorem(statement only with examples), Lagrange's Mean Value theorem(statement only with examples), Cauchy's Mean value theorem (statement only with examples) and examples. Taylor's theorem (without proof), Maclaurian's series and L'Hospital's rule-problems. .	15	0	0	15	22
III	Recapitulation of Definite integrals and its properties.Computation of length of arc, area of plane curves, surface area and volume of revolution in Cartesian form.	10	0	0	10	13
	Total	**45**	**0**	**0**	**45**	**60**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Calculus- G.B.Thomas & R. L. Finney, PearsonEducation,2007
2. Linear Algebra and Its Application- David C Lay, S. R. Lay & J. J. McDonald,Pearson,2015
3. Abstract Algebra- V.K. Khanna & S. K.Bhambri, Vikash Publishing,2017

Reference Books:

1. Differential Calculus–S. Arumugam, A. Samasundaram and A. Isacc Thangapandi, CBS Publishers & Distributors private ltd., 2021.
2. Differential and Integral Calculus- A. G. Greenhill, Alpha Edition,2020.
3. Schaum's Outline of Calculus-Frank Ayres and Elliott Mendelson,5th ed.USA:Mc.Graw.
4. Linear Algebra Done Right-Axler Sheldron, Springer.

B.A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

Title of the Course	**Mathematics II**
Course Code	**MATO 201**
Nature of Course	**Open Elective**
Total Credits	**03(L=3,T=0,P=0)**
Distribution of Marks	**60(TH)+40(IA)**

Course Learning Outcomes: The course will enable the students to:

- Analyze Polynomials and Inequalities: Solve polynomial equations, relate roots and coefficients.
- Evaluate Multivariable Calculus: compute partial derivatives, and perform double and triple integrals in various coordinates.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Euclid's Algorithm- Polynomials with integral coefficients- Remainder theorem- Factor theorem- Fundamental theorem of algebra(statement only) –Irrational and complex roots occurring in conjugate pairs – Relation between roots and coefficients of a polynomial equations, symmetric functions Transformation- Reciprocal equations- Descartes' rule of signs- multiple roots.	20	0	0	20	25
II	Functions of two or more variables-explicit and implicit functions, partial derivatives. Homogeneous functions- Euler's theorem, total derivatives, differentiation of implicit and composite functions, Jacobians, standard properties and illustrative examples. Taylor's and Maclaurin's series for functions of two variables, Maxima-Minima of functions of two variables. .	15	0	0	15	22
III	Definition of line integral and basic Properties ,examples on evaluation of line integrals. Double integral- Definition of Double integrals and its conversion to iterated integrals. Computation of plane surface areas. Triple integral- Definition of triple integrals and evaluation, volume as triple integral.	10	0	0	10	13
	Total	**45**	**0**	**0**	**45**	**60**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Calculus- G.B.Thomas & R. L. Finney, PearsonEducation,2007
2. S. Barnard, J. M. Child, *Higher Algebra*, New Academic Science, 2017

Reference Books:

1. Differential Calculus–S. Arumugam, A. Samasundaram and A. Isacc Thangapandi, CBS Publishers & Distributors private ltd., 2021.
2. Differential and Integral Calculus- A. G. Greenhill, Alpha Edition,2020.
3. Schaum's Outline of Calculus-Frank Ayres and Elliott Mendelson,5th ed.USA: Mc.Graw.

SYLLABUS (2023-24 Batch)

DEPARTMENT OF MATHEMATICS

(Recommended by B.O.S. in Mathematics, M.D.U. in its meeting held on 26.07.2024)

MADHABDEVUNIVERSITY
2024

Graduate Attributes in Mathematics

The graduate attributes in mathematics are the summation of the expected course learning outcomes mentioned in the beginning of each course. Some of them are stated below.

- Disciplinary knowledge:

Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an undergraduate programme of study.

- Communications skills:

  i. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
  ii. Ability to use mathematics as a precise language of communication in other branches of human knowledge.
  iii. Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization.
  iv. Ability to explain the development of mathematics in the civilizational context and its role as queen of all sciences.

- Critical thinking and analytical reasoning:

  i. Ability to employ critical thinking in understanding the concepts in every area of mathematics.
  ii. Ability to analyze the results and apply the various problems appearing in different branches of mathematics.

- Problem solving:

  i. Capability to solve various models such as growth and decay models,radioactive decay model, drug assimilation.
  ii. Ability to solve linear system of equations, linear programming problems and network flow problems.
  iii. Ability to provide new solutions using the domain knowledge of mathematics acquired during this programme.

- Research-related skills:

  i. Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
  ii. To know about the advances in various branches of mathematics.

- Information/digital literacy:

  i. Capability to use appropriate softwares to solve system of equations and differential equations.
  ii. Capability to understand and apply the computer programming concepts to mathematical investigations and problem solving.

- Self-directed learning:

  Ability to work independently and do in-depth study of various notions of mathematics.

- Moral and ethical awareness/reasoning:

  Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

- Life long learning:

  Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.

Programme Learning Outcomes of UG (Hons) Mathematics

UG in mathematics is the culmination of in-depth knowledge of algebra, calculus, Real Analysis, Linear Algebra, Geometry, Differential Equations and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.

1. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.

2. Students undergoing this programme learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems.

They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

3. Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.

4. Completion of this programme will also enable the learners to join teaching profession in higher, primary and secondary schools.

5. This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

Course learning outcomes

Course learning outcomes of each course of Mathematics have been enshrined in the beginning of course contents of each course.

Curriculum Framework of Four Year Under Graduate Programme (FYUGP), Madhabdev University

Academic Level	Semester	Major(60/80)	Minor (24/32)	MDC(9)	AEC(8)	VAC(7)	SEC(10)	Internship/Project(4/12)	Total Credit
	I	Major1(4)	Minor1(4)	MDC1(3)	Life skills(4)	Introduction to Yoga/NSS &Youth development/Sports & Physical Education (2)	Library & Information source/Computer operating system/ Introduction to communications(3)		20
	II	Major2(4)(4)	Minor2(4)	MDC2(3)	MIL/ Alternative English(4)/ Madhabdev studies	Primary skills Rover &Ranger/Basic Yoga /NSS	Library and digital resources/ Scriptwriting/Digital literacy (3)		20
Level5	**Exit-1**	**UG Certificate Programme**							**40**
	III	Major3(4)	Minor3(4)	MDC3(3)		Environmental Studies (3)	Cyber Security(4)		22
		Major4(4)							
	IV	Major5(4)	Minor4(4)					Community Engagement/ Internship(2)	22
		Major6(4)							
		Major7(4)							
		Major8(4)							
Level6	**Exit-2**	**UG Diploma Programme**							**84**
	V	Major9(4)	Minor5(4)						22
		Major10(4)						Internship(2)	
		Major11(4)							
		Major12(4)							
	VI	Major13(4)	Minor6 (4)						22
		Major14(4)					classical	Research Project(2)	
		Major15(4)							
		Major16(4)							
Level7	**Exit-3**	**UG Degree Programme**							**128**
	VII	Major17(4)	Minor7(4)				Research Methodology(4)	Seminar/Presentation/Internship/ Research Project(2)	22
		Major18(4)							
		Major19(4)							
	VIII	Major20(4)	Minor8(4)						24
		Major21(4)							

		Major22(4)						Project/Dissertation(8)	
Level8	**Exit-4**	**UG Degree Honours/ Research Programme**							**174**

2023-24 Batch

DRAFT STRUCTURE OF FOUR YEAR UNDER
GRADUATE PROGRAMMES
(FYUGP) AS PER NEP-2020 GUIDELINES

IN MATHEMATICS FOR MADHABDEV UNIVERSITY

First Semester			
Course Type	**Title of the Paper**	**Paper Code**	**Credit**
CORE MAJOR	Classical algebra and Calculus-I	MATM 101	4
CORE MINOR		MATN 101	4
MDC	History of Mathematics	MDCM 101	3
AEC 1	Life Skills	AECL 101	4
VAC 1 (Any One)	Introduction to NCC	NCCV 101	2
	NSS &Youth Development	NSSV 101	
	Sports and Physical Education Part I	PHEV 101	
	Introduction to Rover Ranger	RARV 101	
	Introduction to Yoga Education	YOGAV 101	
SEC 1 (Any One)	Introduction to Communication	CMMS 101	3
	Introduction to Computer and operating System	DGLS 101	
	Library System and information Source	LISS 101	
Total Credit			**20**
Second Semester			
CORE MAJOR	Group Theory and Calculus-II	MATM 201	4
CORE MINOR		MATN 201	4
MDC	Commerce	MDCC 201	3
AEC 2 (Any One)	Alternative English	AECA 201	4
	MIL	AECL 201	
	Madhabdev Studies	AECM 201	
VAC 2 (Any One)	Introduction to NCC Part II	NCCV 201	2
	NSS &Youth Development -B	NSSV 201	
	Sports and Physical Education Part II	PHEV 201	
	Primary Skills and Aspects of Rover & Ranger	RARV 201	
	Basic Yoga Text	YOGV 201	
	Indian Knowledge System	IKSV 201	
SEC 2 (Any One)	Script Writing	CMMS 201	3
	Digital Literacy	DGLS 201	
	Foundation of Library and Digital Resources	LISS201	
Total Credit			**20**
Third Semester			
CORE MAJOR	Real Analysis-I	MATM 301	4
CORE MAJOR	Linear Algebra -I	MATM 302	4

CORE MINOR	Linear Algebra -I	MATN 301	4
MDC 3			3
VAC 3	Environmental Studies		3
SEC – 3	Cyber Security		4
	Total Credit		**22**
Fourth Semester			
CORE MAJOR	Real Analysis-II	MATM 401	4
CORE MAJOR	Abstract Algebra-I	MATM 402	4
CORE MAJOR	Linear Algebra-II	MATM 403	4
CORE MAJOR	ODE	MATM 404	4
CORE MINOR	ODE	MATN 401	4
Community Engagement/ Internship			2
	Total Credit		**22**
Fifth Semester			
CORE MAJOR	Introduction to Probability	MATM 501	4
CORE MAJOR	Multivariable Calculus	MATM 502	4
CORE MAJOR	Abstract Algebra II	MATM 503	4
CORE MAJOR	Numerical Analysis	MATM 504	4
CORE MINOR	Numerical Analysis	MATN 501	4
Internship			2
	Total Credit		**22**
Sixth Semester			
CORE MAJOR	PDE	MATM 601	4
CORE MAJOR	Complex Analysis	MATM 602	4
CORE MAJOR	Introduction to Statistics	MATM 603	4
CORE MAJOR	Linear Programming	MATM 604	4
CORE MINOR	Linear Programming	MATN 601	4
Research Project			2
	Total Credit		**22**

Seven Semester			
CORE MAJOR	Topology	MATM 701	4
CORE MAJOR	Number Theory	MATM 702	4
CORE MAJOR	Abstract Algebra-III	MATM 703	4
CORE MINOR	PDE	MATN 701	4
Research Project			2
	Total Credit		**22**
Eight Semester			
CORE MAJOR	Functional Analysis	MATM 801	4
CORE MAJOR	Calculus of Variations	MATM 802	4
CORE MAJOR	Graph Theory	MATM 803	4
CORE MINOR	Introduction to Probability	MATN 801	4
Research Project			2
	Total Credit		**22**

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

1st SEMESTER

Title of the Course	**Classical Algebra and Calculus I**
Course Code	**MATM/MATN 101**
Nature of Course	**Major/Minor**
Total Credits	**04(L=3, T=0, P=1)**
Distribution of Marks	**52(TH)+18(PR)+30(IA)**

Course Learning Outcomes: The course will enable the students to:

- Recognize consistent and inconsistent systems of linear equations by the row echelon form of the Augmented matrix, using rank.
- Find Eigenvalues and corresponding Eigenvectors for a square matrix.
- Learn conceptual variations while advancing from one variable to several variables calculus.
- Calculate the limit and examine the continuity, differentiability of a function at a point.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	System of Linear Equations, Row Reduction and Echelon Form, Vector Equation and matrix equation Ax = b. Solution set of a linear system, Linear Dependence and Independence . Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of $\mathbb{R}^n$, dimension of subspaces of $\mathbb{R}^n$ and rank of a matrix, Eigenvalues, Eigen Vectors and Characteristic Equation of a matrix.	24	0	10	34	20
II	Limits, Continuity, Differentiability and properties. Properties of continuous functions. nth Derivatives of Standard functions e^{ax+b}, $(ax+b)^n$, $log(ax+b), sin(ax+b), cos(ax+b)$, $e^{ax}sin(bx+c)$, $e^{ax}cos(bx+c)$. Leibnitz theorem and its applications. .	06	0	10	16	12
III	Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.	15	0	10	25	20
	Total	**45**		**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

List of Practicals

Suggested Software's: Maxima/Scilab/Maple/MatLab/Mathematica/Python/R. Introduction tothe software and commands related to the topic.

1. Basics of software with simple examples.
2. Basics of software with simple examples.
3. Matrices –Algebra of Matrices with problems.
4. Computation of rank of a matrix.
5. Solving the system of homogeneous and non-homogeneous linear equations.
6. Computation of inverse of a matrix.
7. Finding the nth derivatives of functions without Leibnitz theorem.
8. Finding the nth derivatives of functions with Leibnitz's theorem.
9. Partial Differentiation of some standard functions and Jacobians.
10. Verification of Euler's theorem with examples.
11. Finding the Taylor's and Maclaurin's expansion of the given function.
12. Indeterminate forms and evaluation of limits using L-Hospital's rule.

Note: Each problem given in the Lab-manual has to be solved manually.

Recommended Text Books:

1. Calculus- G.B. Thomas & R. L. Finney, Pearson Education, 2007
2. Linear Algebra and Its Application- David C Lay, S. R. Lay, & J. J. McDonald, Pearson, 2015
3. Abstract Algebra- V.K. Khanna & S. K. Bhambri, Vikash Publishing, 2017

Reference Books:

1. Differential Calculus –S. Arumugam, A. Samasundaram and A. Isacc Thangapandi, CBS Publishers & Distributors private ltd., 2021.
2. Differential and Integral Calculus- A. G. Greenhill, Alpha Edition, 2020.
3. Schaum's Outline of Calculus - Frank Ayres and Elliott Mendelson, 5th ed.USA: Mc. Graw.
4. Linear Algebra Done Right-Axler Sheldron, Springer.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

2nd SEMESTER

Title of the Course	**Group Theory and Calculus-II**
Course Code	**MATM/MATN-201**
Nature of the Course	**MAJOR/MINOR**
Total Credits	**04 (L=3, T=0, P=1)**
Distribution of Marks	**52(TH)+18(PR)+30(IA)=100**

Course Learning Outcomes: The course will enable the students:

- To recognize the mathematical objects called Groups.
- To link the fundamental concepts of groups and symmetries of geometrical objects.
- To explain the significance of the notions of cosets, normal subgroups and factor groups.
- To demonstrate the quotient groups, concepts of homomorphism, isomorphism.
- To explain the center of curvature, asymptotes, evolutes and envelops of the given curve.
- To explain to find length of an arc, area of plane curves and surface area, volume ofrevolution.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Idea of Sets and Binary Opertions, Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups.	09	0	20	29	10
II	Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.	09	0		9	12
III	Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, propertiesof permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. normal subgroups, factor groups, Group homomorphisms, properties of homomorphisms, Cayley's theorem, Isomorphisms.	18	0		18	20
IV	Reduction formulae $\int sin^n x\,dx$, $\int cos^n x\,dx$, $\int cos^n x sin^n x\,dx$, $\int_0^{\frac{\pi}{2}} sin^n x\,dx$, $\int_0^{\frac{\pi}{2}} cos^n x\,dx$, $\int_0^{\frac{\pi}{2}} sin^n x\,cos^n x\,dx$ Computation of length of an arc, Area of Plane curves, Surface are and volume of revolution.	09	0	10	19	10
	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. Contemporary Abstract Algebra- J. A. Gallian, 4th Ed., Narosa Publishing House, New Delhi,1999.
2. Differential Calculus- B. C Das, B. N Mukherjee, U. N Dhur and Sons. Pvt Ltd.
3. Integral Calculus- S. Narayan, P. K Mittal, S. Chand Publishing.

Reference Books:

1. A First Course in Abstract Algebra- J. B. Fraleigh, 7th Ed., Pearson, 2002.
2. Abstract Algebra, M. Artin, 2nd Ed., Pearson, 2011.
3. Differential and Integral Calculus with applications- A. G. Greenhill, Alpha Ed., 2020.

Calculus- G. B Thomas and R. L Finney, 9th Ed., Pearson Education, Delhi, 2005

List of Practicals

Suggested Software's: Maxima/Scilab/Maple/MatLab/Mathematica/Python/R. Introduction to the software and commands related to the topic.

1. Program to construct Cayley's table and test commutatively for a given finite set.
2. Program to find all possible cosets of the given finite group.
3. Program to find generators and corresponding possible subgroups of a cyclic group.
4. Program to verify Lagrange's theorem with suitable examples.
5. Program to verify Euler's φ Function for a given finite group.
6. Program to verify the given function is homomorphism and isomorphism.
7. Program to solve problems using reduction formulae.
8. Program to compute surface area.
9. Program to compute volume of revolution.
10. Finding the radius of curvature of the given curve.

Note: Each problem given in the Lab-manual has to be solved manually.

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B.A/B.SC.IN MATHEMATICS PROGRAMME (NEP)

3rd SEMESTER

Title of the Course	**Real Analysis I**
Course Code	**MATM 301**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70(TH)+30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Demonstrate Understanding of Real Number System: Explain upper and lower bounds, LUB property, Archimedean property, and nested interval theorem.
- Distinguish and Analyze Sequences and Series: Justify convergence, analyze Cauchy sequences, and apply convergence tests for infinite series.
- Explain and Apply Continuity: Use the ε-δ definition, justify intermediate and extreme value theorems, and demonstrate uniform continuity.
- Proof and Apply Differentiation: Prove mean value theorems, apply L' Hospital's rules, and justify higher-order derivatives and Taylor's theorem.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Real number system** Upper and lower bounds, LUB property and its applications: Archimedean property, greatest integer function, density of rationals, nth root of a non-negative real number, the nested interval theorem. (Kumar *et. al.*: Ch. 1)	10	0	-	10	14
II	**Real sequences** Sequences and their convergence, Cauchy sequences, monotone sequences, sandwich lemma, sequences diverging to $\pm\infty$, subsequences, sequences defined recursively. (Kumar *et. al.*: Ch. 2)	15	0	-	15	13
III	**Infinite series** Infinite series and their convergence, comparison and limit comparison tests for convergence, rearrangements of terms in an Infinite Series. (Kumar *et. al.*: Ch. 3)	10	0	-	10	13
IV	**Continuity** Continuous functions, ε-δ definition of continuity, intermediate value theorem, extreme value theorem, monotone functions, limits, uniform continuity. (Kumar *et. al.*: Ch. 4)	15			15	15
V	**Differentiation** Differentiable functions, mean value theorems, L'Hospital's rules, higher-order Derivatives, Taylor's theorem, convex functions, Cauchy's form of the Remainder. (Kumar *et. al.*: Ch. 5)	10			10	15
	Total	**60**	**0**		**60**	**70**

Where, L: Lectures T: Tutorials P: Practical

Recommended Text Books:

1. Ajit Kumar & S. Kumaresan, *A basic Course in Real Analysis*, CRC Press, 2014.

Reference Books:

1. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, Fourth Edition, Wiley, 2011.
2. Amber Habib, *Calculus*, CUP, 2022.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)
3rd SEMESTER

Title of the Course	**Linear Algebra I**
Course Code	**MATM 302**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=0,P=1)**
Distribution of Marks	**52(TH)+18(PR)+30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Solve Linear Systems: Apply Gaussian elimination, row-echelon forms, and elementary operations to solve systems of linear equations.
- Demonstrate Matrix Algebra: Perform matrix operations, analyze linear transformations, compute inverses, and use LU decomposition.
- Analyze Determinants: Compute determinants, apply Cramer's rule, and evaluate eigenvalues, eigenvectors, and diagonalization.
- Explain Vector Spaces: Define subspaces, determine basis and dimension, apply the rank-nullity theorem, and perform change of basis and diagonalization.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Systems of Linear Equations** Examples leading to linear systems, visualizing systems of 2 or 3 variables, augmented matrix, elementary operations, row-echelon form, reduced row-echelon form, Gaussian elimination, homogeneous systems.	10	0	10	20	12
II	**Matrix Algebra** Vectors and matrices, matrix operations, matrix form of a linear system, matrices as linear transformations, geometric transformations (rotation, reflection, shear), composition and matrix multiplication, inverse of a matrix, equivalent conditions for invertibility, elementary matrices, LU decomposition. (Nicholson: Ch 2, 4.5)	10	0	10	20	12
III	**Determinants** Determinant via cofactors, determinants and row operations, determinant and matrix product, determinant and volume, determinant and matrix inverse, Cramer's rule, eigenvalues and eigenvectors, characteristic polynomial, diagonalization(Nicholson: Ch 3, Kumaresan 6.1 & 6.2)	10	0	10	20	13
IV	**Vector Space Structure of R^n** Subspaces of Euclidean space, spanning sets, linear independence, equivalence of invertibility of a matrix to independence of its rows and columns, basis and dimension, rank of a matrix, rank-nullity theorem, similarity and diagonalization, change of basis. (Nicholson: Ch 5, 9.1)	15	0	0	15	15
	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook:

1. W. Keith Nicholson, *Linear Algebra with Applications*, Open edition, Lyryx Learning, 2018. https://lyryx.com/wp-content/uploads/2018/01/Nicholson-OpenLAWA-2018A.pdf

Reference Books:

1. Robert Beezer, *A First Course in Linear Algebra*, 2015. http://linear.ups.edu/html/fcla.html
2. Jim Hefferon, *Linear Algebra*, 4th edition, Orthogonal Publishing L3C, 2020. https://hefferon.net/linearalgebra/
3. S. Kumaresan, *Linear Algebra – A Geometric Approach*, Prentice Hall India, 2000.

Online Resources:

1. Gilbert Strang, *Linear Algebra*, MIT OCW. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/

List of Practical (using any software) Marks: 18, Contact hrs: 30

1. Study the convergence of sequences through plotting.
2. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
3. Cauchy's root test by plotting nth roots.
4. Ratio test by plotting the ratio of nth and (n+1) th term.
5. Computation of rank of a matrix.
6. Solving the system of homogeneous and non-homogeneous linear equations.
7. Computation of inverse of a matrix.
8. Finding the nth derivatives of functions without Leibnitz theorem.
9. Finding the nth derivatives of functions with Leibnitz's theorem.
10. Partial Differentiation of some standard functions and Jacobians.
11. Verification of Euler's theorem with examples.
12. Finding the Taylor's and Maclaurin's expansion of the given function.
13. Indeterminate forms and evaluation of limits using L-Hospital's rule.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)
3rd SEMESTER

Title of the Course	**Linear Algebra I**
Course Code	**MATN 301**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=0,P=1)**
Distribution of Marks	**52(TH)+18(PR)+30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Solve Linear Systems: Apply Gaussian elimination, row-echelon forms, and elementary operations to solve systems of linear equations.
- Demonstrate Matrix Algebra: Perform matrix operations, analyze linear transformations, compute inverses, and use LU decomposition.
- Analyze Determinants: Compute determinants, apply Cramer's rule, and evaluate eigenvalues, eigenvectors, and diagonalization.
- Explain Vector Spaces: Define subspaces, determine basis and dimension, apply the rank-nullity theorem, and perform change of basis and diagonalization.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Systems of Linear Equations** Examples leading to linear systems, visualizing systems of 2 or 3 variables, augmented matrix, elementary operations, row-echelon form, reduced row-echelon form, Gaussian elimination, homogeneous systems.	10	0	10	20	12
II	**Matrix Algebra** Vectors and matrices, matrix operations, matrix form of a linear system, matrices as linear transformations, geometric transformations (rotation, reflection, shear), composition and matrix multiplication, inverse of a matrix, equivalent conditions for invertibility, elementary matrices, LU decomposition. (Nicholson: Ch 2, 4.5)	10	0	10	20	12
III	**Determinants** Determinant via cofactors, determinants and row operations, determinant and matrix product, determinant and volume, determinant and matrix inverse, Cramer's rule, eigenvalues and eigenvectors, characteristic polynomial, diagonalization(Nicholson: Ch 3, Kumaresan 6.1 & 6.2)	10	0	10	20	13
IV	**Vector Space Structure of R^n** Subspaces of Euclidean space, spanning sets, linear independence, equivalence of invertibility of a matrix to independence of its rows and columns, basis and dimension, rank of a matrix, rank-nullity theorem, similarity and diagonalization, change of basis. (Nicholson: Ch 5, 9.1)	15	0	0	15	15
	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook:

1. W. Keith Nicholson, *Linear Algebra with Applications*, Open edition, Lyryx Learning, 2018. https://lyryx.com/wp-content/uploads/2018/01/Nicholson-OpenLAWA-2018A.pdf

Reference Books:

1. Robert Beezer, *A First Course in Linear Algebra*, 2015. http://linear.ups.edu/html/fcla.html
2. Jim Hefferon, *Linear Algebra*, 4th edition, Orthogonal Publishing L3C, 2020. https://hefferon.net/linearalgebra/
3. S. Kumaresan, *Linear Algebra – A Geometric Approach*, Prentice Hall India, 2000.

Online Resources:

1. Gilbert Strang, *Linear Algebra*, MIT OCW. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/

List of Practical (using any software) Marks: 18, Contact hrs: 30

1. Study the convergence of sequences through plotting.
2. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
3. Cauchy's root test by plotting nth roots.
4. Ratio test by plotting the ratio of nth and (n+1) th term.
5. Computation of rank of a matrix.
6. Solving the system of homogeneous and non- homogeneous linear equations.
7. Computation of inverse of a matrix.
8. Finding the nth derivatives of functions without Leibnitz theorem.
9. Finding the nth derivatives of functions with Leibnitz's theorem.
10. Partial Differentiation of some standard functions and Jacobians.
11. Verification of Euler's theorem with examples.
12. Finding the Taylor's and Maclaurin's expansion of the given function.
13. Indeterminate forms and evaluation of limits using L-Hospital's rule.

B.A/B.SC.IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**Real Analysis-II**
Course Code	**MATM 401**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70(TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Apply Riemann Integration: Calculate Darboux integrability, use fundamental theorems of calculus, and evaluate improper integrals.
- Analyze Function Convergence: Assess pointwise and uniform convergence, and derive results using power series, Taylor series, and Weierstrass Approximation Theorem.
- Explore Metric Spaces: Define and characterize open and closed sets, limit points, and convergence; demonstrate completeness, compactness, and connectedness.
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UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Riemann integration** Darboux integrability, fundamental theorems of calculus, mean value theorems for integrals, integral form of the remainder, Riemann's original definition, sum of an infinite series as an integral, logarithmic and exponential functions, improper Riemann integrals.. (Kumar *et. al.*: Ch. X)	15	5	0	20	25
II	**Sequences and series of functions** Pointwise convergence, uniform convergence, consequences of uniform convergence, Power Series, Taylor Series of a Smooth Function, Binomial Series, Weierstrass Approximation Theorem. (Kumar *et. al.*: Ch. X)	12	5	0	17	20
III	**Metric spaces** Definition and examples, open balls and open sets, closed sets, limit points, cluster points, closure of a set, dense sets, convergence of sequences, continuity: sequential, \epsilon-\delta method, by open sets. Completeness, compactness and connectedness. (Simmons)	18	5	0	23	25
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Textbooks:

1. Ajit Kumar and S. Kumaresan, *A basic Course in Real Analysis*, CRC Press, 2014.
2. George Finlay Simmons, *Intro Topology & Modern Analysis*, Krieger Publishing Company,2003

Supporting Texts:

1. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, Fourth Edition, Wiley, 2011.
2. T. M. Apostol, *Mathematical Analysis*, Narosa, 1985.
3. S. Kumaresan, *Topology of Metric Spaces*, Narosa, 2005.

B.A/B.SC.IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**Abstract Algebra-I**
Course Code	**MATM 402**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70(TH) + 30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Justify Basic Arithmetic Principles: Explain the well-ordering principle, divisibility properties, GCD, LCM, Euclidean algorithm, prime numbers, and fundamental theorem of arithmetic.
- Analyze Group Theory: Distinguish and apply properties of groups, subgroups, cyclic groups, permutation and matrix groups; justify Lagrange's theorem and group homomorphisms.
- Demonstrate Ring Theory: Define and exemplify rings, integral domains, fields, and ideals; analyze polynomial and matrix rings, and justify homomorphism theorems.
- Evaluate Factorization in Integral Domains: Analyze divisibility, irreducible, primes, Euclidean domains, PIDs, UFDs, and construct fields of quotients.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Basic Arithmetic** Well-ordering principle and its equivalent formulations. Divisibility properties for integers. Division algorithm, GCD, LCM, Euclidean algorithm. Irreducible and Prime numbers, Euclid's Lemma, Fundamental Theorem of Arithmetic. Congruences. Chinese remainder theorem.(Burton)	10	4	0	14	17
II	**Groups** Definition of a group. Permutation groups. Matrix groups, Subgroups, Lagrange's Theorem, Theorems of Fermat, Euler and Wilson. Cyclic groups. Group homomorphisms. Homomorphism theorems.(Gallian)	10	4	0	14	17
III	**Rings** Definition of a rings, Integral domains and fields. Division rings, Finite integral domain is a field. Ideals. Prime and Maximal ideals, Polynomial rings, Matrix rings, Homomorphism of rings. Quotient rings.(Gallian)	13	3	0	16	18
IV	**Factorisation in Integral domains** Divisibility in Integral domains. Irreducibles and Primes, Construction of Field of quotients, Euclidean domains, PIDs and UFDs.(Gallian)	12	4	0	16	18
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Texts Books :

1. David Burton, *Elementary Number Theory*, 7th Ed., 2011, The McGraw-Hill Companies, Inc., New York, USA.
2. Joseph A.Gallian: *Contemporary Abstract Algebra*, 7th Ed., 2010, Brooks/Cole, Cengage Learning, Belmont, CA, USA

Reference Books:

1. N. Jacobson: Basic Algebra, Vols. I & II, Hindustan Pub. Co., 1984.
2. John B. Fraleigh: *A First Course in Abstract Algebra*, 7th Ed., 2014, Pearson Education Limited, Edinburgh, England

B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)

4th SEMESTER

Title of the Course	**Linear Algebra-II**
Course Code	**MATM 403**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Determine and compute the basis and dimension of vector spaces and subspaces. Apply these concepts to solve problems involving the representation of vectors in different bases.
- Represent linear transformations with matrices and perform operations such as matrix multiplication to understand their effect on vector spaces.
- Apply linear transformations to solve real-world problems, including Geometry of some of linear transformations in the plane.
- Define and compute eigenvalues and eigenvectors of a matrix. Demonstrate their significance in the context of linear transformations and matrix theory and the Diagonalization process.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Vector Space** Definition of vector space and examples, Subspaces, Linear span, Linear dependence and independence, Basis and dimension, coordinates, Matrix of change of basis, Sum of subspaces, subspaces associated to a matrix. (Nicholson: Ch 6, Kumaresan: Ch 2)	10	3	0	13	15
II	**Linear Transformations** Definitions and Examples, Kernel and Image of a Linear Transformation, isomorphisms, Dimension theorem (rank-nullity theorem), Applications of rank-nullity theorem, Matrix of a linear transformation, Compositions and matrix of composition, similarity of matrices, Geometry of some of linear transformations in the plane (Nicholson: Ch 7, Kumaresan Ch. 4)	14	3	0	17	20
III	**Eigenvalues and Diagonalization:** Definition of Eigenvalues and Eigenvectors of linear operators and matrices, Geometric Interpretation, Eigenspaces, Diagonalizability, Invariant Subspaces and Cayley Hamilton Theorem. (Friedberg, Ch. 5, Kumaresan 7.)	10	3	0	13	15
IV	**Inner Product Spaces** Dot Product in R^n, Inner product spaces, norm of vectors, Cauchy-Schwarz inequality and applications, orthogonality, Gram-Schmidt orthogonalization process and QR factorization, Orthogonal linear operators, Orthogonal complements, Orthogonal Projection, Reflection through planes. Diagonalization of Symmetric Matrices. (Nicholson: Ch 8 & 10, Kumaresan Ch. 5)	14	3	0	17	20

	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. W. Keith Nicholson, *Linear Algebra with Applications*, Open edition, Lyryx Learning, 2018. https://lyryx.com/wp-content/uploads/2018/01/Nicholson-OpenLAWA-2018A.pdf
2. Stephen Friedberg, Arnold J. Insel and Lawrence E. Spence, *Linear Algebra* 5th Ed. Pearson
3. S. Kumaresan, *Linear Algebra – A Geometric Approach*, Prentice Hall India, 2000.

Reference Books:

1. Jim DeFranza and Daniel Gagliardi, *Introduction to Linear Algebra with Applications*, Tata McGraw Hill, 2017.
2. Jim Hefferon, *Linear Algebra*, 4th edition, Orthogonal Publishing L3C, 2020. https://hefferon.net/linearalgebra/.
3. David C. Lay, *Linear Algebra and its Applications*, 4rd edition, Pearson India, 2002.

Online Resources:

1. Gilbert Strang, *Linear Algebra*, MIT OCW. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/
2. NPTEL Course: Computational Mathematics with Sage Math (https://nptel.ac.in/courses/111106149)

B.A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**ODE**
Course Code	**MATM 404**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Use the techniques to solve differential equations.
- Apply these techniques in various mathematical models used in real life problems.
- Develop the concept of Differential Equations, and develop the skill to solve differential equation of different order.
- Finding solutions of linear homogeneous second order ODE by power series.
- Fundamental concepts of Laplace transforms in solving non-homogeneous equations when non-homogeneous function is either discontinuous or zero for large time.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**First Order Differential Equations** Simple first order differential equations and methods to solve them. (Section 1.1-1.2 of Martin Braun.) Separable equations. (Section 1.3 of Martin Braun) Orthogonal trajectories. Exact differential equations. Integrating factors. Methods of solving some non-exact differential equations. (Section 1.9 of Martin Braun) Picard's theorem on existence and uniqueness of solutions of first order ODE. Only statement, proof need not be given. Illustrate the result with some examples. (Section 1.10 of Martin Braun) Numerical approximations: Euler's method, three term Taylor's method, Improved Euler's method. Illustration of the methods with examples. (Section 1.13 of Martin Braun) Some of the applications: The Van meergen art forgeries; population models; spread of technological innovations; atomic waste disposal problem; mixing problems. (We may make some choices of applications and illustrate the methods learned in first order ODE)	10	3	0	13	15
II	**Second order linear ODE** Introduction. Statement of existence and uniqueness theorem for linear homogeneous second order ODE. Properties of the solutions of second order linear homogeneous second order ODE; fundamental set of solutions, Wronskian of two solutions. The relation between the Wronskian and the coefficients of the differential equations. (Section 2.1 of Martin Braun) Constant coefficient linear homogeneous second order ODE. The solutions when the roots of the characteristic equation are complex, distinct real roots, equal real roots. Method of reduction of order.	10	3	0	13	15

III	**Non homogeneous linear second order ODE** Non-homogeneous linear second order ODEs. Method of variation of parameters. Method of judicious guessing in some special cases. (Sections 2.3-2.5 of Martin Braun)	10	3	0	13	15
IV	**Power Series Solution** Finding solutions of linear homogeneous second order ODE by power series. Existence theorem statement. (Proof need not be given) (Section 2.8 of Martin Braun), Singular points. Euler's equations and its solution. (This equation and the method of solving is the prelude to Frobenius method.) Regular singular points. Frobenius method. Indicial equations.	10	3	0	13	15
V	**Laplace Transform** Laplace Transform: Definition of Laplace transform, Existence theorem for Laplace transform. Linearity property of Laplace transform, Laplace transform of some elementary functions. (algebraic functions, trigonometric functions, exponential functions, hyperbolic functions). First Shifting theorem, Second shifting theorem, Change of scale property, Laplace transform of derivatives, Laplace transform of Integrals, inverse Laplace transformations, use of Laplace transformations solving ODE. . (Sections 2.9–2.11 of Martin Braun)	5	3	0	8	10
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. M. Braun, *Differential Equations and their applications*, Springer. Texts in Applied Mathematics Series.
2. M. B. Finan, https://faculty.atu.edu/mfinan/3243/DFQ2015.pdf.

Reference Books

1. William F. Trench, http://ramanujan.math.trinity.edu/wtrench/texts/TRENCH_ DIFF_EQNS_I.PDF.

B.A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**ODE**
Course Code	**MATN 401**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Use the techniques to solve differential equations.
- Apply these techniques in various mathematical models used in real life problems.
- Develop the concept of Differential Equations, and develop the skill to solve differential equation of different order.
- Finding solutions of linear homogeneous second order ODE by power series.
- Fundamental concepts of Laplace transforms in solving non-homogeneous equations when non-homogeneous function is either discontinuous or zero for large time.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**First Order Differential Equations** Simple first order differential equations and methods to solve them. (Section 1.1-1.2 of Martin Braun.) Separable equations. (Section 1.3 of Martin Braun) Orthogonal trajectories. Exact differential equations. Integrating factors. Methods of solving some non-exact differential equations. (Section 1.9 of Martin Braun) Picard's theorem on existence and uniqueness of solutions of first order ODE. Only statement, proof need not be given. Illustrate the result with some examples. (Section 1.10 of Martin Braun) Numerical approximations: Euler's method, three term Taylor's method, Improved Euler's method. Illustration of the methods with examples. (Section 1.13 of Martin Braun) Some of the applications: The Van meergen art forgeries; population models; spread of technological innovations; atomic waste disposal problem; mixing problems. (We may make some choices of applications and illustrate the methods learned in first order ODE)	10	3	0	13	15

II	**Second order linear ODE** Introduction. Statement of existence and uniqueness theorem for linear homogeneous second order ODE. Properties of the solutions of second order linear homogeneous second order ODE; fundamental set of solutions, Wronskian of two solutions. The relation between the Wronskian and the coefficients of the differential equations. (Section 2.1 of Martin Braun) Constant coefficient linear homogeneous second order ODE. The solutions when the roots of the characteristic equation are complex, distinct real roots, equal real roots. Method of reduction of order.	10	3	0	13	15
III	**Non homogeneous linear second order ODE** Non-homogeneous linear second order ODEs. Method of variation of parameters. Method of judicious guessing in some special cases. (Sections 2.3-2.5 of Martin Braun)	10	3	0	13	15
IV	**Power Series Solution** Finding solutions of linear homogeneous second order ODE by power series. Existence theorem statement. (Proof need not be given) (Section 2.8 of Martin Braun), Singular points. Euler's equations and its solution. (This equation and the method of solving is the prelude to Frobenius method.) Regular singular points. Frobenius method. Indicial equations.	10	3	0	13	15
V	**Laplace Transform** Laplace Transform: Definition of Laplace transform, Existence theorem for Laplace transform. Linearity property of Laplace transform, Laplace transform of some elementary functions. (algebraic functions, trigonometric functions, exponential functions, hyperbolic functions). First Shifting theorem, Second shifting theorem, Change of scale property, Laplace transform of derivatives, Laplace transform of Integrals, inverse Laplace transformations, use of Laplace transformations solving ODE. . (Sections 2.9–2.11 of Martin Braun)	5	3	0	8	10
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. M. Braun, *Differential Equations and their applications*, Springer. Texts in Applied Mathematics Series.
2. M. B. Finan, https://faculty.atu.edu/mfinan/3243/DFQ2015.pdf.

Reference Books

1. William F. Trench, http://ramanujan.math.trinity.edu/wtrench/texts/TRENCH_ DIFF_EQNS_I.PDF.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Introduction to Probability**
Course Code	**MATM 501**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the foundational principles of probability theory.
- Demonstrate the use of discrete random variables and their probability distributions.
- Apply the concepts of probability mass functions (PMFs) and cumulative distribution functions (CDFs).
- Define and distinguish between continuous random variables and their probability distributions.
- Explain the concept of joint probability distributions for two or more random variables.

Overview:

The lectures should integrate simulations using mathematical software/languages such as R/ Python/ Matlab. Chapters 12 and 13 of [Pishro-Nik] provide an introduction to simulation using Matlab and R. [Huber] gives many examples of using R in teaching probability.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Basic Concepts** Interpretations of probability, random experiments, probability measure, discrete and continuous probability models, conditional probability, independent events, total probability, Bayes' rule, conditional independence, sampling with or without replacement, ordered and unordered sampling. [Pishro-Nik, Ch 1 and 2]	9	3		12	13
II	**Discrete Random Variables** Discrete random variables, probability mass function, independence, standard distributions (Bernoulli, geometric, binomial, negative binomial, hypergeometric, Poisson), cumulative distribution function, expectation, functions of random variables, variance. [Pishro-Nik, Ch 3]	9	3		12	15
III	**Continuous Random Variables** Continuous random variables, probability density function, expectation, functions of random variables, variance, standard distributions (uniform, exponential, normal, gamma). [Pishro-Nik, Ch 4 except 4.3]	9	3		12	13
IV	**Joint Distributions** Jointly distributed discrete random variables, joint probability mass function, jointly distributed continuous random variables, joint probability density function, joint cumulative distribution function, conditioning and independence, functions of two random variables, conditional expectation and variance,	9	3		12	14

	covariance and correlation, binormal distribution, multiple jointly distributed random variables. [Pishro-Nik, Ch 5 and 6.1.1, 6.1.2]					
V	**Limit Theorems** Markov and Chebyshev inequalities, sample mean, (Weak) law of large numbers, Central Limit Theorem (with applications but without proof). [Pishro-Nik, 6.2.0 to 6.2.2 and 7.1.0, 7.1.1]	9	3		12	15
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbooks:

1. H. Pishro-Nik, *Introduction to Probability, Statistics, and Random Processes*, Kappa Research LLC, 2014. https://www.probabilitycourse.com .
2. Mark Huber, *Probability: Lectures and Labs*. https://www.markhuberdatascience.org/book.

Reference Books:

1. George Casella, Roger L. Berger, *Statistical Inference*, Cengage, 2007.
2. John A. Rice, *Mathematical Statistics and Data Analysis*, 3rd edition, Cengage, 2013.
3. Sheldon Ross, *A First Course in Probability*, 9th edition, Pearson Education India, 2013.

Online Resources:

1. Dimitri P. Bertsekas and John N. Tsitsiklis, *Introduction to Probability*, MIT OCW. https://ocw.mit.edu/courses/res-6-012-introduction-to-probability-spring-2018/
2. Department of Statistics at Penn State, *STAT414: Introduction to Probability Theory*. https://online.stat.psu.edu/stat414/

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Multivariable Calculus**
Course Code	**MATM 502**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcome: Students will be able to

- Explain the concepts of functions of several variables, related theorems and properties.
- Apply line, double and triple integrals in present scenarios, utilize key theorems in vector calculus.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Functions of several variables, limit and continuity of functions of two variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl.	12	4	0	16	20
II	Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates.	10	4	0	14	15
III	Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path.	12	4	0	16	20
IV	Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.	11	3	0	14	15
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. J. Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

Reference Books:

1. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi,2007.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Abstract Algebra II**
Course Code	**MATM 503**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain and demonstrate the structure-preserving maps between groups and their consequences.
- Demonstrate and define Constructible Numbers, Trisection of angles, Squaring a circle and Doubling a cube.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Groups Actions** Group Actions, Orbits, Isotropy subgroups, Class equations, Transitive actions, Characterisation of transitive actions, Sylow theorems, Simple groups, Solvable and Nilpotent groups. Dihedral groups. [Fraleigh;Ch.3 and Ch.7]	12	04	0	16	16
II	**Polynomials** Divisibility properties of Polynomials. Division algorithm and consequences, Irreducible and prime polynomials. Theorem of Gauss. Eisenstein's Irreducibility Criterion. Linear and Polynomial congruences. Zeroes of Polynomials. Symmetric polynomials, Fundamental theorem of algebra. [Jacobson;Ch.16 and Ch.17]	10	04	0	14	15
III	**Field Extensions** Finite field extensions, Zeros of an irreducible polynomial, Kronecker's theorem, Algebraically closed fields, Construction of an algebraic closure, Construction of Finite fields. Automorphisms of field extensions. Examples, Roots of unity, Cyclotomic field extensions. [Fraleigh ; Ch. 6 and Ch.10]	15	03	0	18	24
IV	**Historical Discussion of Geometric Constructions** Constructible Numbers, Trisection of angles, Squaring a circle and Doubling a cube. *(Constructible regular polygons, Gauss-Wantzel Theorem (Statement only.))* [Gallian; Ch. 22]	8	04	0	12	15
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., 2014, Pearson Education Limited, Edinburgh, England.
2. Joseph A. Gallian, *Contemporary Abstract Algebra*, 7th Ed., 2010, Brooks/Cole, Cengage Learning, Belmont, CA, USA .
3. N. Jacobson, *Basic Algebra*, Vols. I & II, Hindustan Pub. Co., 1984.

Reference Books:

1. Joseph . Rotmann, *Galois Theory*, 2nd Ed. 1998, Universitext Springer Verlag.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Numerical Analysis**
Course Code	**MATM 504**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=0, P=1)**
Distribution of Marks	**52 (TH)+18(PR)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the principles behind solving nonlinear equations and apply methods such as Bisection, Newton-Raphson, and Secant methods; analyze the convergence and stability of these methods.
- Demonstrate strong problem-solving and analytical skills specific to numerical analysis.
- Apply software and programming languages (e.g., MATLAB, Python) to implement numerical methods effectively.

Overview: An introduction to Numerical Methods that focuses on Solutions to Nonlinear, Systems of Linear and Nonlinear Equations, Interpolation, Approximation, Numerical Differentiation, and Integration, with an emphasis on Approximation Techniques. The course will also take up applications to topics in Chemical, Physical, Environmental, Electronics, Economics, and Diverse Areas of Engineering.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Error Analysis** Introduction to Error Analysis and computer arithmetic (Douglas: Ch 1)	5	0	0	5	5
II	**Solutions of Nonlinear Equations in One Variable** The Bisection Method, The Method of False Position, Fixed-Point Iteration, Newton's Method, Secant Method. Applications: Ideal and Non ideal Gas Laws, Greenhouse Gases and Rainwater, and Design of an Electric Circuit. (Douglas: Ch 1,2: Chapra: Ch 8)	10	0	8	18	12
III	**Interpolation** Lagrange's Formula, Newton's Divided Difference Formula, Newton's Forward and Backward Difference Formula and Stirling's Formula. Applications: Temperature at Various Points on a Heated Plate, and Sea level Concentration of Dissolved Oxygen for Fresh Water. (Douglas: Ch 3: Chapra: Ch 18)	10	0	8	18	12
IV	**Approximation** Linear Least Square Approximation, Polynomial Least Square Approximation, Pade Approximation, and the Power Method. Applications: Linear Regression and Population Models, Tensile Strength of Plastic at a time t, and The Volume of Super-Heated Steam at Various Temperatures. (Douglas: Ch 8,9: Chapra: Ch 20)	10	0	6	16	11
V	**Numerical Differentiation and Integration** Three Point Formula, Five Point Formula, Second Derivative Midpoint Formula, Trapezoidal Rule, Simpson's 1/3 & 3/8 Rule, Romberg Integration. Applications: Velocity and Acceleration of a Jet fighter's position on an Aircraft, Integration to Determine the Total Quantity of Heat, and Effective Force on the Mast of a Racing Sailboat. (Douglas: Ch 4: Chapra: Ch 24)	10	0	8	18	12

	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook(s):

1. Richard L. Burden, J. Douglas Faires, *Numerical Analysis*, Ninth edition, Cengage Learning, 2010. https://faculty.ksu.edu.sa/sites/default/files/numerical_analysis_9th.pdf.
2. Steven C. Chapra, Raymond P. Canale, J. Douglas Faires, *Numerical Methods for Engineers*, Seventh edition, McGraw-Hill Education, 2015. https://www.gdcboysang.ac.in/About/Droid/uploads/Numerical%20Methods.pdf
3. Mathews and Fink, Numerical Methods using MatLab.

Reference Books:

1. S. D. Conte, C. de Boor, *Elementary Numerical Analysis-An Algorithmic Approach*, McGraw-Hill.
2. Laurene V. Fausett, *Applied Numerical Analysis using MATLAB*, Pearson Education.
3. S.S. Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd.

List of Practicals (using any software) Marks: 18 Contact hrs. 30

1. Find the root of an equation using Bisection Method.
2. Find the root of an equation using Newton Raphson Method.
3. Find the root of an equation using Secant Method.
4. Find the root of an equation using Regula Falsi Method.
5. Solve a system of equation using LU decomposition Method.
6. Solve a system of equation using Gauss-Jacobi Method.
7. Solve a system of equation using SOR Method or Gauss-Siedel Method.
8. Interpolate the data using Lagrange Interpolation or Newton Interpolation.
9. Apply Numerical integration by Simpson's rule.
10. Apply Numerical integration by Trapezoidal rule.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Numerical Analysis**
Course Code	**MATN 501**
Nature of the Course	**MINOR**
Total Credits	**04 (L=3, T=0, P=1)**
Distribution of Marks	**52 (TH)+18(PR)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the principles behind solving nonlinear equations and apply methods such as Bisection, Newton-Raphson, and Secant methods; analyze the convergence and stability of these methods.
- Demonstrate strong problem-solving and analytical skills specific to numerical analysis.
- Apply software and programming languages (e.g., MATLAB, Python) to implement numerical methods effectively.

Overview: An introduction to Numerical Methods that focuses on Solutions to Nonlinear, Systems of Linear and Nonlinear Equations, Interpolation, Approximation, Numerical Differentiation, and Integration, with an emphasis on Approximation Techniques. The course will also take up applications to topics in Chemical, Physical, Environmental, Electronics, Economics, and Diverse Areas of Engineering.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Error Analysis** Introduction to Error Analysis and computer arithmetic (Douglas: Ch 1)	5	0	0	5	5
II	**Solutions of Nonlinear Equations in One Variable** The Bisection Method, The Method of False Position, Fixed-Point Iteration, Newton's Method, Secant Method. Applications: Ideal and Non ideal Gas Laws, Greenhouse Gases and Rainwater, and Design of an Electric Circuit. (Douglas: Ch 1,2: Chapra: Ch 8)	10	0	8	18	12
III	**Interpolation** Lagrange's Formula, Newton's Divided Difference Formula, Newton's Forward and Backward Difference Formula and Stirling's Formula. Applications: Temperature at Various Points on a Heated Plate, and Sea level Concentration of Dissolved Oxygen for Fresh Water. (Douglas: Ch 3: Chapra: Ch 18)	10	0	8	18	12
IV	**Approximation** Linear Least Square Approximation, Polynomial Least Square Approximation, Pade Approximation, and the Power Method. Applications: Linear Regression and Population Models, Tensile Strength of Plastic at a time t, and The Volume of Super-Heated Steam at Various Temperatures. (Douglas: Ch 8,9: Chapra: Ch 20)	10	0	6	16	11
V	**Numerical Differentiation and Integration** Three Point Formula, Five Point Formula, Second Derivative Midpoint Formula, Trapezoidal Rule, Simpson's 1/3 & 3/8 Rule, Romberg Integration. Applications: Velocity and Acceleration of a Jet fighter's position on an Aircraft,	10	0	8	18	12

	Integration to Determine the Total Quantity of Heat, and Effective Force on the Mast of a Racing Sailboat. (Douglas: Ch 4: Chapra: Ch 24)					
	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook(s):

1. Richard L. Burden, J. Douglas Faires, *Numerical Analysis*, Ninth edition, Cengage Learning, 2010. https://faculty.ksu.edu.sa/sites/default/files/numerical_analysis_9th.pdf
2. Steven C. Chapra, Raymond P. Canale, J. Douglas Faires, *Numerical Methods for Engineers*, Seventh edition, McGraw-Hill Education, 2015. https://www.gdcboysang.ac.in/About/Droid/uploads/Numerical%20Methods.pdf
3. Mathews and Fink, Numerical Methods using MatLab

Reference Books:

1. S. D. Conte, C. de Boor, *Elementary Numerical Analysis-An Algorithmic Approach*, McGraw-Hill.
2. Laurene V. Fausett, *Applied Numerical Analysis using MATLAB*, Pearson Education.
3. S.S. Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd.

List of Practicals (using any software) Marks: 18 Contact hrs. 30

1. Find the root of an equation using Bisection Method.
2. Find the root of an equation using Newton Raphson Method.
3. Find the root of an equation using Secant Method.
4. Find the root of an equation using Regula Falsi Method.
5. Solve a system of equation using LU decomposition Method.
6. Solve a system of equation using Gauss-Jacobi Method.
7. Solve a system of equation using SOR Method or Gauss-Siedel Method.
8. Interpolate the data using Lagrange Interpolation or Newton Interpolation.
9. Apply Numerical integration by Simpson's rule.
10. Apply Numerical integration by Trapezoidal rule.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**PDE**
Course Code	**MATM 601**
Nature of the course	**Major**
Total Credit	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)**

Course Learning Outcomes: This course will enable the students to:

- Explain the basic concepts of partial differential equations and their significance in various applications.
- Analyze the concept of differential equations and develop the skill to solve differential equations of different orders.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**First Order Partial Differential Equations:** Basics of PDE, an introduction with some examples with an illustration of solving them. (Chapter 1, Sections 1.1-1.7 of [1] and Section 1 of [2]) First order PDE and their classification with examples. Some simple examples and solutions. (Chapter 2, Section 2.1 of [1] and Section 5 of [2]) Quick review of several variable calculus; Gradient vector, Directional derivative, chain rule. Solvability of semi linear, quasi linear and linear equations. Method of characteristics. Lagrange's method. (First order equations involve geometric ideas. (Chapter 2, Sections 2.1-2.5 of [1] and Sections 7, 8, 9 and 10 of [2]) Cauchy problem for first order quasi linear problem. We may explain the theorem and skip the proof.	15	05	-	20	24
II	**Second order PDEs** Introduction. General form of second order PDE. Classification by characteristics in to three different types, namely hyperbolic, elliptic and parabolic. Typical examples of these three types of PDEs. The canonical forms and general solutions. (Chapter 3 of [1] and Section 11 of [2]) Wave equation, One dimensional homogeneous wave equation and general solution. The initial value problem and d'Alembert's formula for the solution and applications. (Chapter 4, Sections 4.1–4.5 and 4.6 of [1] Section [12] of [2]) **Initial/Boundary value problems.** Oscillations of strings of finite length. Non-homogeneous wave equation. Duhamel's principle. Chapter 4, Sections 4.5 and 4.6 of [1]	15	05	-	20	23
III	**Laplace Equation** Laplace equation on rectangular domains and circular domains. Separation of variables. Solutions of boundary value problems with Dirichlet and Neumann boundary conditions. Eigen functions and eigenvalue expansions of Laplace equation in rectangles and circular domains.	15	05	-	20	23

	Solutions of the Laplace equation for unit ball in R3 with special boundary condition. Solution of the Laplace equation on the exterior of the unit ball in R3 with special boundary condition. Uniqueness and maximum principle for Dirichlet and Neumann problem for rectangular and circular domains. (Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, 7.7 and 7.8 of [1], Sections 19 and 20 of [2])					
	Total	**45**	**15**	**-**	**60**	**70**

Recommended Text Books:

1. Y. Pinchover, J. Rubenstein, An Introduction to Partial Differential Equations, Cambridge University Press, 2005.
2. Marcel B Finan, A First Course in Quasi-Linear Partial Differential Equations for Physical Sciences and Engineering. https://faculty.atu.edu/mfinan/4343/ PDEbook.pdf

Reference Books:

1. Walter A Strauss, Partial Differential Equations–An Introduction, John Wiley.
2. Erwin Kreyszig Advanced Engineering Mathematics, 10th Edition, John Wiley. http://www.wiley.com/college/kreyszig
3. Alan Jeffrey, Advanced Engineering Mathematics, Academic Press.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**Complex Analysis**
Course Code	**MATM 602**
Nature of the course	**Major**
Total Credit	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning outcomes: After going through this course the students will be able to describe:

- Explain the importance of differentiability and analyticity of complex functions and how they lead to the derivation of the Cauchy-Riemann equations.
- Apply Taylor and Laurent series expansions of analytic functions; classify the nature of singularities, poles, and residues, and utilize the Cauchy Residue theorem.
- Utilize problem-solving skills using the Residue theorem.
- Explain and analyze the properties of path integrals.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Field of Complex numbers** Polar form of a complex number. Metric properties; Topological notions; continuity, Non-existence of a continuous argument on C* (Lemma 4.3.7). convergence of sequences of series of complex numbers etc. A quick review (Chapters 1 and 2 of SK.) **Functions from R to C** Differentiation and integration of complex value functions of real variables; (Sections 5.1 and 6.1 of SK.)	9	3	-	12	14
II	**Holomorphic functions properties** Cauchy-Riemann equations, Sufficiency part of characterization of holomorphic functions in terms of CR equations. (Sections 5.3, 5.4 (only as much as required),5.5, and 5.7 of SK) **Power series** A quick review of infinite series, definition of a power series, radius of convergence, continuity and (term-wise) differentiability of a power series function in its disk of convergence. Definition of an analytic function. (Sections: 2.2. 2.3 and 5.5 of SK)	9	3	-	12	14
III	**Path Integrals properties** ML-Inequality, and its uses. Fundamental theorem of path integrals and its relation to existence of primitives (Sections 6.1, 6.2 and 6.3 of SK) **Cauchy Theory** Cauchy-Goursat theorem for triangles, Cauchy's theorem for star-shaped domains and their extensions. (Sections 7.1 and 7.3 of SK)	9	3	-	12	14
IV	**Cauchy Integral Formula and Properties of Holomorphic Functions** Winding Numbers (Section 10.1 of SK), Cauchy integral formula and its consequences: Holomorphic iff analytic, Cauchy estimates, Liouville's theorem. Fundamental theorem of algebra, Uniqueness theorem, maximum modulus and minimum modulus principles and open mapping theorem. (Chapter 8 of SK) **Isolated singularities via the limits** Cauchy integral formula for an annulus, Laurent series,	9	3	-	12	14

	characterization of singularities in terms of Laurent series.					
V	**Extended Complex Plane** Point at infinity, Riemann sphere, behaviour of functions at infinity, Fractional linear transformations. (Section 11.1 to 11.3 of SK) **Residue Theory** Residues and the residue theorem (Section 11.1). **Computation of real integrals using residue theorem:** One example in each of the types (Sections 15.1 and 15.2 of SK) Argument principle and Rouche's theorem.	9	3		12	14
	Total	45	15	-	60	70

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. S Kumaresan, *A Pathway to Complex Analysis*, Techno world, 2021.
2. J. Conway, *Functions of One Complex variable*, 2nd Edition, Springer International Edition, 1973

Reference Books:

1. J Bak and D.J. Newman, *Complex Analysis*, 2nd Edition, Springer-International Edition 1997
2. T.W. Gamelin, *Complex Analysis*, Springer-International Edition 2004.
   Videos: https:/youtube.com/kumarhcu, Playlist=Complex Analysis.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**Introduction to Statistics**
Course Code	**MATM 603**
Nature of the course	**Major**
Total Credit	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Explain sampling distributions and their relation to population distributions.
- Define point estimation and evaluate properties of point estimators such as unbiasedness, consistency, and efficiency.
- Apply interval estimation techniques and interpret confidence intervals in real-world data.
- Interpret hypothesis test results and make informed decisions based on statistical evidence.
- Utilize mathematical software/languages (R, Python, MATLAB) for calculations and simulations.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Sampling Distributions** Moments, moment generating function (mgf), mgf's of standard distributions, mgf technique, random sample, sample mean, sample variance, standard error of the mean, large sample approximations, sampling from finite populations, chi-square distribution, t distribution, F distribution. ([1] 4.3, 4.5, 8.1 to 8.6)	9	03	-	12	14
II	**Point Estimation** Point estimator, bias, efficiency, consistency, sufficiency, method of moments, maximum likelihood estimation. ([1] 10.1 to 10.8)	9	03	-	12	14
III	**Interval Estimation** Confidence intervals, degree of confidence, one-sided confidence intervals, estimation of means, difference of means, proportions, difference of proportions, variance and ratio of variances. ([1] 11.1 to 11.7)	9	03	-	12	14
IV	**Hypothesis Testing** Null and alternative hypotheses, acceptance and rejection regions, Type I and II errors, power of a test, Neyman-Pearson lemma, power function of a test, likelihood ratio tests, tests concerning means, tests concerning difference of means, tests concerning variances, contingency tables, goodness of fit. ([1] 12.1 to 12.6, 13.1 to 13.4)	9	03	-	12	14

V	**Regression** Bivariate regression, linear regression, method of least squares, normal regression analysis, normal correlation analysis, multiple linear regression, multicollinearity. ([1] Ch 14)	9	03		12	14
	Total	**45**	**15**	**-**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. Irwin Miller and Marylees Miller, *John E. Freund's Mathematical Statistics with Applications*, 8th edition, Pearson Education India, 2013.
2. David Freedman, Robert Pisani and Roger Purves, *Statistics*, 4th edition, Viva-Norton Student Edition, 2009.
3. Mark Huber, *Statistical Inference: Lectures and Labs*. https://www.markhuberdatascience.org/book

Reference Books:

1. George Casella, Roger L. Berger, *Statistical Inference*, Cengage, 2007.
2. Morris H. De Groot and Mark J. Schervish, *Probability and Statistics*, 4th edition, Pearson Education India, 2016.

Online Resources:

1. Department of Statistics at Penn State, *STAT415: Introduction to Mathematical Statistics.* https://online.stat.psu.edu/stat415/
2. Jeremy Balka, *Making Statistics Make Sense*, https://www.jbstatistics.com/ (Videos available on the YouTube channel @jbstatistics)

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**Linear Programming**
Course Code	**MATM 604**
Nature of the course	**Major**
Total Credits	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcome: After going through this course the students will be able to understand the theoretical basics of linear programming, will be able to formulate practical problems as linear programming problems, and will be able to implement a linear programming model using tools.

- Explain sampling distributions and their relation to population distributions.
- Define point estimation and evaluate properties of point estimators such as unbiasedness, consistency, and efficiency.
- Apply interval estimation techniques and interpret confidence intervals in real-world data.
- Interpret hypothesis test results and make informed decisions based on statistical evidence.
- Utilize mathematical software/languages (R, Python, MATLAB) for calculations and simulations**.**

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	15	05	-	20	23
II	Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation,	15	05	-	20	23
III	Hungarian method for solving assignment problem. Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.	15	05	-	20	24
	Total	**45**	**15**		**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.

Reference Books:

1. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
2. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)
6th SEMESTER

Title of the Course	**Linear Programming**
Course Code	**MATN-601**
Nature of the Course	**MINOR**
Total Credits	**04(L=3, T=1,P=0)**
Distribution of Marks	**70(TH)+ 30(IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Explain sampling distributions and their relation to population distributions.
- Define point estimation and evaluate properties of point estimators such as unbiasedness, consistency, and efficiency.
- Apply interval estimation techniques and interpret confidence intervals in real-world data.
- Interpret hypothesis test results and make informed decisions based on statistical evidence.
- Utilize mathematical software/languages (R, Python, MATLAB) for calculations and simulations**.**

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	15	05	-	20	23
II	Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation,	15	05	-	20	23
III	Hungarian method for solving assignment problem. Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.	15	05	-	20	24
	Total	**45**	**15**		**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.

Reference Books:

1. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
2. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**History of Mathematics**
Course Code	**MDCM101**
Nature of the Course	**MDC**
Total Credits	**03(L=2, T=1,P=0)**
Distribution of Marks	**(TH)+ (IA)=**

Course Learning Outcomes: This course will enable the students to:

- Introduce the historical perspective of mathematics such as numerical symbol, word numerals, place value notation.
- Explain the arithmetic algorithms, construction of sine tables and Diophantine equation inancient and medieval India.
- Explain how mathematics has evolved in India.
- Analyze and critically reflect on ancient and modern mathematical issues.
- Conduct historical research on ancient Indian mathematical ideas with the texts of classicalmathematics and their historical interpretation.
- Explain some of the mathematical concepts developed in ancient time and evaluate the relevancein modern mathematics and sciences.

UNITS	CONTENTS	L	T	P	Total Hours	Total Marks
I	A glimpse of ancient India; Hindus and mathematics; Scopeand development of Hindu mathematics.	06	01	-	07	
II	Numeral terminology; The development of Numerical Symbol; The decimal place-value system; Persistence of theold system; Word numerals; Alphabetic notations; The zero symbol; The place-value notation in Hindu literature.	10	01	-	11	
III	Euclid: Introduction to the Elements; Book I and Pythagorean Theorem; Book II and Geometric Algebra. Archimedes; Estimating the values of pi. Ramanujan's viewon Magic square.	13	01	-	14	
IV	Ancient and Medieval India: Arithmetic algorithms; Geometry; Linear congruence; Construction of Sine tables; Transmission to and from India. Diophantine Equations in Greece and India; Early Mathematics in India. Linear Equations in One and Two unknown. The Rule of three	12	01	-	13	
	Total	**41**	**04**	**-**	**45**	

Where, L: Lectures T: Tutorials P: Practicals

Recommended TextBooks:

1. History of Hindu Mathematics (Part I), Datta B., Narayan Singh A., Gyan Publishing House, 2021.
2. A History of Mathematics: An Introduction, Kartz Victor J., Pearson, 2009
3. Ramanujan's Notebooks: Part I, Berndt Bruce C., Springer, 1985.
4. The History of Mathematics: An Introduction, Burton David M., Mc Graw Hill, 2011.

SYLLABUS (2024-25 Batch onwards)
DEPARTMENT OF MATHEMATICS

(Recommended by B.O.S. in Mathematics, M.D.U. in its meeting held on 26.07.2024)

MADHABDEVUNIVERSITY
2024

Graduate Attributes in Mathematics

The graduate attributes in mathematics are the summation of the expected course learning outcomes mentioned in the beginning of each course. Some of them are stated below.

- Disciplinary knowledge:

Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an undergraduate programme of study.

- Communications skills:

  i. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
  ii. Ability to use mathematics as a precise language of communication in other branches of human knowledge.
  iii. Ability to show the importance of mathematics as precursor to various scientific developments since the beginning of the civilization.
  iv. Ability to explain the development of mathematics in the civilizational context and its role as queen of all sciences.

- Critical thinking and analytical reasoning:

  i. Ability to employ critical thinking in understanding the concepts in every area of mathematics.
  ii. Ability to analyze the results and apply the various problems appearing in different branches of mathematics.

- Problem solving:

  i. Capability to solve various models such as growth and decay models,radioactive decay model, drug assimilation.
  ii. Ability to solve linear system of equations, linear programming problems and network flow problems.
  iii. Ability to provide new solutions using the domain knowledge of mathematics acquired during this programme.

- Research-related skills:

  i. Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
  ii. To know about the advances in various branches of mathematics.

- Information/digital literacy:

  i. Capability to use appropriate softwares to solve system of equations and differential equations.
  ii. Capability to understand and apply the computer programming concepts to mathematical investigations and problem solving.

- Self-directed learning:

  Ability to work independently and do in-depth study of various notions of mathematics.

- Moral and ethical awareness/reasoning:

  Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

- Life long learning:

  Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning.

Programme Learning Outcomes of UG (Hons) Mathematics

UG in mathematics is the culmination of in-depth knowledge of algebra, calculus, Real Analysis, Linear Algebra, Geometry, Differential Equations and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.

1. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.

2. Students undergoing this programme learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems.

They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

3. Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.

4. Completion of this programme will also enable the learners to join teaching profession in higher, primary and secondary schools.

5. This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

Course learning outcomes

Course learning outcomes of each course of Mathematics have been enshrined in the beginning of course contents of each course.

Curriculum Framework of Four Year Under Graduate Programme (FYUGP), Madhabdev University

Academic Level	Semester	Major(60/80)	Minor (24/32)	MDC(9)	AEC(8)	VAC(7)	SEC(10)	Internship/Project(4/12)	Total Credit
	I	Major1(4)	Minor1(4)	MDC1(3)	Life skills(4)	Introduction to Yoga/NSS &Youth development/Sports & Physical Education (2)	Library & Information source/Computer operating system/ Introduction to communications(3)		20
	II	Major2(4)(4)	Minor2(4)	MDC2(3)	MIL/ Alternative English(4)/ Madhabdev studies	Primary skills Rover &Ranger/Basic Yoga /NSS	Library and digital resources/ Scriptwriting/Digital literacy (3)		20
Level5	**Exit-1**	**UG Certificate Programme**							**40**
	III	Major3(4)	Minor3(4)	MDC3(3)		Environmental Studies (3)	Cyber Security(4)		22
		Major4(4)							
	IV	Major5(4)	Minor4(4)					Community Engagement/ Internship(2)	22
		Major6(4)							
		Major7(4)							
		Major8(4)							
Level6	**Exit-2**	**UG Diploma Programme**							**84**
	V	Major9(4)	Minor5(4)						22
		Major10(4)						Internship(2)	
		Major11(4)							
		Major12(4)							
	VI	Major13(4)	Minor6 (4)						22
		Major14(4)					classical	Research Project(2)	
		Major15(4)							
		Major16(4)							
Level7	**Exit-3**	**UG Degree Programme**							**128**
	VII	Major17(4)	Minor7(4)				Research Methodology(4)	Seminar/Presentation/Internship/ Research Project(2)	22
		Major18(4)							
		Major19(4)							
	VIII	Major20(4)	Minor8(4)						24
		Major21(4)							

		Major22(4)						Project/Dissertation(8)	
Level8	**Exit-4**	**UG Degree Honours/ Research Programme**							**174**

(2024-25 Batch onwards)

DRAFT STRUCTURE OF FOUR YEAR UNDER
GRADUATE PROGRAMMES
(FYUGP) AS PER NEP-2020 GUIDELINES

IN MATHEMATICS FOR MADHABDEV UNIVERSITY

First Semester			
Course Type	**Title of the Paper**	**Paper Code**	**Credit**
CORE MAJOR	Foundations and Calculus-I	MATM 101	4
CORE MINOR		MATN 101	4
MDC	History of Mathematics	MDCM 101	3
AEC 1	Life Skills	AECL 101	4
VAC 1 (Any One)	Introduction to NCC	NCCV 101	2
	NSS &Youth Development	NSSV 101	
	Sports and Physical Education Part I	PHEV 101	
	Introduction to Rover Ranger	RARV 101	
	Introduction to Yoga Education	YOGAV 101	
SEC 1 (Any One)	Introduction to Communication	CMMS 101	3
	Introduction to Computer and operating System	DGLS 101	
	Library System and information Source	LISS 101	
Total Credit			**20**
Second Semester			
CORE MAJOR	Classical algebra and Calculus-II	MATM 201	4
CORE MINOR		MATN 201	4
MDC	Commerce	MDCC 201	3
AEC 2 (Any One)	Alternative English	AECA 201	4
	MIL	AECL 201	
	Madhabdev Studies	AECM 201	
VAC 2 (Any One)	Introduction to NCC Part II	NCCV 201	2
	NSS &Youth Development -B	NSSV 201	
	Sports and Physical Education Part II	PHEV 201	
	Primary Skills and Aspects of Rover & Ranger	RARV 201	
	Basic Yoga Text	YOGV 201	
	Indian Knowledge System	IKSV 201	
SEC 2 (Any One)	Script Writing	CMMS 201	3
	Digital Literacy	DGLS	

		201	
	Foundation of Library and Digital Resources	LISS201	
Total Credit			**20**
Third Semester			
CORE MAJOR	Real Analysis-I	MATM 301	4
CORE MAJOR	Linear Algebra -I	MATM 302	4
CORE MINOR	Linear Algebra -I	MATN 301	4
MDC 3			3
VAC 3	Environmental Studies		3
SEC – 3	Cyber Security		4
	Total Credit		**22**
Fourth Semester			
CORE MAJOR	Real Analysis-II	MATM 401	4
CORE MAJOR	Abstract Algebra-I	MATM 402	4
CORE MAJOR	Linear Algebra-II	MATM 403	4
CORE MAJOR	ODE	MATM 404	4
CORE MINOR	ODE	MATN 401	4
Community Engagement/ Internship			2
	Total Credit		**22**
Fifth Semester			
CORE MAJOR	Introduction to Probability	MATM 501	4
CORE MAJOR	Multivariable Calculus	MATM 502	4
CORE MAJOR	Abstract Algebra II	MATM 503	4
CORE MAJOR	Numerical Analysis	MATM 504	4
CORE MINOR	Numerical Analysis	MATN 501	4
Internship			2
	Total Credit		**22**
Sixth Semester			
CORE MAJOR	PDE	MATM 601	4
CORE MAJOR	Complex Analysis	MATM 602	4
CORE MAJOR	Introduction to Statistics	MATM 603	4
CORE MAJOR	Linear Programming	MATM 604	4
CORE MINOR	Linear Programming	MATN 601	4
Research Project			2
	Total Credit		**22**

Seven Semester			
CORE MAJOR	Topology	MATM 701	4
CORE MAJOR	Number Theory	MATM 702	4
CORE MAJOR	Abstract Algebra-III	MATM 703	4
CORE MINOR	PDE	MATN 701	4
Research Project			2
	Total Credit		**22**
Eight Semester			

CORE MAJOR	Functional Analysis	MATM 801	4
CORE MAJOR	Calculus of Variations	MATM 802	4
CORE MAJOR	Graph Theory	MATM 803	4
CORE MINOR	Introduction to Probability	MATN 801	4
Research Project			2
	Total Credit		**22**

B.A/B.SC. IN MATHEMATICS PROGRAMME (NEP)
1st SEMESTER

Title of the Course	**Foundations and Calculus-I**
Course Code	**MATM/MATN 101**
Nature of Course	**Major/Minor**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70(TH)+30(IA)**

Course Learning Outcomes: The course will enable the students to:

- Demonstrate understanding of statements, quantifiers, compound statements, implications, and mathematical proofs.
- Apply set theory including operations on sets, family of sets, power sets, Cartesian products, and relations.
- Analyze functions and their properties, including one-one functions, onto functions, bijections, composition, and inverses.
- Compute area between curves, volume by cross-sections and shell method, arc-length, center of mass, and apply Pappus' theorem.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Statements and Logic:** Statements, Statements with quantifiers, Compound statements, Implications, Proofs in Mathematics. Sets, Operations on sets, Family of sets, Power sets, Cartesian product of sets. Functions, One-one functions, onto functions and bijections, Composition of functions, Inverse of a function, Image of subsets under functions, Inverse image of subsets under functions. Relations on sets, Types of relations, Equivalence relations, Equivalence classes and partitions of a set. The Induction Principle, The Strong Induction Principle, The Well-ordering Principle, Equivalence of the three principles. Sets with same cardinality, Finite sets, Countable sets, Comparing cardinality, Uncountable sets.	22	08	0	30	35
II	**Applications of Differentiation and Integration:** Absolute and relative extrema, Fermat's theorem, critical points, Rolle's theorem, mean value theorem, constancy theorem, increasing/decreasing test, first derivative test, convexity/ concavity, inflection points, concavity test, second derivative test, curve sketching, first derivative test for absolute extremes, optimization problems, indeterminate forms and L' Hospital's rule. [Stewart, 3.7, 4.1 to 4.6] Area between curves, volume by integrating cross-sections, shell method, arc-length of plane and space curves, centre of mass, Pappus' theorem. [Stewart, 7.1 to 7.5, 10.7, 10.8] .	23	07	0	30	35
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Text Books:

1. Ajit Kumar, S. Kumaresan and Bhaba Kumar Sarma,*A Foundation Course in Mathematics*, Narosa Publishing House, 2018.
2. James Stewart, *Essential Calculus: Early Transcendentals*, Metric Version, Cengage, 2014.

Reference Books:

1. Shobha Bagai, Amber Habib and Geetha Venkataraman, *A Bridge to Mathematics*, SAGE, 2017.
2. David Guichard, *Single Variable Calculus*. https://www.whitman.edu/mathematics/calculus/
3. George B. Thomas, Jr. and Ross L. Finney, *Calculus and Analytic Geometry*, 9th edition, Pearson Education India, 2010.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)
2nd SEMESTER

Title of the Course	**Classical algebra and Calculus-II**
Course Code	**MATM/MATN-201**
Nature of the Course	**MAJOR/MINOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70(TH)+30(IA)=100**

Course Learning Outcomes: The course will enable the students to:

- Analyze Polynomials and Inequalities: Solve polynomial equations, relate roots and coefficients, and apply inequalities (A.M., G.M., H.M., Cauchy-Schwarz, Holder's, Minkowski's).
- Apply Complex Numbers: Use polar representation, nth roots of unity, and De Moivre's theorem
- Solve Linear Systems and Determinants: Work with determinants, linear equations, row reduction, echelon forms, and matrix equations.
- Evaluate Multivariable Calculus: Analyze parametric curves, compute partial derivatives, and perform double and triple integrals in various coordinates.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Classical Algebra** Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications. [Barnard] Relations between the roots and the coefficients of polynomial equations, Symmetric function of roots, Descartes Rule of sign, Solutions of cubic and biquadratic equations. [Barnard] Inequalities involving A.M, G.M, and H.M., Cauchy Schwarz inequality, Holder's inequality, Minkowski's inequality. [Venkat Ch 1 up to 1.6] Determinants, system of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax= b, solution sets of linear systems. [Lay, Ch. 1.1 – 1.6, 2.1 – 2.3 and 3.1 – 3.3]	15	4	0	19	20
II	**Parametric Curves** Plane curves, tangents and arc-length, polar coordinates, quadric surfaces, vector functions and space curves, differentiation and integration of vector functions. [Stewart, Ch 9 and 10.6 to 10.8, leaving out enclosed areas and curvature]	07	4		11	15
III	**Partial Derivatives** Functions of several variables, level curves and surfaces, limits and continuity, partial derivatives, Clairaut's theorem, tangent planes and linear approximations, differentiability, chain rule, implicit differentiation, directional derivatives, gradient, local extremes, first derivative test, second derivative test, absolute maximum and minimum, Lagrange multipliers. [Stewart, 11.1	15	4		19	20

	to 11.8]					
IV	**Double and Triple Integrals** Double integrals over rectangles, double integrals over general regions, polar coordinates, triple integrals, cylindrical and spherical coordinates, change of variables. [Stewart, Ch 12 except 12.4].	08	3		11	15
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. S. Barnard, J. M. Child, *Higher Algebra*, New Academic Science, 2017
2. B. J. Venkatachala, *Inequalities. An Approach through Problems*-Springer 2018.(https://pdfcoffee.com/qdownload/b-j-venkatachala-inequalities-an-approach-through-problems-springer-2018pdf-pdf-free.html)
3. David C. Lay, *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian, Reprint, 2007.
4. James Stewart, *Essential Calculus: Early Transcendentals*, Metric Version, Cengage, 2014.

Reference Books:

1. George B. Thomas, Jr. and Ross L. Finney, *Calculus and Analytic Geometry*, 9th edition, Pearson Education India, 2010.

Online Resources:

Denis Auroux, *Multivariable Calculus*, MIT OCW. https://ocw.mit.edu/courses/18-02sc-multivariable-calculus-fall-2010/

B.A/B.SC.IN MATHEMATICS PROGRAMME (NEP)

3rd SEMESTER

Title of the Course	**Real Analysis I**
Course Code	**MATM 301**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70(TH)+30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Demonstrate Understanding of Real Number System: Explain upper and lower bounds, LUB property, Archimedean property, and nested interval theorem.
- Distinguish and Analyze Sequences and Series: Justify convergence, analyze Cauchy sequences, and apply convergence tests for infinite series.
- Explain and Apply Continuity: Use the ε-δ definition, justify intermediate and extreme value theorems, and demonstrate uniform continuity.
- Proof and Apply Differentiation: Prove mean value theorems, apply L' Hospital's rules, and justify higher-order derivatives and Taylor's theorem.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Real number system** Upper and lower bounds, LUB property and its applications: Archimedean property, greatest integer function, density of rationals, nth root of a non-negative real number, the nested interval theorem. (Kumar *et. al.*: Ch. 1)	10	0	-	10	14
II	**Real sequences** Sequences and their convergence, Cauchy sequences, monotone sequences, sandwich lemma, sequences diverging to $\pm\infty$, subsequences, sequences defined recursively. (Kumar *et. al.*: Ch. 2)	15	0	-	15	13
III	**Infinite series** Infinite series and their convergence, comparison and limit comparison tests for convergence, rearrangements of terms in an Infinite Series. (Kumar *et. al.*: Ch. 3)	10	0	-	10	13
IV	**Continuity** Continuous functions, ε-δ definition of continuity, intermediate value theorem, extreme value theorem, monotone functions, limits, uniform continuity. (Kumar *et. al.*: Ch. 4)	15			15	15
V	**Differentiation** Differentiable functions, mean value theorems, L'Hospital's rules, higher-order Derivatives, Taylor's theorem, convex functions, Cauchy's form of the Remainder. (Kumar *et. al.*: Ch. 5)	10			10	15
	Total	**60**	**0**		**60**	**70**

Where, L: Lectures T: Tutorials P: Practical

Recommended Text Books:

1. Ajit Kumar & S. Kumaresan, *A basic Course in Real Analysis*, CRC Press, 2014.

Reference Books:

1. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, Fourth Edition, Wiley, 2011.
2. Amber Habib, *Calculus*, CUP, 2022.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)
3rd SEMESTER

Title of the Course	**Linear Algebra I**
Course Code	**MATM 302**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=0,P=1)**
Distribution of Marks	**52(TH)+18(PR)+30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Solve Linear Systems: Apply Gaussian elimination, row-echelon forms, and elementary operations to solve systems of linear equations.
- Demonstrate Matrix Algebra: Perform matrix operations, analyze linear transformations, compute inverses, and use LU decomposition.
- Analyze Determinants: Compute determinants, apply Cramer's rule, and evaluate eigenvalues, eigenvectors, and diagonalization.
- Explain Vector Spaces: Define subspaces, determine basis and dimension, apply the rank-nullity theorem, and perform change of basis and diagonalization.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Systems of Linear Equations** Examples leading to linear systems, visualizing systems of 2 or 3 variables, augmented matrix, elementary operations, row-echelon form, reduced row-echelon form, Gaussian elimination, homogeneous systems.	10	0	10	20	12
II	**Matrix Algebra** Vectors and matrices, matrix operations, matrix form of a linear system, matrices as linear transformations, geometric transformations (rotation, reflection, shear), composition and matrix multiplication, inverse of a matrix, equivalent conditions for invertibility, elementary matrices, LU decomposition. (Nicholson: Ch 2, 4.5)	10	0	10	20	12
III	**Determinants** Determinant via cofactors, determinants and row operations, determinant and matrix product, determinant and volume, determinant and matrix inverse, Cramer's rule, eigenvalues and eigenvectors, characteristic polynomial, diagonalization(Nicholson: Ch 3, Kumaresan 6.1 & 6.2)	10	0	10	20	13
IV	**Vector Space Structure of R^n** Subspaces of Euclidean space, spanning sets, linear independence, equivalence of invertibility of a matrix to independence of its rows and columns, basis and dimension, rank of a matrix, rank-nullity theorem, similarity and diagonalization, change of basis. (Nicholson: Ch 5, 9.1)	15	0	0	15	15
	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook:

1. W. Keith Nicholson, *Linear Algebra with Applications*, Open edition, Lyryx Learning, 2018. https://lyryx.com/wp-content/uploads/2018/01/Nicholson-OpenLAWA-2018A.pdf

Reference Books:

1. Robert Beezer, *A First Course in Linear Algebra*, 2015. http://linear.ups.edu/html/fcla.html
2. Jim Hefferon, *Linear Algebra*, 4th edition, Orthogonal Publishing L3C, 2020. https://hefferon.net/linearalgebra/
3. S. Kumaresan, *Linear Algebra – A Geometric Approach*, Prentice Hall India, 2000.

Online Resources:

1. Gilbert Strang, *Linear Algebra*, MIT OCW. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/

List of Practical (using any software) Marks: 18, Contact hrs: 30

1. Study the convergence of sequences through plotting.
2. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
3. Cauchy's root test by plotting nth roots.
4. Ratio test by plotting the ratio of nth and (n+1) th term.
5. Computation of rank of a matrix.
6. Solving the system of homogeneous and non-homogeneous linear equations.
7. Computation of inverse of a matrix.
8. Finding the nth derivatives of functions without Leibnitz theorem.
9. Finding the nth derivatives of functions with Leibnitz's theorem.
10. Partial Differentiation of some standard functions and Jacobians.
11. Verification of Euler's theorem with examples.
12. Finding the Taylor's and Maclaurin's expansion of the given function.
13. Indeterminate forms and evaluation of limits using L-Hospital's rule.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)
3rd SEMESTER

Title of the Course	**Linear Algebra I**
Course Code	**MATN 301**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=0,P=1)**
Distribution of Marks	**52(TH)+18(PR)+30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Solve Linear Systems: Apply Gaussian elimination, row-echelon forms, and elementary operations to solve systems of linear equations.
- Demonstrate Matrix Algebra: Perform matrix operations, analyze linear transformations, compute inverses, and use LU decomposition.
- Analyze Determinants: Compute determinants, apply Cramer's rule, and evaluate eigenvalues, eigenvectors, and diagonalization.
- Explain Vector Spaces: Define subspaces, determine basis and dimension, apply the rank-nullity theorem, and perform change of basis and diagonalization.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Systems of Linear Equations** Examples leading to linear systems, visualizing systems of 2 or 3 variables, augmented matrix, elementary operations, row-echelon form, reduced row-echelon form, Gaussian elimination, homogeneous systems.	10	0	10	20	12
II	**Matrix Algebra** Vectors and matrices, matrix operations, matrix form of a linear system, matrices as linear transformations, geometric transformations (rotation, reflection, shear), composition and matrix multiplication, inverse of a matrix, equivalent conditions for invertibility, elementary matrices, LU decomposition. (Nicholson: Ch 2, 4.5)	10	0	10	20	12
III	**Determinants** Determinant via cofactors, determinants and row operations, determinant and matrix product, determinant and volume, determinant and matrix inverse, Cramer's rule, eigenvalues and eigenvectors, characteristic polynomial, diagonalization(Nicholson: Ch 3, Kumaresan 6.1 & 6.2)	10	0	10	20	13
IV	**Vector Space Structure of R^n** Subspaces of Euclidean space, spanning sets, linear independence, equivalence of invertibility of a matrix to independence of its rows and columns, basis and dimension, rank of a matrix, rank-nullity theorem, similarity and diagonalization, change of basis. (Nicholson: Ch 5, 9.1)	15	0	0	15	15
	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook:

1. W. Keith Nicholson, *Linear Algebra with Applications*, Open edition, Lyryx Learning, 2018. https://lyryx.com/wp-content/uploads/2018/01/Nicholson-OpenLAWA-2018A.pdf

Reference Books:

1. Robert Beezer, *A First Course in Linear Algebra*, 2015. http://linear.ups.edu/html/fcla.html
2. Jim Hefferon, *Linear Algebra*, 4th edition, Orthogonal Publishing L3C, 2020. https://hefferon.net/linearalgebra/
3. S. Kumaresan, *Linear Algebra – A Geometric Approach*, Prentice Hall India, 2000.

Online Resources:

1. Gilbert Strang, *Linear Algebra*, MIT OCW. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/

List of Practical (using any software) Marks: 18, Contact hrs: 30

1. Study the convergence of sequences through plotting.
2. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
3. Cauchy's root test by plotting nth roots.
4. Ratio test by plotting the ratio of nth and (n+1) th term.
5. Computation of rank of a matrix.
6. Solving the system of homogeneous and non- homogeneous linear equations.
7. Computation of inverse of a matrix.
8. Finding the nth derivatives of functions without Leibnitz theorem.
9. Finding the nth derivatives of functions with Leibnitz's theorem.
10. Partial Differentiation of some standard functions and Jacobians.
11. Verification of Euler's theorem with examples.
12. Finding the Taylor's and Maclaurin's expansion of the given function.
13. Indeterminate forms and evaluation of limits using L-Hospital's rule.

B.A/B.SC.IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**Real Analysis-II**
Course Code	**MATM 401**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70(TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Apply Riemann Integration: Calculate Darboux integrability, use fundamental theorems of calculus, and evaluate improper integrals.
- Analyze Function Convergence: Assess pointwise and uniform convergence, and derive results using power series, Taylor series, and Weierstrass Approximation Theorem.
- Explore Metric Spaces: Define and characterize open and closed sets, limit points, and convergence; demonstrate completeness, compactness, and connectedness.
-

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Riemann integration** Darboux integrability, fundamental theorems of calculus, mean value theorems for integrals, integral form of the remainder, Riemann's original definition, sum of an infinite series as an integral, logarithmic and exponential functions, improper Riemann integrals.. (Kumar *et. al.*: Ch. X)	15	5	0	20	25
II	**Sequences and series of functions** Pointwise convergence, uniform convergence, consequences of uniform convergence, Power Series, Taylor Series of a Smooth Function, Binomial Series, Weierstrass Approximation Theorem. (Kumar *et. al.*: Ch. X)	12	5	0	17	20
III	**Metric spaces** Definition and examples, open balls and open sets, closed sets, limit points, cluster points, closure of a set, dense sets, convergence of sequences, continuity: sequential, \epsilon-\delta method, by open sets. Completeness, compactness and connectedness. (Simmons)	18	5	0	23	25
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Textbooks:

1. Ajit Kumar and S. Kumaresan, *A basic Course in Real Analysis*, CRC Press, 2014.
2. George Finlay Simmons, *Intro Topology & Modern Analysis*, Krieger Publishing Company,2003

Supporting Texts:

1. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, Fourth Edition, Wiley, 2011.
2. T. M. Apostol, *Mathematical Analysis*, Narosa, 1985.
3. S. Kumaresan, *Topology of Metric Spaces*, Narosa, 2005.

B.A/B.SC.IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**Abstract Algebra-I**
Course Code	**MATM 402**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70(TH) + 30(IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Justify Basic Arithmetic Principles: Explain the well-ordering principle, divisibility properties, GCD, LCM, Euclidean algorithm, prime numbers, and fundamental theorem of arithmetic.
- Analyze Group Theory: Distinguish and apply properties of groups, subgroups, cyclic groups, permutation and matrix groups; justify Lagrange's theorem and group homomorphisms.
- Demonstrate Ring Theory: Define and exemplify rings, integral domains, fields, and ideals; analyze polynomial and matrix rings, and justify homomorphism theorems.
- Evaluate Factorization in Integral Domains: Analyze divisibility, irreducible, primes, Euclidean domains, PIDs, UFDs, and construct fields of quotients.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Basic Arithmetic** Well-ordering principle and its equivalent formulations. Divisibility properties for integers. Division algorithm, GCD, LCM, Euclidean algorithm. Irreducible and Prime numbers, Euclid's Lemma, Fundamental Theorem of Arithmetic. Congruences. Chinese remainder theorem.(Burton)	10	4	0	14	17
II	**Groups** Definition of a group. Permutation groups. Matrix groups, Subgroups, Lagrange's Theorem, Theorems of Fermat, Euler and Wilson. Cyclic groups. Group homomorphisms. Homomorphism theorems.(Gallian)	10	4	0	14	17
III	**Rings** Definition of a rings, Integral domains and fields. Division rings, Finite integral domain is a field. Ideals. Prime and Maximal ideals, Polynomial rings, Matrix rings, Homomorphism of rings. Quotient rings.(Gallian)	13	3	0	16	18
IV	**Factorisation in Integral domains** Divisibility in Integral domains. Irreducibles and Primes, Construction of Field of quotients, Euclidean domains, PIDs and UFDs.(Gallian)	12	4	0	16	18
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P:Practicals

Recommended Texts Books :

1. David Burton, *Elementary Number Theory*, 7th Ed., 2011, The McGraw-Hill Companies, Inc., New York, USA.
2. Joseph A.Gallian: *Contemporary Abstract Algebra*, 7th Ed., 2010, Brooks/Cole, Cengage Learning, Belmont, CA, USA

Reference Books:

1. N. Jacobson: Basic Algebra, Vols. I & II, Hindustan Pub. Co., 1984.
2. John B. Fraleigh: *A First Course in Abstract Algebra*, 7th Ed., 2014, Pearson Education Limited, Edinburgh, England

B.A/B.SC.IN MATHEMATICS PROGRAMME(NEP)

4th SEMESTER

Title of the Course	**Linear Algebra-II**
Course Code	**MATM 403**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Determine and compute the basis and dimension of vector spaces and subspaces. Apply these concepts to solve problems involving the representation of vectors in different bases.
- Represent linear transformations with matrices and perform operations such as matrix multiplication to understand their effect on vector spaces.
- Apply linear transformations to solve real-world problems, including Geometry of some of linear transformations in the plane.
- Define and compute eigenvalues and eigenvectors of a matrix. Demonstrate their significance in the context of linear transformations and matrix theory and the Diagonalization process.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Vector Space** Definition of vector space and examples, Subspaces, Linear span, Linear dependence and independence, Basis and dimension, coordinates, Matrix of change of basis, Sum of subspaces, subspaces associated to a matrix. (Nicholson: Ch 6, Kumaresan: Ch 2)	10	3	0	13	15
II	**Linear Transformations** Definitions and Examples, Kernel and Image of a Linear Transformation, isomorphisms, Dimension theorem (rank-nullity theorem), Applications of rank-nullity theorem, Matrix of a linear transformation, Compositions and matrix of composition, similarity of matrices, Geometry of some of linear transformations in the plane (Nicholson: Ch 7, Kumaresan Ch. 4)	14	3	0	17	20
III	**Eigenvalues and Diagonalization:** Definition of Eigenvalues and Eigenvectors of linear operators and matrices, Geometric Interpretation, Eigenspaces, Diagonalizability, Invariant Subspaces and Cayley Hamilton Theorem. (Friedberg, Ch. 5, Kumaresan 7.)	10	3	0	13	15
IV	**Inner Product Spaces** Dot Product in R^n, Inner product spaces, norm of vectors, Cauchy-Schwarz inequality and applications, orthogonality, Gram-Schmidt orthogonalization process and QR factorization, Orthogonal linear operators, Orthogonal complements, Orthogonal Projection, Reflection through planes. Diagonalization of Symmetric Matrices. (Nicholson: Ch 8 & 10, Kumaresan Ch. 5)	14	3	0	17	20

	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. W. Keith Nicholson, *Linear Algebra with Applications*, Open edition, Lyryx Learning, 2018. https://lyryx.com/wp-content/uploads/2018/01/Nicholson-OpenLAWA-2018A.pdf
2. Stephen Friedberg, Arnold J. Insel and Lawrence E. Spence, *Linear Algebra* 5th Ed. Pearson
3. S. Kumaresan, *Linear Algebra – A Geometric Approach*, Prentice Hall India, 2000.

Reference Books:

1. Jim DeFranza and Daniel Gagliardi, *Introduction to Linear Algebra with Applications*, Tata McGraw Hill, 2017.
2. Jim Hefferon, *Linear Algebra*, 4th edition, Orthogonal Publishing L3C, 2020. https://hefferon.net/linearalgebra/.
3. David C. Lay, *Linear Algebra and its Applications*, 4rd edition, Pearson India, 2002.

Online Resources:

1. Gilbert Strang, *Linear Algebra*, MIT OCW. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/
2. NPTEL Course: Computational Mathematics with Sage Math (https://nptel.ac.in/courses/111106149)

B.A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**ODE**
Course Code	**MATM 404**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Use the techniques to solve differential equations.
- Apply these techniques in various mathematical models used in real life problems.
- Develop the concept of Differential Equations, and develop the skill to solve differential equation of different order.
- Finding solutions of linear homogeneous second order ODE by power series.
- Fundamental concepts of Laplace transforms in solving non-homogeneous equations when non-homogeneous function is either discontinuous or zero for large time.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**First Order Differential Equations** Simple first order differential equations and methods to solve them. (Section 1.1-1.2 of Martin Braun.) Separable equations. (Section 1.3 of Martin Braun) Orthogonal trajectories. Exact differential equations. Integrating factors. Methods of solving some non-exact differential equations. (Section 1.9 of Martin Braun) Picard's theorem on existence and uniqueness of solutions of first order ODE. Only statement, proof need not be given. Illustrate the result with some examples. (Section 1.10 of Martin Braun) Numerical approximations: Euler's method, three term Taylor's method, Improved Euler's method. Illustration of the methods with examples. (Section 1.13 of Martin Braun) Some of the applications: The Van meergen art forgeries; population models; spread of technological innovations; atomic waste disposal problem; mixing problems. (We may make some choices of applications and illustrate the methods learned in first order ODE)	10	3	0	13	15
II	**Second order linear ODE** Introduction. Statement of existence and uniqueness theorem for linear homogeneous second order ODE. Properties of the solutions of second order linear homogeneous second order ODE; fundamental set of solutions, Wronskian of two solutions. The relation between the Wronskian and the coefficients of the differential equations. (Section 2.1 of Martin Braun) Constant coefficient linear homogeneous second order ODE. The solutions when the roots of the characteristic equation are complex, distinct real roots, equal real roots. Method of reduction of order.	10	3	0	13	15

III	**Non homogeneous linear second order ODE** Non-homogeneous linear second order ODEs. Method of variation of parameters. Method of judicious guessing in some special cases. (Sections 2.3-2.5 of Martin Braun)	10	3	0	13	15
IV	**Power Series Solution** Finding solutions of linear homogeneous second order ODE by power series. Existence theorem statement. (Proof need not be given) (Section 2.8 of Martin Braun), Singular points. Euler's equations and its solution. (This equation and the method of solving is the prelude to Frobenius method.) Regular singular points. Frobenius method. Indicial equations.	10	3	0	13	15
V	**Laplace Transform** Laplace Transform: Definition of Laplace transform, Existence theorem for Laplace transform. Linearity property of Laplace transform, Laplace transform of some elementary functions. (algebraic functions, trigonometric functions, exponential functions, hyperbolic functions). First Shifting theorem, Second shifting theorem, Change of scale property, Laplace transform of derivatives, Laplace transform of Integrals, inverse Laplace transformations, use of Laplace transformations solving ODE. . (Sections 2.9–2.11 of Martin Braun)	5	3	0	8	10
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. M. Braun, *Differential Equations and their applications*, Springer. Texts in Applied Mathematics Series.
2. M. B. Finan, https://faculty.atu.edu/mfinan/3243/DFQ2015.pdf.

Reference Books

1. William F. Trench, http://ramanujan.math.trinity.edu/wtrench/texts/TRENCH_ DIFF_EQNS_I.PDF.

B.A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

4th SEMESTER

Title of the Course	**ODE**
Course Code	**MATN 401**
Nature of the Course	**MAJOR**
Total Credits	**04(L=3,T=1,P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Use the techniques to solve differential equations.
- Apply these techniques in various mathematical models used in real life problems.
- Develop the concept of Differential Equations, and develop the skill to solve differential equation of different order.
- Finding solutions of linear homogeneous second order ODE by power series.
- Fundamental concepts of Laplace transforms in solving non-homogeneous equations when non-homogeneous function is either discontinuous or zero for large time.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**First Order Differential Equations** Simple first order differential equations and methods to solve them. (Section 1.1-1.2 of Martin Braun.) Separable equations. (Section 1.3 of Martin Braun) Orthogonal trajectories. Exact differential equations. Integrating factors. Methods of solving some non-exact differential equations. (Section 1.9 of Martin Braun) Picard's theorem on existence and uniqueness of solutions of first order ODE. Only statement, proof need not be given. Illustrate the result with some examples. (Section 1.10 of Martin Braun) Numerical approximations: Euler's method, three term Taylor's method, Improved Euler's method. Illustration of the methods with examples. (Section 1.13 of Martin Braun) Some of the applications: The Van meergen art forgeries; population models; spread of technological innovations; atomic waste disposal problem; mixing problems. (We may make some choices of applications and illustrate the methods learned in first order ODE)	10	3	0	13	15
II	**Second order linear ODE** Introduction. Statement of existence and uniqueness theorem for linear homogeneous second order ODE. Properties of the solutions of second order linear homogeneous second order ODE; fundamental set of solutions, Wronskian of two solutions. The relation between the Wronskian and the coefficients of the differential equations. (Section 2.1 of Martin Braun) Constant coefficient linear homogeneous second order ODE. The solutions when the roots of the characteristic equation are complex, distinct real roots, equal real roots. Method of reduction of order.	10	3	0	13	15
III	**Non homogeneous linear second order ODE** Non-homogeneous linear second order ODEs. Method of variation of parameters. Method of judicious guessing in some special cases. (Sections 2.3-2.5 of Martin Braun)	10	3	0	13	15

IV	**Power Series Solution** Finding solutions of linear homogeneous second order ODE by power series. Existence theorem statement. (Proof need not be given) (Section 2.8 of Martin Braun), Singular points. Euler's equations and its solution. (This equation and the method of solving is the prelude to Frobenius method.) Regular singular points. Frobenius method. Indicial equations.	10	3	0	13	15
V	**Laplace Transform** Laplace Transform: Definition of Laplace transform, Existence theorem for Laplace transform. Linearity property of Laplace transform, Laplace transform of some elementary functions. (algebraic functions, trigonometric functions, exponential functions, hyperbolic functions). First Shifting theorem, Second shifting theorem, Change of scale property, Laplace transform of derivatives, Laplace transform of Integrals, inverse Laplace transformations, use of Laplace transformations solving ODE. . (Sections 2.9–2.11 of Martin Braun)	5	3	0	8	10
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. M. Braun, *Differential Equations and their applications*, Springer. Texts in Applied Mathematics Series.
2. M. B. Finan, https://faculty.atu.edu/mfinan/3243/DFQ2015.pdf.

Reference Books

1. William F. Trench, http://ramanujan.math.trinity.edu/wtrench/texts/TRENCH_DIFF_EQNS_I.PDF.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Introduction to Probability**
Course Code	**MATM 501**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the foundational principles of probability theory.
- Demonstrate the use of discrete random variables and their probability distributions.
- Apply the concepts of probability mass functions (PMFs) and cumulative distribution functions (CDFs).
- Define and distinguish between continuous random variables and their probability distributions.
- Explain the concept of joint probability distributions for two or more random variables.

Overview:

The lectures should integrate simulations using mathematical software/languages such as R/ Python/ Matlab. Chapters 12 and 13 of [Pishro-Nik] provide an introduction to simulation using Matlab and R. [Huber] gives many examples of using R in teaching probability.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Basic Concepts** Interpretations of probability, random experiments, probability measure, discrete and continuous probability models, conditional probability, independent events, total probability, Bayes' rule, conditional independence, sampling with or without replacement, ordered and unordered sampling. [Pishro-Nik, Ch 1 and 2]	9	3		12	13
II	**Discrete Random Variables** Discrete random variables, probability mass function, independence, standard distributions (Bernoulli, geometric, binomial, negative binomial, hypergeometric, Poisson), cumulative distribution function, expectation, functions of random variables, variance. [Pishro-Nik, Ch 3]	9	3		12	15
III	**Continuous Random Variables** Continuous random variables, probability density function, expectation, functions of random variables, variance, standard distributions (uniform, exponential, normal, gamma). [Pishro-Nik, Ch 4 except 4.3]	9	3		12	13
IV	**Joint Distributions** Jointly distributed discrete random variables, joint probability mass function, jointly distributed continuous random variables, joint probability density function, joint cumulative distribution function, conditioning and independence, functions of two random variables, conditional expectation and variance, covariance and correlation, binormal distribution, multiple jointly distributed random variables. [Pishro-Nik, Ch 5 and	9	3		12	14

	6.1.1, 6.1.2]					
V	**Limit Theorems** Markov and Chebyshev inequalities, sample mean, (Weak) law of large numbers, Central Limit Theorem (with applications but without proof). [Pishro-Nik, 6.2.0 to 6.2.2 and 7.1.0, 7.1.1]	9	3		12	15
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbooks:

1. H. Pishro-Nik, *Introduction to Probability, Statistics, and Random Processes*, Kappa Research LLC, 2014. https://www.probabilitycourse.com .
2. Mark Huber, *Probability: Lectures and Labs*. https://www.markhuberdatascience.org/book.

Reference Books:

1. George Casella, Roger L. Berger, *Statistical Inference*, Cengage, 2007.
2. John A. Rice, *Mathematical Statistics and Data Analysis*, 3rd edition, Cengage, 2013.
3. Sheldon Ross, *A First Course in Probability*, 9th edition, Pearson Education India, 2013.

Online Resources:

1. Dimitri P. Bertsekas and John N. Tsitsiklis, *Introduction to Probability*, MIT OCW. https://ocw.mit.edu/courses/res-6-012-introduction-to-probability-spring-2018/
2. Department of Statistics at Penn State, *STAT414: Introduction to Probability Theory*. https://online.stat.psu.edu/stat414/

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Multivariable Calculus**
Course Code	**MATM 502**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcome: Students will be able to

- Explain the concepts of functions of several variables, related theorems and properties.
- Apply line, double and triple integrals in present scenarios, utilize key theorems in vector calculus.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Functions of several variables, limit and continuity of functions of two variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl.	12	4	0	16	20
II	Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates.	10	4	0	14	15
III	Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path.	12	4	0	16	20
IV	Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.	11	3	0	14	15
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. J. Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

Reference Books:

1. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi,2007.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Abstract Algebra II**
Course Code	**MATM 503**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain and demonstrate the structure-preserving maps between groups and their consequences.
- Demonstrate and define Constructible Numbers, Trisection of angles, Squaring a circle and Doubling a cube.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Groups Actions** Group Actions, Orbits, Isotropy subgroups, Class equations, Transitive actions, Characterisation of transitive actions, Sylow theorems, Simple groups, Solvable and Nilpotent groups. Dihedral groups. [Fraleigh;Ch.3 and Ch.7]	12	04	0	16	16
II	**Polynomials** Divisibility properties of Polynomials. Division algorithm and consequences, Irreducible and prime polynomials. Theorem of Gauss. Eisenstein's Irreducibility Criterion. Linear and Polynomial congruences. Zeroes of Polynomials. Symmetric polynomials, Fundamental theorem of algebra. [Jacobson;Ch.16 and Ch.17]	10	04	0	14	15
III	**Field Extensions** Finite field extensions, Zeros of an irreducible polynomial, Kronecker's theorem, Algebraically closed fields, Construction of an algebraic closure, Construction of Finite fields. Automorphisms of field extensions. Examples, Roots of unity, Cyclotomic field extensions. [Fraleigh ; Ch. 6 and Ch.10]	15	03	0	18	24
IV	**Historical Discussion of Geometric Constructions** Constructible Numbers, Trisection of angles, Squaring a circle and Doubling a cube. *(Constructible regular polygons, Gauss-Wantzel Theorem (Statement only.))* [Gallian; Ch. 22]	8	04	0	12	15
	Total	**45**	**15**	**0**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., 2014, Pearson Education Limited, Edinburgh, England.
2. Joseph A. Gallian, *Contemporary Abstract Algebra*, 7th Ed., 2010, Brooks/Cole, Cengage Learning, Belmont, CA, USA .
3. N. Jacobson, *Basic Algebra*, Vols. I & II, Hindustan Pub. Co., 1984.

Reference Books:

1. Joseph . Rotmann, *Galois Theory*, 2nd Ed. 1998, Universitext Springer Verlag.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Numerical Analysis**
Course Code	**MATM 504**
Nature of the Course	**MAJOR**
Total Credits	**04 (L=3, T=0, P=1)**
Distribution of Marks	**52 (TH)+18(PR)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the principles behind solving nonlinear equations and apply methods such as Bisection, Newton-Raphson, and Secant methods; analyze the convergence and stability of these methods.
- Demonstrate strong problem-solving and analytical skills specific to numerical analysis.
- Apply software and programming languages (e.g., MATLAB, Python) to implement numerical methods effectively.

Overview: An introduction to Numerical Methods that focuses on Solutions to Nonlinear, Systems of Linear and Nonlinear Equations, Interpolation, Approximation, Numerical Differentiation, and Integration, with an emphasis on Approximation Techniques. The course will also take up applications to topics in Chemical, Physical, Environmental, Electronics, Economics, and Diverse Areas of Engineering.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Error Analysis** Introduction to Error Analysis and computer arithmetic (Douglas: Ch 1)	5	0	0	5	5
II	**Solutions of Nonlinear Equations in One Variable** The Bisection Method, The Method of False Position, Fixed-Point Iteration, Newton's Method, Secant Method. Applications: Ideal and Non ideal Gas Laws, Greenhouse Gases and Rainwater, and Design of an Electric Circuit. (Douglas: Ch 1,2: Chapra: Ch 8)	10	0	8	18	12
III	**Interpolation** Lagrange's Formula, Newton's Divided Difference Formula, Newton's Forward and Backward Difference Formula and Stirling's Formula. Applications: Temperature at Various Points on a Heated Plate, and Sea level Concentration of Dissolved Oxygen for Fresh Water. (Douglas: Ch 3: Chapra: Ch 18)	10	0	8	18	12
IV	**Approximation** Linear Least Square Approximation, Polynomial Least Square Approximation, Pade Approximation, and the Power Method. Applications: Linear Regression and Population Models, Tensile Strength of Plastic at a time t, and The Volume of Super-Heated Steam at Various Temperatures. (Douglas: Ch 8,9: Chapra: Ch 20)	10	0	6	16	11
V	**Numerical Differentiation and Integration** Three Point Formula, Five Point Formula, Second Derivative Midpoint Formula, Trapezoidal Rule, Simpson's 1/3 & 3/8 Rule, Romberg Integration. Applications: Velocity and Acceleration of a Jet fighter's position on an Aircraft, Integration to Determine the Total Quantity of Heat, and Effective Force on the Mast of a Racing Sailboat. (Douglas: Ch 4: Chapra: Ch 24)	10	0	8	18	12

	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook(s):

1. Richard L. Burden, J. Douglas Faires, *Numerical Analysis*, Ninth edition, Cengage Learning, 2010. https://faculty.ksu.edu.sa/sites/default/files/numerical_analysis_9th.pdf.
2. Steven C. Chapra, Raymond P. Canale, J. Douglas Faires, *Numerical Methods for Engineers*, Seventh edition, McGraw-Hill Education, 2015. https://www.gdcboysang.ac.in/About/Droid/uploads/Numerical%20Methods.pdf
3. Mathews and Fink, Numerical Methods using MatLab.

Reference Books:

1. S. D. Conte, C. de Boor, *Elementary Numerical Analysis-An Algorithmic Approach*, McGraw-Hill.
2. Laurene V. Fausett, *Applied Numerical Analysis using MATLAB*, Pearson Education.
3. S.S. Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd.

List of Practicals (using any software) Marks: 18 Contact hrs. 30

1. Find the root of an equation using Bisection Method.
2. Find the root of an equation using Newton Raphson Method.
3. Find the root of an equation using Secant Method.
4. Find the root of an equation using Regula Falsi Method.
5. Solve a system of equation using LU decomposition Method.
6. Solve a system of equation using Gauss-Jacobi Method.
7. Solve a system of equation using SOR Method or Gauss-Siedel Method.
8. Interpolate the data using Lagrange Interpolation or Newton Interpolation.
9. Apply Numerical integration by Simpson's rule.
10. Apply Numerical integration by Trapezoidal rule.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

5th SEMESTER

Title of the Course	**Numerical Analysis**
Course Code	**MATN 501**
Nature of the Course	**MINOR**
Total Credits	**04 (L=3, T=0, P=1)**
Distribution of Marks	**52 (TH)+18(PR)+30 (IA)=100**

Course Learning Outcomes: This course will enable the students to:

- Explain the principles behind solving nonlinear equations and apply methods such as Bisection, Newton-Raphson, and Secant methods; analyze the convergence and stability of these methods.
- Demonstrate strong problem-solving and analytical skills specific to numerical analysis.
- Apply software and programming languages (e.g., MATLAB, Python) to implement numerical methods effectively.

Overview: An introduction to Numerical Methods that focuses on Solutions to Nonlinear, Systems of Linear and Nonlinear Equations, Interpolation, Approximation, Numerical Differentiation, and Integration, with an emphasis on Approximation Techniques. The course will also take up applications to topics in Chemical, Physical, Environmental, Electronics, Economics, and Diverse Areas of Engineering.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Error Analysis** Introduction to Error Analysis and computer arithmetic (Douglas: Ch 1)	5	0	0	5	5
II	**Solutions of Nonlinear Equations in One Variable** The Bisection Method, The Method of False Position, Fixed-Point Iteration, Newton's Method, Secant Method. Applications: Ideal and Non ideal Gas Laws, Greenhouse Gases and Rainwater, and Design of an Electric Circuit. (Douglas: Ch 1,2: Chapra: Ch 8)	10	0	8	18	12
III	**Interpolation** Lagrange's Formula, Newton's Divided Difference Formula, Newton's Forward and Backward Difference Formula and Stirling's Formula. Applications: Temperature at Various Points on a Heated Plate, and Sea level Concentration of Dissolved Oxygen for Fresh Water. (Douglas: Ch 3: Chapra: Ch 18)	10	0	8	18	12
IV	**Approximation** Linear Least Square Approximation, Polynomial Least Square Approximation, Pade Approximation, and the Power Method. Applications: Linear Regression and Population Models, Tensile Strength of Plastic at a time t, and The Volume of Super-Heated Steam at Various Temperatures. (Douglas: Ch 8,9: Chapra: Ch 20)	10	0	6	16	11
V	**Numerical Differentiation and Integration** Three Point Formula, Five Point Formula, Second Derivative Midpoint Formula, Trapezoidal Rule, Simpson's 1/3 & 3/8 Rule, Romberg Integration. Applications: Velocity and Acceleration of a Jet fighter's position on an Aircraft,	10	0	8	18	12

	Integration to Determine the Total Quantity of Heat, and Effective Force on the Mast of a Racing Sailboat. (Douglas: Ch 4: Chapra: Ch 24)					
	Total	**45**	**0**	**30**	**75**	**52**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Textbook(s):

1. Richard L. Burden, J. Douglas Faires, *Numerical Analysis*, Ninth edition, Cengage Learning, 2010. https://faculty.ksu.edu.sa/sites/default/files/numerical_analysis_9th.pdf
2. Steven C. Chapra, Raymond P. Canale, J. Douglas Faires, *Numerical Methods for Engineers*, Seventh edition, McGraw-Hill Education, 2015. https://www.gdcboysang.ac.in/About/Droid/uploads/Numerical%20Methods.pdf
3. Mathews and Fink, Numerical Methods using MatLab

Reference Books:

1. S. D. Conte, C. de Boor, *Elementary Numerical Analysis-An Algorithmic Approach*, McGraw-Hill.
2. Laurene V. Fausett, *Applied Numerical Analysis using MATLAB*, Pearson Education.
3. S.S. Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd.

List of Practicals (using any software) Marks: 18 Contact hrs. 30

1. Find the root of an equation using Bisection Method.
2. Find the root of an equation using Newton Raphson Method.
3. Find the root of an equation using Secant Method.
4. Find the root of an equation using Regula Falsi Method.
5. Solve a system of equation using LU decomposition Method.
6. Solve a system of equation using Gauss-Jacobi Method.
7. Solve a system of equation using SOR Method or Gauss-Siedel Method.
8. Interpolate the data using Lagrange Interpolation or Newton Interpolation.
9. Apply Numerical integration by Simpson's rule.
10. Apply Numerical integration by Trapezoidal rule.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**PDE**
Course Code	**MATM 601**
Nature of the course	**Major**
Total Credit	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)**

Course Learning Outcomes: This course will enable the students to:

- Explain the basic concepts of partial differential equations and their significance in various applications.
- Analyze the concept of differential equations and develop the skill to solve differential equations of different orders.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**First Order Partial Differential Equations:** Basics of PDE, an introduction with some examples with an illustration of solving them. (Chapter 1, Sections 1.1-1.7 of [1] and Section 1 of [2]) First order PDE and their classification with examples. Some simple examples and solutions. (Chapter 2, Section 2.1 of [1] and Section 5 of [2]) Quick review of several variable calculus; Gradient vector, Directional derivative, chain rule. Solvability of semi linear, quasi linear and linear equations. Method of characteristics. Lagrange's method. (First order equations involve geometric ideas. (Chapter 2, Sections 2.1-2.5 of [1] and Sections 7, 8, 9 and 10 of [2]) Cauchy problem for first order quasi linear problem. We may explain the theorem and skip the proof.	15	05	-	20	24
II	**Second order PDEs** Introduction. General form of second order PDE. Classification by characteristics in to three different types, namely hyperbolic, elliptic and parabolic. Typical examples of these three types of PDEs. The canonical forms and general solutions. (Chapter 3 of [1] and Section 11 of [2]) Wave equation, One dimensional homogeneous wave equation and general solution. The initial value problem and d'Alembert's formula for the solution and applications. (Chapter 4, Sections 4.1–4.5 and 4.6 of [1] Section [12] of [2]) **Initial/Boundary value problems.** Oscillations of strings of finite length. Non-homogeneous wave equation. Duhamel's principle. Chapter 4, Sections 4.5 and 4.6 of [1]	15	05	-	20	23
III	**Laplace Equation** Laplace equation on rectangular domains and circular domains. Separation of variables. Solutions of boundary value problems with Dirichlet and Neumann boundary conditions. Eigen functions and eigenvalue expansions of Laplace equation in rectangles and circular domains.	15	05	-	20	23

	Solutions of the Laplace equation for unit ball in R3 with special boundary condition. Solution of the Laplace equation on the exterior of the unit ball in R3 with special boundary condition. Uniqueness and maximum principle for Dirichlet and Neumann problem for rectangular and circular domains. (Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, 7.7 and 7.8 of [1], Sections 19 and 20 of [2])					
	Total	**45**	**15**	**-**	**60**	**70**

Recommended Text Books:

1. Y. Pinchover, J. Rubenstein, An Introduction to Partial Differential Equations, Cambridge University Press, 2005.
2. Marcel B Finan, A First Course in Quasi-Linear Partial Differential Equations for Physical Sciences and Engineering. https://faculty.atu.edu/mfinan/4343/ PDEbook.pdf

Reference Books:

1. Walter A Strauss, Partial Differential Equations–An Introduction, John Wiley.
2. Erwin Kreyszig Advanced Engineering Mathematics, 10th Edition, John Wiley. http://www.wiley.com/college/kreyszig
3. Alan Jeffrey, Advanced Engineering Mathematics, Academic Press.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**Complex Analysis**
Course Code	**MATM 602**
Nature of the course	**Major**
Total Credit	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning outcomes: After going through this course the students will be able to describe:

- Explain the importance of differentiability and analyticity of complex functions and how they lead to the derivation of the Cauchy-Riemann equations.
- Apply Taylor and Laurent series expansions of analytic functions; classify the nature of singularities, poles, and residues, and utilize the Cauchy Residue theorem.
- Utilize problem-solving skills using the Residue theorem.
- Explain and analyze the properties of path integrals.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Field of Complex numbers** Polar form of a complex number. Metric properties; Topological notions; continuity, Non-existence of a continuous argument on C* (Lemma 4.3.7). convergence of sequences of series of complex numbers etc. A quick review (Chapters 1 and 2 of SK.) **Functions from R to C** Differentiation and integration of complex value functions of real variables; (Sections 5.1 and 6.1 of SK.)	9	3	-	12	14
II	**Holomorphic functions properties** Cauchy-Riemann equations, Sufficiency part of characterization of holomorphic functions in terms of CR equations. (Sections 5.3, 5.4 (only as much as required),5.5, and 5.7 of SK) **Power series** A quick review of infinite series, definition of a power series, radius of convergence, continuity and (term-wise) differentiability of a power series function in its disk of convergence. Definition of an analytic function. (Sections: 2.2. 2.3 and 5.5 of SK)	9	3	-	12	14
III	**Path Integrals properties** ML-Inequality, and its uses. Fundamental theorem of path integrals and its relation to existence of primitives (Sections 6.1, 6.2 and 6.3 of SK) **Cauchy Theory** Cauchy-Goursat theorem for triangles, Cauchy's theorem for star-shaped domains and their extensions. (Sections 7.1 and 7.3 of SK)	9	3	-	12	14
IV	**Cauchy Integral Formula and Properties of Holomorphic Functions** Winding Numbers (Section 10.1 of SK), Cauchy integral formula and its consequences: Holomorphic iff analytic, Cauchy estimates, Liouville's theorem. Fundamental theorem of algebra, Uniqueness theorem, maximum modulus and minimum modulus principles and open mapping theorem. (Chapter 8 of SK) **Isolated singularities via the limits** Cauchy integral formula for an annulus, Laurent series,	9	3	-	12	14

	characterization of singularities in terms of Laurent series.					
V	**Extended Complex Plane** Point at infinity, Riemann sphere, behaviour of functions at infinity, Fractional linear transformations. (Section 11.1 to 11.3 of SK) **Residue Theory** Residues and the residue theorem (Section 11.1). **Computation of real integrals using residue theorem:** One example in each of the types (Sections 15.1 and 15.2 of SK) Argument principle and Rouche's theorem.	9	3		12	14
	Total	45	15	-	60	70

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. S Kumaresan, *A Pathway to Complex Analysis*, Techno world, 2021.
2. J. Conway, *Functions of One Complex variable*, 2nd Edition, Springer International Edition, 1973

Reference Books:

1. J Bak and D.J. Newman, *Complex Analysis*, 2nd Edition, Springer-International Edition 1997
2. T.W. Gamelin, *Complex Analysis*, Springer-International Edition 2004.
   Videos: https:/youtube.com/kumarhcu, Playlist=Complex Analysis.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**Introduction to Statistics**
Course Code	**MATM 603**
Nature of the course	**Major**
Total Credit	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Explain sampling distributions and their relation to population distributions.
- Define point estimation and evaluate properties of point estimators such as unbiasedness, consistency, and efficiency.
- Apply interval estimation techniques and interpret confidence intervals in real-world data.
- Interpret hypothesis test results and make informed decisions based on statistical evidence.
- Utilize mathematical software/languages (R, Python, MATLAB) for calculations and simulations.

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	**Sampling Distributions** Moments, moment generating function (mgf), mgf's of standard distributions, mgf technique, random sample, sample mean, sample variance, standard error of the mean, large sample approximations, sampling from finite populations, chi-square distribution, t distribution, F distribution. ([1] 4.3, 4.5, 8.1 to 8.6)	9	03	-	12	14
II	**Point Estimation** Point estimator, bias, efficiency, consistency, sufficiency, method of moments, maximum likelihood estimation. ([1] 10.1 to 10.8)	9	03	-	12	14
III	**Interval Estimation** Confidence intervals, degree of confidence, one-sided confidence intervals, estimation of means, difference of means, proportions, difference of proportions, variance and ratio of variances. ([1] 11.1 to 11.7)	9	03	-	12	14
IV	**Hypothesis Testing** Null and alternative hypotheses, acceptance and rejection regions, Type I and II errors, power of a test, Neyman-Pearson lemma, power function of a test, likelihood ratio tests, tests concerning means, tests concerning difference of means, tests concerning variances, contingency tables, goodness of fit. ([1] 12.1 to 12.6, 13.1 to 13.4)	9	03	-	12	14

V	**Regression** Bivariate regression, linear regression, method of least squares, normal regression analysis, normal correlation analysis, multiple linear regression, multicollinearity. ([1] Ch 14)	9	03		12	14
	Total	**45**	**15**	**-**	**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. Irwin Miller and Marylees Miller, *John E. Freund's Mathematical Statistics with Applications*, 8th edition, Pearson Education India, 2013.
2. David Freedman, Robert Pisani and Roger Purves, *Statistics*, 4th edition, Viva-Norton Student Edition, 2009.
3. Mark Huber, *Statistical Inference: Lectures and Labs*. https://www.markhuberdatascience.org/book

Reference Books:

1. George Casella, Roger L. Berger, *Statistical Inference*, Cengage, 2007.
2. Morris H. De Groot and Mark J. Schervish, *Probability and Statistics*, 4th edition, Pearson Education India, 2016.

Online Resources:

1. Department of Statistics at Penn State, *STAT415: Introduction to Mathematical Statistics.* https://online.stat.psu.edu/stat415/
2. Jeremy Balka, *Making Statistics Make Sense*, https://www.jbstatistics.com/ (Videos available on the YouTube channel @jbstatistics)

BA/BSC IN MATHEMATICS PROGRAMME (NEP)

6th SEMESTER

Title of the Course	**Linear Programming**
Course Code	**MATM 604**
Nature of the course	**Major**
Total Credits	**4(L=3, T=1, P=0)**
Distribution of Marks	**70 (TH)+30 (IA)=100**

Course Learning Outcome: After going through this course the students will be able to understand the theoretical basics of linear programming, will be able to formulate practical problems as linear programming problems, and will be able to implement a linear programming model using tools.

- Explain sampling distributions and their relation to population distributions.
- Define point estimation and evaluate properties of point estimators such as unbiasedness, consistency, and efficiency.
- Apply interval estimation techniques and interpret confidence intervals in real-world data.
- Interpret hypothesis test results and make informed decisions based on statistical evidence.
- Utilize mathematical software/languages (R, Python, MATLAB) for calculations and simulations**.**

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	15	05	-	20	23
II	Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation,	15	05	-	20	23
III	Hungarian method for solving assignment problem. Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.	15	05	-	20	24
	Total	**45**	**15**		**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.

Reference Books:

1. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
2. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.

BA/BSC IN MATHEMATICS PROGRAMME (NEP)
6th SEMESTER

Title of the Course	**Linear Programming**
Course Code	**MATN-601**
Nature of the Course	**MINOR**
Total Credits	**04(L=3, T=1,P=0)**
Distribution of Marks	**70(TH)+ 30(IA)=100**

Course Learning Outcome: After going through this course the students will be able to

- Explain sampling distributions and their relation to population distributions.
- Define point estimation and evaluate properties of point estimators such as unbiasedness, consistency, and efficiency.
- Apply interval estimation techniques and interpret confidence intervals in real-world data.
- Interpret hypothesis test results and make informed decisions based on statistical evidence.
- Utilize mathematical software/languages (R, Python, MATLAB) for calculations and simulations**.**

UNITS	CONTENTS	L	T	P	Total Hours	Marks
I	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	15	05	-	20	23
II	Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation,	15	05	-	20	23
III	Hungarian method for solving assignment problem. Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.	15	05	-	20	24
	Total	**45**	**15**		**60**	**70**

Where, L: Lectures T: Tutorials P: Practicals

Recommended Text Books:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.

Reference Books:

1. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
2. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.

B. A/B.SC. IN MATHEMATICS PROGRAMME (NEP)

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**History of Mathematics**
Course Code	**MDCM101**
Nature of the Course	**MDC**
Total Credits	**03(L=2, T=1,P=0)**
Distribution of Marks	**(TH)+ (IA)=**

Course Learning Outcomes: This course will enable the students to:

- Introduce the historical perspective of mathematics such as numerical symbol, word numerals, place value notation.
- Explain the arithmetic algorithms, construction of sine tables and Diophantine equation inancient and medieval India.
- Explain how mathematics has evolved in India.
- Analyze and critically reflect on ancient and modern mathematical issues.
- Conduct historical research on ancient Indian mathematical ideas with the texts of classicalmathematics and their historical interpretation.
- Explain some of the mathematical concepts developed in ancient time and evaluate the relevancein modern mathematics and sciences.

UNITS	CONTENTS	L	T	P	Total Hours	Total Marks
I	A glimpse of ancient India; Hindus and mathematics; Scopeand development of Hindu mathematics.	06	01	-	07	
II	Numeral terminology; The development of Numerical Symbol; The decimal place-value system; Persistence of theold system; Word numerals; Alphabetic notations; The zero symbol; The place-value notation in Hindu literature.	10	01	-	11	
III	Euclid: Introduction to the Elements; Book I and Pythagorean Theorem; Book II and Geometric Algebra. Archimedes; Estimating the values of pi. Ramanujan's viewon Magic square.	13	01	-	14	
IV	Ancient and Medieval India: Arithmetic algorithms; Geometry; Linear congruence; Construction of Sine tables; Transmission to and from India. Diophantine Equations in Greece and India; Early Mathematics in India. Linear Equations in One and Two unknown. The Rule of three	12	01	-	13	
	Total	**41**	**04**	**-**	**45**	

Where, L: Lectures T: Tutorials P: Practicals

Recommended TextBooks:

1. History of Hindu Mathematics (Part I), Datta B., Narayan Singh A., Gyan Publishing House, 2021.
2. A History of Mathematics: An Introduction, Kartz Victor J., Pearson, 2009
3. Ramanujan's Notebooks: Part I, Berndt Bruce C., Springer, 1985.
4. The History of Mathematics: An Introduction, Burton David M., Mc Graw Hill, 2011.