

**Scheme and Syllabi**  
**of**  
***Integrated BSc-MSc Mathematics***  
**(wef 2025-26)**

as per  
**NEP-2020, NCrF, NHEQF**



**Central University of Haryana, Mahendergarh**

<b>Approved by :</b>	<b>BOS</b>	<b>School Board</b>	<b>Academic Council</b>
Approval Status :	✓	✓	✓
Approval Date :	02.06.2025	11.06.2025	30.06.2025

### Scheme: 3-Year Scheme of Integrated BSc-MSc in Mathematics

Year	Sem	Major (Disciplinary/Interdisciplinary)				Minor/ VET#	AEC (8)	MDC* (9)	SEC (9)	VAC (6-8)	Cr	Credits Exit
I (100)	I	Algebra & Geometry				4 VET	4	4	4	2	22	<b>44</b> Cert**: <b>4.5</b>
	II	Calculus				4 VET	4	4	4	2	22	
II (200)	III	Real Analysis	Prob. & Stats	Numerical Analysis		4 VET/M		4		2	22	<b>43</b> Dip**: 5
	IV	Multivar. Calculus	Group Theory	ODEs		4 VET/M			3	2	21	
III (300)	V	Vector Calculus	Linear Algebra	PDEs	DSE-1	4 VET/M					20	<b>40</b> UG: 5.5
	VI	Metric Spaces	Abstract Algebra	OR	DSE-2	4 VET/M					20	
<b>Summer Internship (2-4 credits: 4-8 weeks) to be completed for UG degree</b>												
<b>Total (UG-3yr)</b>		<b>64</b>				<b>24</b>	<b>8</b>	<b>12</b>	<b>9</b>	<b>8</b>		<b>127-129</b>

**AEC:** English and MIL **SEC:** C Programming, Computing with Python, MATLAB & Maple Programming

**DSE1:** Number Theory, Integral Transforms & Fourier Analysis, Mechanics

**DSE2:** Special Functions, Discrete Mathematics, Classical Mechanics,

**DSE3:** Optimization Techniques, Advanced Algebra, Theory of Diff. Eqs, Advanced Numerical Methods

**VET:** Digital Office Applications, Mathematics for Professional Success **VAC:** Vedic Mathematics, Basics of Financial Mathematics

**MDC from Maths Dept.:** Intro. To Math Analysis, Intro. To Calculus, Intro. To Numerical Methods, Introductory Linear Algebra, Mathematics for Social Sciences

**Math Minor:** Algebra & Geometry, Calculus, Real Analysis/ODEs

\*\* Additionally, a 4-credit Skill Enhancement Course (Online/Offline/Blended) is required for Certificate/Diploma

# Minimum 12 credits from Vocational Education and Training (VET), and

\*Minimum 12 Credits for Minor, in case it is opted for. + MDC must be three different courses from at least two depts.

Sr.	Broad Category of Course	Minimum Credit Requirements		
		3-year Bachelor's Degree	4-Year Bachelor's Degree (Honours)	4-Year Bachelor's Degree (Honours with Research)
1	Major	60	84	80
2	Minor* (including VET#)	24	40	32
3	Ability Enhancement Courses (AEC)	08	08	08
4	Multidisciplinary	09	09	09
5	Skill Enhancement Courses (SEC)	09	09	09
6	Value Added Courses (common for all UG)	06-08	06-08	06-08
7	Summer Internship	02-04	02-04	02-04
8	Research Project / Dissertation	---	---	12
	Total	120	160	160

#. Minimum 12 credits from Vocational Education and Training (VET), and \*Minimum 12 Credits for Minor degree, in case it is opted for  
**Note:** The University may prescribe additional credit requirements, in addition to the minimum credits, for a programme of study.

## Typical Scheme for UG Degree (BSc Mathematics): First Three Years

Sem-I (22 credits)				Sem-II (22 credits)			
Title	Code	LTP	Crdt	Title	Code	LTP	Crdt
<b>Algebra and Geometry</b>	MAT 101 DM 40	<b>310</b>	<b>4</b>	<b>Calculus</b>	MAT 102 DM 40	<b>310</b>	<b>4</b>
<i>Vocational Education and Training Course</i>	VET		<b>4</b>	<i>Vocational Education and Training Course</i>	VET		<b>4</b>
<i>Ability Enhancement Course</i>	AEC		<b>4</b>	<i>Ability Enhancement Course</i>	AEC		<b>4</b>
<i>Skill Enhancement Course</i>	SEC		<b>4</b>	<i>Skill Enhancement Course</i>	SEC		<b>4</b>
<i>Value Added Course</i>	VAC		<b>2</b>	<i>Value Added Course</i>	VAC		<b>2</b>
<i>MDC-1 from other depts</i>			<b>4</b>	<i>MDC-2 from other depts</i>			<b>4</b>
# Summer Internship (2-4 credits: 4-8 weeks), mandatory for <b>Exit with Certificate</b> , must be approved by the Dept well before its start.							
Sem-III (22 credits)				Sem-IV (21 credits)			
Title	Code	LTP	Crdt	Title	Code	LTP	Crdt
<b>Real Analysis</b>	MAT 201 DM 40	<b>310</b>	<b>4</b>	<b>Multivariable Calculus</b>	MAT 202 DM 40	<b>310</b>	<b>4</b>
<b>Probability and Statistics</b>	MAT 203 DM 40	<b>310</b>	<b>4</b>	<b>Group Theory</b>	MAT 204 DM 40	<b>310</b>	<b>4</b>
<b>Numerical Analysis</b>	MAT 205 DM 30	<b>300</b>	<b>3</b>	<b>Ordinary Differential Equations</b>	MAT 206 DM 40	<b>310</b>	<b>4</b>
<b>Numerical Analysis Lab</b>	MAT 205 DMP 10	<b>002</b>	<b>1</b>	<b>MATLAB &amp; Maple Programming</b>	MAT 210 SE 30	<b>104</b>	<b>3</b>
<i>VET/Minor</i>			<b>4</b>	<i>VET/Minor</i>			<b>4</b>
<i>Value Added Course</i>	VAC		<b>2</b>	<i>Value Added Course</i>	VAC		<b>2</b>
<i>MDC-3 from other depts</i>			<b>4</b>				
# Summer Internship (2-4 credits: 4-8 weeks), mandatory for <b>Exit with Diploma</b> , must be approved by the Dept well before its start.							
Sem-V (20 credits)				Sem-VI (20 credits)			
Title	Code	LTP	Crdt	Title	Code	LTP	Crdt
<b>Vector Calculus</b>	MAT 301 DM 40	<b>310</b>	<b>4</b>	<b>Metric Spaces</b>	MAT 302 DM 40	<b>310</b>	<b>4</b>
<b>Linear Algebra</b>	MAT 303 DM 40	<b>310</b>	<b>4</b>	<b>Abstract Algebra</b>	MAT 304 DM 40	<b>310</b>	<b>4</b>
<b>Partial Differential Equations</b>	MAT 305 DM 40	<b>310</b>	<b>4</b>	<b>Operations Research</b>	MAT 306 DM 40	<b>310</b>	<b>4</b>
<i>DSE-1</i>			<b>4</b>	<i>DSE-2</i>			<b>4</b>
<i>VET/Minor</i>			<b>4</b>	<i>VET/Minor</i>			<b>4</b>
# Summer Internship (2-4 credits: 4-8 weeks), mandatory for <b>Exit with 3-year/4-year BSc degree</b> , must be approved by the Dept well before its start. VET, VAC, SEC, DSE may be offered from SWAYAM as decided by the Dept from time to time.							

AEC: English Communication, Modern Indian Language

SEC: Computing with Python, C Programming, MATLAB & Maple Programming

VET: Digital Office Applications, Mathematics for Professional Success, Courses from other depts./SWAYAM

VAC: Vedic Mathematics, Basics of Financial Mathematics, Courses from other depts./SWAYAM

DSE-1

<i>Number Theory</i>	MAT 307 DS 40
<i>Integral Transforms and Fourier Analysis</i>	MAT 309 DS 40
<i>Mechanics</i>	MAT 311 DS 40

DSE-2

<i>Special Functions</i>	MAT 308 DS 40
<i>Discrete Mathematics</i>	MAT 312 DS 40
<i>Classical Mechanics</i>	MAT 314 DS 40

## Scheme for 2025-26 Entry Batch

Sem-I (22 credits)				Sem-II (23 credits)			
Title	Code	LTP	Crdt	Title	Code	LTP	Crdt
<b>Algebra and Geometry</b>	MAT 101 DM 40	<b>310</b>	<b>4</b>	<b>Calculus</b>	MAT 102 DM 40	<b>310</b>	<b>4</b>
<i>Digital Office Applications</i>	MAT 100 VE 40	204	4	<i>Mathematics for Professional Success</i>	MAT 110 VE 40	310	4
<i>हिन्दी भाषा: रचना एवं व्यवहार</i>	HIN 110 AE 40	400	4	<i>English Communication</i>	ENG 110 AE 40	400	4
<i>Computing with Python</i>	MAT 110 SE 40	204	4	<i>C Programming</i>	MAT 120 SE 40	204	4
<i>Vedic Mathematics</i>	MAT 100 VA 20	200	2	<i>Financial Mathematics for Actuaries (SWAYAM):VAC</i>	noc26_ma69	300	3
<i>MDC-1 from other depts</i>			<b>4</b>	<i>MDC-2 from other depts</i>			<b>4</b>
# Summer Internship (2-4 credits: 4-8 weeks), mandatory for <b>Exit with Certificate</b> , must be approved by the Dept well before its start.							
Sem-III (22 credits)				Sem-IV (21 credits)			
Title	Code	LTP	Crdt	Title	Code	LTP	Crdt
<b>Real Analysis</b>	MAT 201 DM 40	<b>310</b>	<b>4</b>	<b>Multivariable Calculus</b>	MAT 202 DM 40	<b>310</b>	<b>4</b>
<b>Probability and Statistics</b>	MAT 203 DM 40	<b>310</b>	<b>4</b>	<b>Group Theory</b>	MAT 204 DM 40	<b>310</b>	<b>4</b>
<b>Numerical Analysis</b>	MAT 205 DM 30	<b>300</b>	<b>3</b>	<b>Ordinary Differential Equations</b>	MAT 206 DM 40	<b>310</b>	<b>4</b>
<b>Numerical Analysis Lab</b>	MAT 205 DMP 10	<b>002</b>	<b>1</b>	<b>MATLAB &amp; Maple Programming</b>	MAT 210 SE 30	<b>104</b>	<b>3</b>
<i>VET/Minor</i>			4	<i>VET/Minor</i>			4
<i>Value Added Course</i>	VAC		2	<i>Value Added Course</i>	VAC		2
<i>MDC-3 from other depts</i>			4				
# Summer Internship (2-4 credits: 4-8 weeks), mandatory for <b>Exit with Diploma</b> , must be approved by the Dept well before its start.							
Sem-V (20 credits)				Sem-VI (20 credits)			
Title	Code	LTP	Crdt	Title	Code	LTP	Crdt
<b>Vector Calculus</b>	MAT 301 DM 40	<b>310</b>	<b>4</b>	<b>Metric Spaces</b>	MAT 302 DM 40	<b>310</b>	<b>4</b>
<b>Linear Algebra</b>	MAT 303 DM 40	<b>310</b>	<b>4</b>	<b>Abstract Algebra</b>	MAT 304 DM 40	<b>310</b>	<b>4</b>
<b>Partial Differential Equations</b>	MAT 305 DM 40	<b>310</b>	<b>4</b>	<b>Operations Research</b>	MAT 306 DM 40	<b>310</b>	<b>4</b>
<i>DSE-1</i>			4	<i>DSE-2</i>			4
<i>VET/Minor</i>			4	<i>VET/Minor</i>			4
# Summer Internship (2-4 credits: 4-8 weeks), mandatory for <b>Exit with 3-year/4-year BSc degree</b> , must be approved by the Dept well before its start.							
<i>VET, VAC, SEC, DSE may be offered from SWAYAM as decided by the Dept from time to time.</i>							

AEC: English Communication, Modern Indian Language

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VET: Digital Office Applications, Mathematics for Professional Success, Courses from other depts./SWAYAM

VAC: Vedic Mathematics, Basics of Financial Mathematics, Courses from other depts./SWAYAM

DSE-1

<i>Number Theory</i>	MAT 307 DS 40
<i>Integral Transforms and Fourier Analysis</i>	MAT 309 DS 40
<i>Mechanics</i>	MAT 311 DS 40

DSE-2

<i>Special Functions</i>	MAT 308 DS 40
<i>Discrete Mathematics</i>	MAT 312 DS 40
<i>Classical Mechanics</i>	MAT 314 DS 40

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Sr.	Course/Item	Code	Page No.	LTP	SDGs	IKS
1	<b>Algebra and Geometry</b>	<b>MAT 101 DM 40</b>	<b>5</b>	<b>310</b>	<b>3,4,9</b>	<b>Y</b>
2	<b>Calculus</b>	<b>MAT 102 DM 40</b>	<b>6</b>	<b>310</b>	<b>2,4,6</b>	<b>Y</b>
3	<b>Real Analysis</b>	<b>MAT 201 DM 40</b>	<b>7</b>	<b>310</b>	<b>4,9,11</b>	<b>Y</b>
4	<b>Probability and Statistics</b>	<b>MAT 203 DM 40</b>	<b>8</b>	<b>310</b>	<b>4,5,13</b>	<b>Y</b>
5	<b>Numerical Analysis</b>	<b>MAT 205 DM 30</b>	<b>9</b>	<b>300</b>	<b>3,6,9</b>	
6	<b>Numerical Analysis Lab</b>	<b>MAT 205 DMP 10</b>	<b>10</b>	<b>002</b>	<b>3,6,9</b>	
7	<b>Multivariable Calculus</b>	<b>MAT 202 DM 40</b>	<b>11</b>	<b>310</b>	<b>9,11,13</b>	<b>Y</b>
8	<b>Group Theory</b>	<b>MAT 204 DM 40</b>	<b>12</b>	<b>310</b>	<b>3,4,9</b>	<b>Y</b>
9	<b>Ordinary Differential Equations</b>	<b>MAT 206 DM 40</b>	<b>13</b>	<b>310</b>	<b>9,13,15</b>	
10	<b>Vector Calculus</b>	<b>MAT 301 DM 40</b>	<b>14</b>	<b>310</b>	<b>7,14,15</b>	
11	<b>Linear Algebra</b>	<b>MAT 303 DM 40</b>	<b>15</b>	<b>310</b>	<b>3,4,13</b>	
12	<b>Partial Differential Equations</b>	<b>MAT 305 DM 40</b>	<b>16</b>	<b>310</b>	<b>7,11,13</b>	
13	<i>Number Theory</i>	<b>MAT 307 DS 40</b>	<b>17</b>	<b>310</b>	<b>4,9,16</b>	<b>Y</b>
14	<i>Integral Transforms and Fourier Analysis</i>	<b>MAT 309 DS 40</b>	<b>18</b>	<b>310</b>	<b>3,7,9</b>	
15	<i>Mechanics</i>	<b>MAT 311 DS 40</b>	<b>19</b>	<b>310</b>	<b>9,11,15</b>	
16	<b>Metric Spaces</b>	<b>MAT 302 DM 40</b>	<b>20</b>	<b>310</b>	<b>4,11,13</b>	
17	<b>Abstract Algebra</b>	<b>MAT 304 DM 40</b>	<b>21</b>	<b>310</b>	<b>3,4,16</b>	
18	<b>Operations Research</b>	<b>MAT 306 DM 40</b>	<b>22</b>	<b>310</b>	<b>2,3,9</b>	<b>Y</b>
19	<i>Special Functions</i>	<b>MAT 308 DS 40</b>	<b>23</b>	<b>310</b>	<b>3,6,9</b>	
20	<i>Discrete Mathematics</i>	<b>MAT 312 DS 40</b>	<b>24</b>	<b>310</b>	<b>4,9,17</b>	<b>Y</b>
21	<i>Classical Mechanics</i>	<b>MAT 314 DS 40</b>	<b>25</b>	<b>310</b>	<b>3,9,13</b>	
22	<b>Computing with Python</b>	<b>MAT 110 SE 40</b>	<b>26</b>	<b>204</b>		
23	<b>C Programming</b>	<b>MAT 120 SE 40</b>	<b>27</b>	<b>204</b>		
24	<b>MATLAB and Maple Programming</b>	<b>MAT 210 SE 30</b>	<b>28</b>	<b>104</b>		
25	<b>Digital Office Applications</b>	<b>MAT 100 VE 40</b>	<b>29</b>	<b>204</b>		
26	<b>Mathematics for Professional Success</b>	<b>MAT 110 VE 40</b>	<b>30</b>	<b>310</b>		
27	Vedic Mathematics	<b>MAT 100 VA 20</b>	<b>31</b>	<b>200</b>		
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Title: **Algebra and Geometry**

Code: **MAT 101 DM 40**

LTPC: **3104**

**Objectives:** To introduce basic structures of algebra like matrices, system of linear equation and linear transformation which are the main pillars of modern mathematics. Students can develop geometry with a degree of confidence and will gain fluency in the basics of Euclidean geometry. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.

**Outcomes:** After going through this course the students will be able to

- *Understand the importance of roots of real and complex polynomials, learn various methods of obtaining roots and familiarize with relations, equivalence relations and partitions.*
- *Employ De Moivre's theorem in a number of applications to solve numerical problems.*
- *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.*
- *Explain the properties of three-dimensional shapes.*

**Contents:**

#### Unit-I

Elementary theorems on the roots of an equations including Cardan's method, The remainder and factor theorems, Synthetic division, Factored form of a polynomial, The Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Imaginary roots, Integral and rational roots; Polar representation of complex numbers, The nth roots of unity, De Moivre's theorem for integer and rational indices and its applications.

#### Unit-II

Sets, Relations and functions, Equivalence classes, The division algorithm, Divisibility and the Euclidean algorithm, The fundamental theorem of arithmetic, Modular arithmetic and congruence, Systems of linear equations, Row reduction and echelon forms, Linear independence, The rank of a matrix and applications; Matrix operations, Determinants, The inverse of a matrix, Eigenvalues and eigenvectors, The Cayley-Hamilton theorem.

#### Unit-III

Planes: Distance of a point from a plane, Angle between two planes, pair of planes, Bisectors of angles between two planes.

Straight lines: Equations of straight lines, Distance of a point from a straight line, Distance between two straight lines, Distance between a straight line and a plane.

Spheres: Different forms, Intersection of two spheres, Orthogonal intersection, Tangents and normal, Radical plane, Radical line, Coaxial system of spheres, Pole, Polar and Conjugacy.

#### Unit-IV

Space curves, Algebraic curves, Ruled surfaces, Classification of quadric surfaces, Cone, Cylinder, Central conicoids, Tangent plane, Normal, Polar lines and planes

#### References:

1. Robert J. T. Bell (1994). An Elementary Treatise on Coordinate Geometry of Three Dimensions. Macmillan India Ltd, (**Textbook**).
2. Mark V. Lawson (2020). Algebra and Geometry. 2<sup>nd</sup> edition, CRC Press (**Textbook**).
3. Titu Andreescu, & Dorin Andrica (2014). Complex Numbers from A to...Z. (2nd edition). Birkhäuser.
4. D. Chatterjee (2009). Analytical Geometry: Two and Three Dimensions. Narosa Publishing House.
5. Leonard Eugene Dickson (2009). First Course in the Theory of Equations. The Project Gutenberg EBook (<http://www.gutenberg.org/ebooks/29785>)
6. Edgar G. Goodaire & Michael M. Parmenter (2015). Discrete Mathematics with Graph Theory (3rd edition). Pearson Education Pvt. Ltd. India.
7. Bernard Kolman & David R. Hill (2003). Introductory Linear Algebra with Applications (7th edition). Pearson Education Pvt. Ltd. India.

Title: **Calculus**

Code: **MAT 102 DM 40**

LTPC: **3104**

**Objectives:** *To understand axiomatic foundation of real number system, in particular notion of completeness and some of its consequences; understand concepts of limit, continuity, compactness, differentiability, and integrability. To develop a basic level of competency in mathematical skills*

**Outcomes:** *After going through this course the students will be able to*

- *Calculate the limit and examine the continuity of a function at a point.*
- *Understand the consequences of various mean value theorems for differentiable functions.*
- *Sketch curves in Cartesian and polar coordinate systems.*
- *Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life sciences and a host of other disciplines.*

**Contents:**

**Unit-I**

$\epsilon - \delta$  definition of limit of a real valued function, Continuity of a real valued function, Properties of continuous functions, Intermediate value theorem, Geometrical interpretation of continuity, Types of discontinuity; Uniform continuity, Integration of real valued function, Reduction formulae.

**Unit-II**

Differentiability, Geometrical interpretation of differentiability, Monotone functions, Maxima and Minima, Indeterminate forms, Darboux's theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Successive differentiation, Leibnitz's theorem.

**Unit-III**

Curvature, Asymptotes, Singular points, Points of inflexion, Concavity and convexity, Tangents at origin, Multiple points, Position and nature of double points; Tracing of Cartesian, polar and parametric curves.

**Unit-IV**

Maclaurin's and Taylor's theorems for expansion of a function in an infinite series, Taylor's theorem in finite form with Lagrange, Cauchy and Roche-Schlomilch forms of remainder.

**References:**

1. George B. Thomas Jr., R L Finney. Calculus and Analytical Geometry (14th ed.). Pearson (**Textbook**).
2. Howard Anton, I. Bivens & Stephan Davis (2016). Calculus (10th ed.). Wiley, India
3. Gabriel Klambauer (1986). Aspects of Calculus. Springer-Verlag.
4. Wieslaw Krawcewicz & Bindhyachal Rai (2003). Calculus with Maple Labs. Narosa.

**Title: Real Analysis**

**Code: MAT 201 DM 40**

**LTPC: 3104**

**Objectives:** *This course presents a rigorous treatment of fundamental concepts in analysis. To introduce students to the fundamentals of mathematical analysis and reading and writing mathematical proofs. The course objective is to understand the axiomatic foundation of the real number system, in particular the notion of completeness and some of its consequences; understand the concepts neighbourhood of a point, countable sets, sequence and series, rigorously defined; Students should also have attained a basic level of competency in developing their own mathematical arguments and communicating them to others in writing.*

**Outcomes:** After going through this course the students will be able to

- Understand many properties of the real line  $\mathbb{R}$  and learn to define sequence in terms of functions from  $\mathbb{R}$  to a subset of  $\mathbb{R}$ .
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
- Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
- Understand and distinguish between pointwise and uniform convergence of sequences and series of functions.

**Contents:**

#### **Unit-I**

Algebraic and order properties of  $\mathbb{R}$ , Absolute value of a real number; Bounded above and bounded below sets, Supremum and infimum of a nonempty subset of  $\mathbb{R}$ , The completeness property of  $\mathbb{R}$ , Archimedean property, Density of rational numbers in  $\mathbb{R}$ , Definition and types of intervals, Nested intervals property; Neighborhood of a point in  $\mathbb{R}$ , Open, closed and perfect sets in  $\mathbb{R}$ , Connected subsets of  $\mathbb{R}$ , Cantor set, Countable and uncountable sets.

#### **Unit-II**

Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotone sequences, Monotone convergence theorem, Subsequences, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's convergence criterion.

#### **Unit-III**

Convergence and divergence of infinite series of positive real numbers, Necessary condition for convergence, Cauchy criterion for convergence; Tests for convergence of positive term series; Comparison tests, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test, Logarithmic test and Gauss test, Integral test, Alternating series, Leibniz test, Absolute and conditional convergence, Rearrangement of series and Riemann's theorem.

#### **Unit-IV**

Pointwise and uniform convergence of sequence and series of functions, Weierstrass's M- test, Dirichlet test and Abel's test for uniform convergence, Uniform convergence and continuity, Uniform convergence, differentiability and integrability.

**References:**

1. R. G. Bartle & D. R. Sherbert (2015). Introduction to Real Analysis (4th ed.). Wiley India, (Textbook).
2. W. Rudin (2017), Real and Complex Analysis, Tata McGRAW Hill.
3. G. G. Bilodeau, P. R. Thie & G. E. Keough (2015). An Introduction to Analysis (2nd ed.), Jones and Bartlett India Pvt. Ltd.
4. K. A. Ross (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Springer.

Title: **Probability and Statistics**

Code: **MAT 203 DM 40**

LTPC: **3104**

**Objectives:** *To provide an understanding of the basic concepts in probability theory and statistical analysis. Students will learn the fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation, correlation and regression. After taking this course, students will be able to develop practical skills in statistical analysis using tools & software.*

**Outcomes:** After going through this course the students will be able to

- *Understand fundamental concepts of probability theory.*
- *Analyze and compute discrete and continuous probability distributions.*
- *Understand distributions in the study of the joint behaviour of two random variables.*
- *Establish a formulation helping to predict one variable in terms of the other that is, correlation and linear regression.*

**Contents:**

#### **Unit-I**

Basic notions of probability, Conditional probability and independence, Baye's theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

#### **Unit-II**

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.

#### **Unit-III**

Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

#### **Unit-IV**

The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

**References:**

1. Irwin Miller & Marylees Miller (2014). John E. Freund's Mathematical Statistics with Applications (8th ed.). Pearson. Dorling Kindersley Pvt. Ltd. India, (**Textbook**).
2. Robert V. Hogg, Joseph W. McKean & Allen T. Craig (2013). Introduction to Mathematical Statistics (7th ed.), Pearson Education.
3. Jim Pitman (1993). Probability, Springer-Verlag.
4. Sheldon M. Ross (2014). Introduction to Probability Models (11th ed.). Elsevier.
5. M. Yaglom and I. M. Yaglom (1983). Probability and Information. D. Reidel Publishing Company.
6. V.K. Kapoor and S. C. Gupta (2018). Fundamental of Mathematical Statistics, S. Chand & Sons.

**Title: Numerical Analysis**

**Code: MAT 205 DM 30**

**LTPC: 3003**

**Objective:** *The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. These shortcomings of analytical solutions lead us to various numerical techniques developed for different types of mathematical problems seem to be an excellent option. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.*

**Outcomes:** After completing this course, student is expected to learn the following:

- *Overview the errors in computation and their measurements*
- *Apply numerical techniques to obtain approximate solutions to otherwise intractable mathematical problems*
- *Learn numerical technique to find the solutions of nonlinear equations, system of linear equations, interpolation problems, numerical differentiations and integration, Initial and boundary value problems*
- *Familiarized the students with convergence, advantages and limitations of these numerical techniques*

**Contents:**

**Unit: I**

Errors in approximation, absolute, relative and percentage errors, round-off error. Solution of algebraic and transcendental equations: bisection method, Regula-Falsi method, Secant method, method of iteration, Newton Raphson method, Fixed point iteration methods, order of convergence. Systems of simultaneous equations: Gauss elimination method, Gauss Jordan method, LU decomposition method, Iterative methods: Jacobi method and Gauss-Seidel method.

**Unit: II**

Finite differences, Interpolation techniques for equal intervals-Newton forward and backward, Gauss forward, Gauss Backward, Stirling, Bessel formulae. Interpolation with unequal intervals-Newton's divided difference method, Lagrange method. Hermite interpolation.

**Unit: III**

Numerical differentiation using Newton forward and backward formulae. Numerical integration: Newton-Cotes formulas, trapezoidal rule, Simpson rule, Gauss-Legendre, Gauss-Chebyshev formulas, Romberg's integration, Curve fitting: straight line fitting, parabolic curve fitting, fitting of exponential curve, fitting of other curves.

**Unit: IV**

Solution of ordinary differential equations: Taylor series method, Picard's method, Euler method, Euler modified method, Runge-Kutta methods, Milne's and Adam's predictor and corrector methods.

**References:**

1. Gupta, R. K. Numerical Methods: Fundamentals and Applications. 1st ed., Cambridge University Press, 2019.
2. Thangaraj, P. Computer Oriented Numerical Methods. PHI Learning Pvt. Ltd, 2013.
3. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. Numerical Methods for Scientific & Engineering Computation. New Age International, 2012.
4. Burden R. L. and Faires J. D. Numerical Analysis. 9th Edition, Cengage Learning, 2011.
5. Chapra, S. C. and Canale, R. P. Numerical Methods for Engineers. McGraw Hill, International Edition, 1998.
6. Mathews, J. H. Numerical Methods for Mathematics, Science and Engineering. Prentice- Hall, 1992.

**Title: Numerical Analysis Lab**

**Code: MAT 205 DMP 10**

**LTPC: 0021**

**Course Objective:** The lab component of this course is aimed to design the programs using C/Python for various numerical methods studied in the theory course.

**Course Outcomes:**

After completing this course, student is expected to learn the following:

- Write efficient and well documented codes for various numerical methods and present outputs in an informative way.
- Able to solve problems covered in the theory paper (Numerical Analysis) with more accuracy using computer code.

The students are required to design the programs using C/Python for the following numerical problems based on methods studied in the theory course. This list is merely indicative, and can be expanded to include other numerical problems.

1. To detect the interval(s) which contain(s) root of equation  $f(x)=0$  and implement bisection method to find root of  $f(x)=0$  in the detected interval.
2. To find the root of  $f(x)=0$  using Regula Falsi and Secant methods
3. To find the root of  $f(x)=0$  using Newton -Raphson and fixed point iteration methods.
4. To solve linear system of equations using Gauss elimination (without pivoting) method.
5. To solve linear system of equations using Gauss Jordan method.
6. To solve linear system of equations using Jacobi and Gauss-Seidel methods
7. To compute the intermediate value using the Newton's forward difference interpolation formula.
8. To implement Lagrange interpolation formula
9. To compute Newton divided difference (NDD) table and use it compute interpolating value with NDD formula.
10. To integrate a function numerically using trapezoidal and Simpson's rules.
11. To compute integration numerically from a data set using trapezoidal and Simpson's rules
12. To fit a straight line to a given data set
13. To solve the initial value problem using Euler and modified Euler's methods.
14. To apply Milne's and Adam's predictor and corrector methods for solution of initial value problems
15. To solve the initial value problem using Runge-Kutta methods.

**Title: Multivariable Calculus**

**Code: MAT 202 DM 40**

**LTPC: 3104**

**Objectives:** *To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.*

**Outcomes:** After going through this course the students will be able to

- *Learn conceptual variations while advancing from one variable to several variables in calculus.*
- *Apply multivariable calculus in optimization problems.*
- *Inter-relationship amongst the line integral, double and triple integral formulations.*
- *Applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.*
- *Realize importance of Green's, Gauss's and Stokes' theorems in other branches of mathematics.*

**Contents:**

**Unit-I**

Functions of several variables: Level curves and surfaces, Limits and continuity, Partial differentiation, Chain rule, Higher order partial derivatives, Total differential and differentiability, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.

**Unit-II**

Jacobians, Change of variables, Euler's theorem for homogeneous functions, Taylor's theorem for functions of two and more variables, Extrema of functions of two and more variables, Method of Lagrange multipliers, Constrained optimization problems,

**Unit-III**

Double integration over rectangular and nonrectangular regions, Double integrals in polar co-ordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, Triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals.

**Unit-IV**

Definition of vector field, Divergence, curl, gradient and vector identities. Line integrals, Applications of line integrals, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Stokes' theorem, The Gauss divergence theorem.

**References:**

1. George B. Thomas Jr., R L Finney. Calculus and Analytical Geometry (14th ed.). Pearson Education, (**Textbook**).
2. James Stewart (2012). Multivariable Calculus (7th edition). Brooks/Cole. Cengage, (**Textbook**).
3. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). Basic Multivariable Calculus, Springer India Pvt. Limited.
4. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). Calculus (3rd ed.). Pearson Education. Dorling Kindersley (India) Pvt. Ltd.

**Title: Group Theory**

**Code: MAT 204 DM 40**

**LTPC: 3104**

**Objectives:** *To introduce basic structures of algebra like group, dihedral groups, permutation group, Abelian group, non-Abelian group and cyclic group which are the main pillars of modern group theory. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.*

**Outcomes:** After going through this course, the students will be able to

- *Recognize the mathematical objects called groups.*
- *Link the fundamental concepts of groups and symmetries of geometrical objects.*
- *Explain the significance of the notions of cosets, normal subgroups, and factor groups.*
- *Analyze consequences of Lagrange's theorem.*
- *Learn about structure preserving maps between groups and their consequences.*

**Contents:**

**Unit-I**

Elementary properties of groups, Symmetries of a square, Dihedral group, Quaternion group,  $GL(n, F)$ ,  $SL(n, F)$ , Properties of permutations, Symmetric and alternating groups, Subgroups, Examples of subgroups, Abelian group, Cyclic group and its properties, Euler-phi function.

**Unit-II**

Properties of cosets, Lagrange's theorem, Normal subgroups, Simple groups, Factor groups, Cauchy's theorem for finite abelian groups; Centralizer, Normalizer, Center of a group, Product of two subgroups; Direct product, Classification of subgroups of cyclic groups.

**Unit-III**

Group homomorphisms, Isomorphisms, Properties of isomorphisms; First, second and third isomorphism theorems for groups. Cayley's theorem and its applications., Inner and outer automorphisms of a group.

**Unit-IV**

Group actions, Orbits and stabilizers, Conjugacy classes, Orbit-stabilizer theorem, Class equation of a group, Finite simple groups, Sylow theorems and applications including non-simplicity tests.

**References:**

1. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th ed.). Cengage, (**Textbook**).
2. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th ed.). Pearson (**Textbook**).
3. Michael Artin (2014). Algebra (2nd ed.). Pearson.
4. I.N. Herstein (2006). Topics in Algebra (2nd ed.). Wiley India.
5. Nathan Jacobson (2009). Basic Algebra I (2nd ed.). Dover Publications.
6. Ramji Lal (2017). Algebra 1: Groups, Rings, Fields and Arithmetic. Springer.
7. I.S. Luthar & I.B.S. Passi (2013). Algebra: Volume 1: Groups. Narosa.
8. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd ed.). Wiley

Title: **Ordinary Differential Equations**

Code: **MAT 206 DM 40**

LTPC: **3104**

**Objectives:** *To introduce ordinary differential equations, general, particular, explicit, implicit and singular solutions of a differential equation. This course introduces methods of finding analytical solutions of various ordinary differential equations.*

**Outcomes:** After going through this course the students will be able to

- Understand the genesis of ordinary differential equations
- Find exact solutions of first order differential equations and linear differential equations of higher order
- Use Picard's method for obtaining successive approximations of the solution and use Power series method, especially in cases when there is no method available to solve such equations
- Formulate simple mathematical models based on ordinary differential equations

**Contents:**

#### **Unit-I**

Basic concepts and genesis of ODEs, Order and degree of a DE, Differential equations of first order and first degree, Variables separable and reducible to variable separable, Homogeneous equations and reducible to homogeneous DEs, Lagrange's equation and Bernoulli's equation, Exact differential equations, Integrating factor, Reducible to exact equations, First order higher degree differential equations solvable for x, y and p. Clairaut's form and reducible to Clairaut's form, singular solutions. Picard's method of successive approximations and the statement of Picard's theorem for the existence and uniqueness of the solutions.

#### **Unit-II**

Basic theory of linear differential equations, Linear dependence/independence of solutions on an interval, Wronskian and its properties, Solutions of homogeneous linear differential equations of second order with constant coefficients, Transformation of the equation by changing the dependent variable (method of Reduction of order), Coupled linear differential equations with constant coefficients, Statements and proofs of theorems on the second order homogeneous linear equation.

#### **Unit-III**

Principle of superposition for a homogeneous linear differential equation, Linear homogeneous and non-homogeneous differential equations of higher order with constant coefficients, Transformations of the equation by changing the independent variable (Cauchy-Euler equation, Legendre's linear equation), Method of variation of parameters and method of undetermined coefficients, Inverse operator method.

#### **Unit-IV**

Orthogonal trajectories, Acceleration-velocity model, Minimum velocity of escape from Earth's gravitational field, Growth and decay models, Radioactive decay, Malthusian and logistic population models, Free and forced mechanical oscillations of a vertically suspended spring, Resonance, LCR circuits.

**References:**

1. Shepley L. Ross (2007). Differential Equations (3rd edition), Wiley India, (**Textbook**).
2. E.A. Coddington (2007). Introduction to Ordinary Differential Equations (18th 36 ed.), PHI.
3. Belinda Barnes & Glenn Robert Fulford (2015). Mathematical Modelling with Case Studies: A Differential Equation Approach Using Maple and MATLAB (2nd ed.). Chapman & Hall/CRC Press, Taylor & Francis.
4. H. I. Freedman (1980). Deterministic Mathematical Models in Population Ecology. Marcel Dekker Inc.
5. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
6. George F. Simmons (2017). Differential Equations with Applications and Historical Notes (3rd ed.). CRC Press. Taylor & Francis.
7. B. Rai, D. P. Choudhury & H. I. Freedman (2013). A Course in Ordinary Differential Equations (2nd ed.) Narosa.

**Title: Vector Calculus**

**Code: MAT 301 DM 40**

**LTPC: 3104**

**Objectives:** *This course provides a comprehensive understanding of vector mechanics and mathematical physics, covering the fundamental principles of vector algebra, calculus, and their applications.*

**Outcomes:** *After going through this course, the students will be able to*

- *Find the Triple product of Products and their Applications*
- *Derive expressions for tangent, normal vectors, and curvature in vector functions*
- *Analyze particle motion in gravitational fields and under central forces*
- *Understand the importance of curvilinear coordinate systems in complex physical scenarios*

**Contents:**

**Unit I**

Vectors, Scalars and Dot Product, Triple Products, Scalar and Vector Fields, Methods of Integration and Examples, Applications (Work, Torque, Volume of Parallelepiped)

**Unit-II**

Vector Functions and their Limits, Continuity and Differentiability, Derivative of a Vector Function, Tangent, Normal Vectors, Curvature, Torsion, Arc Length and Unit Tangent Vector, Partial Differentiation, Directional Derivatives.

**Unit-III**

Kinematics of a Particle, Displacement, Velocity, Acceleration, Circular Motion, Motion in the Gravitational Field, Motion of a Particle under Central Force, Momentum and Angular Momentum of a System of Particles, Centroid of a System, Kinetic Energy of a System.

**Unit-IV**

Curvilinear Coordinates, Orthogonal Curvilinear Coordinates, Gradient, Divergence and Curl in Curvilinear Coordinates, Examples in Cylindrical and Spherical Coordinates

**References:**

1. George B. Thomas, Maurice D. Weir and Joel Hass, Thomas Calculus, 13/e, Pearson Publishers, 2013, **(Textbook)**.
2. R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, 3/e, Alpha Science International Ltd., 2002.
3. Michael Greenberg, Advanced Engineering Mathematics, 2/e, Pearson, 2018.
4. S. Narayan, A Textbook of Vector Calculus, S. Chand Publishing, 2003

Title: **Linear Algebra**

Code: **MAT 303 DM 40**

LTPC: **3104**

**Objectives:** *To give a brief introduction of vector spaces, linear transformation, matrix representation and various linear operators, which can be used for further applications in various field.*

**Outcomes:** After completing this course, the students will be able to

- Describe the concepts of the terms basis, dimension, and apply these concepts to various vector spaces and subspaces.
- Use the concept of linear transformations, matrix representation and change of basis, including kernel, range.
- Understand the notion of bilinear forms, triangularization and primary decomposition theorem.
- Compute inner products and determine orthogonality on vector spaces, applying Gram-Schmidt orthogonalization process to find the orthonormal basis

**Contents:**

#### **Unit-I**

System of linear equation, vector spaces: definition and examples, subspaces, linear dependence, basis and dimension, sum and direct sum, quotient spaces, linear transformations: kernel and image of a linear transformation, rank and nullity of a linear transformation, matrix mappings

#### **Unit-II**

Linear mappings and matrices: matrix representation of linear transformation, change of basis, similarity, polynomial of matrices, characteristic polynomial, Cayley-Hamilton theorem, diagonalization, minimal polynomial, companion matrix

#### **Unit-III**

Canonical and bilinear forms: triangular form, invariance, primary decomposition, Jordan canonical form, rational canonical form, bilinear and quadratic forms, reduction and classification of quadratic forms.

#### **Unit-IV**

Inner product space, examples and properties, norms and distances, orthonormal basis, the Gram-Schmidt orthogonalization, orthogonal complements, the adjoint of a linear operator on an inner product space, normal and self-adjoint operators, unitary operators

**References:**

1. Hoffman, K. and Kunze, R. Linear Algebra. 2nd edition, Pearson India, 2015.
2. Axler, S. Linear Algebra Done Right. 2nd edition, Springer-Verlag, 2014.
3. Lang, S. Linear Algebra. 3rd edition, Springer-Verlag, New York, 2013.
4. Lipschutz, S. and Lipson, M. Linear Algebra. 3rd edition, Tata McGraw-Hill, 2005.
5. Friedberg, S. H., Insel, A. J. and Spence, L. E. Linear Algebra. 4th edition, 2002

**Title: Partial Differential Equations**

**Code: MAT 305 DM 40**

**LTPC: 3104**

**Objectives:** *To introduce partial differential equations, general, particular, explicit, implicit and singular solutions of a partial differential equation. This course further explains the analytic techniques in computing the solutions of various partial differential equations.*

**Outcomes:** After going through this course the students will be able to

- *Understand the genesis of partial differential equations*
- *Find exact solutions of first order partial differential equations*
- *Apply a range of techniques to solve second order partial differential equations.*
- *Model physical phenomena using partial differential equations such as the heat and wave equations*

**Contents:**

**Unit-I**

Basics of PDE's, Order and degree of Partial differential equations (PDE), Classification of partial differential equations, Types of solutions of partial differential equations, Lagrange's method, Special types of equations, Charpit's method.

**Unit-II**

Classification of linear partial differential equations of second order, Homogeneous and non-homogeneous equations with constant coefficients.

**Unit-III**

Partial differential equations reducible to equations with constant coefficient, Second order PDE with variable coefficients, Classification of second order PDEs, Reduction to canonical or normal form; Monge's method.

**Unit-IV**

Method of separation of variables, Solutions of Heat, Laplace, and Wave equations in one and two-dimensions. Types of boundary value problems: Dirichlet, Neumann, Robin.

**References:**

1. I. N. Sneddon (2006). Elements of Partial Differential Equations. Dover Publications, (**Textbook**).
2. Fourier Series and Boundary Value Problems (Brown and Churchill), 2006, McGraw- Hill.
3. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
4. TynMyint-U & Lokenath Debnath (2013). Linear Partial Differential Equations for Scientists and Engineers (4th edition). Springer India.
5. H. T. H. Piaggio (2004). An Elementary Treatise on Differential Equations and Their Applications. CBS Publishers.
6. L.C. Evans (2014), Partial Differential Equations, American Mathematical Society, Indian 2nd edition.
7. S. B. Rao & H. R. Anuradha (1996). Differential Equations with Applications. University Press.

Title: **Number Theory**

Code: **MAT 307 DS 40**

LTPC: **3104**

**Objectives:** *This course is aimed at undergraduate mathematics majors. It is a first course in number theory, and is intended to introduce students to number theoretic problems and to different areas of number theory. Number theory has a very long history compared to some other areas of mathematics, and has many applications,*

**Outcomes:** After going through this course the students will be able to

- *Learn about some important results in the theory of numbers including the prime number theorem, Chinese remainder theorem, Wilson's theorem and their consequences.*
- *Learn about number theoretic functions, modular arithmetic and their applications.*
- *Familiarize with modular arithmetic and find primitive roots of prime and composite numbers.*
- *Learn about finite and simple continued fractions, and irrationality of ..... and*
- *Know about open problem number theory, namely, the Goldbach conjecture and twin-prime conjecture.*

**Contents:**

#### **Unit-I**

Representation of the real numbers by decimals, divisibility, G.C.D and L.C.M., Linear Diophantine equation, Congruence relation and its properties, Linear congruence and Chinese remainder theorem, Fermat's little theorem, Wilson's theorem. Arithmetical functions  $\varphi(n)$ ,  $\mu(n)$  and  $d(n)$  and  $\sigma(n)$ , Mobius inversion formula.

#### **Unit-II**

Order of an integer modulo  $n$ , Primitive roots for primes, Composite numbers having primitive roots, Indices and its properties. Congruences of higher degree, Congruences of prime power moduli and prime modulo, power residue Definition of quadratic residue of an odd prime.

#### **Unit-III**

Euler's criterion. Quadratic residue, Legendre symbols, lemma of Gauss and reciprocity law. Jacobi symbols, irrational numbers, irrationality. Finite continued fractions, simple continued fractions, infinite simple continued fractions.

#### **Unit-IV**

Periodic continued fractions, approximation of irrational numbers by convergent, best possible approximation, Farey series, rational approximation, Prime counting function, Prime number theorem, Goldbach conjecture, Twin-prime conjecture, Perfect numbers conjecture, Fermat and Mersenne primes,

#### **References:**

1. David M. Burton (2007). Elementary Number Theory (7th edition). McGraw-Hill, (**Textbook**).
2. Neville Robbins (2007). Beginning Number Theory (2nd edition). Narosa, (**Textbook**).
3. Gareth A. Jones & J. Mary Jones (2005). Elementary Number Theory. Springer.
4. I. Niven (2012). An Introduction to the Theory of Numbers (5th edition). John Wiley & Sons.

Title: **Integral Transforms and Fourier Analysis**

Code: **MAT 309 DS 40**

LTPC: **3104**

**Objectives:** *This Course is aimed at exposing the students to learn the Laplace transforms and Fourier transforms. To equip with the methods of finding Laplace transform and Fourier Transforms of different functions. To make them familiar with the methods of solving differential equations, partial differential equations, IVP and BVP using Laplace transforms and Fourier transforms.*

**Outcomes:** After going through this course the students will be able to

- *Learn Laplace transforms and its properties. Transform of Dirac delta function and unit step function*
- *Solve ordinary differential equations using Laplace transforms.*
- *Familiarise with Fourier transforms of functions belonging to  $L^1(\mathbb{R})$  class*
- *Explain Parseval's identity and applications of Fourier transforms to boundary value problems.*
- *Learn Fourier series, Bessel's inequality, term by term differentiation and integration of Fourier series. Apply the concepts of the course in real life problems*

**Contents:**

#### **Unit-I**

Laplace transform, Linearity, Existence theorem, Laplace transforms of derivatives and integrals, Shifting theorems, Change of scale property, Laplace transforms of periodic functions, Dirac's delta function, Unit step function.

#### **Unit-II**

Differentiation and integration of transforms, Convolution theorem, Inverse Laplace transform, Linearity property of inverse Laplace transform, Translations theorems of inverse Laplace transform, Inverse transform of derivatives, Applications of Laplace transform in obtaining solutions of ordinary differential equations.

#### **Unit-III**

Fourier Series: Fourier cosine and sine series, Fourier series, Differentiation and integration of Fourier series, Bessel's inequality.

Fourier Transforms: Fourier and inverse Fourier transforms, Fourier sine and cosine transforms, Inverse Fourier sine and cosine transforms, Linearity property, Change of scale property, Shifting property.

#### **Unit-IV**

Relation between Fourier and Laplace transforms, Convolution theorem, Parseval's identity, Transform of derivatives, Applications of infinite Fourier transforms to boundary value problems, Finite Fourier transform and its inverse.

**References:**

1. James Ward Brown & Ruel V. Churchill (2011). Fourier Series and Boundary Value Problems. McGraw-Hill Education, (**Textbook**).
2. Walter Rudin (2017). Fourier Analysis on Groups. Dover Publications, (**Textbook**).
3. Charles K. Chui (1992). An Introduction to Wavelets. Academic Press.
4. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th ed.). Wiley,
5. A. Zygmund (2002). Trigonometric Series (3rd ed.). Cambridge University Press

Title: **Mechanics**

Code: **MAT 311 DS 40**

LTPC: **3104**

**Objectives:** *This course aims to impart knowledge in mechanics used for the derivation of important results and problems related to rigid bodies. The objective is to give the students a mechanical approach for solving the problems related to the mechanics.*

**Outcomes:** After completing this course, the students will be able to

- *Familiarize with subject matter, which has been the single centre, to which were drawn mathematicians, physicists, astronomers, and engineers together.*
- *Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.*
- *Determine the centre of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.*
- *Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.*
- *Learn that a particle moving under a central force describes a plane curve and know the Kepler's laws of the planetary motions, which were deduced by him long before the mathematical theory given by Newton.*

**Contents:**

#### **Unit-I**

Equilibrium of a particle, Equilibrium of a system of particles, Necessary conditions of equilibrium, Moment of a force about a point, Moment of a force about a line, Couples, Moment of a couple, Equipollent system of forces, Work and potential energy, Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.

#### **Unit-II**

Centres of gravity of plane area including a uniform thin straight rod, triangle, circular arc, semicircular area and quadrant of a circle, Centre of gravity of a plane area bounded by a curve, Centre of gravity of a volume of revolution; Flexible strings, Common catenary, Intrinsic and Cartesian equations of the common catenary, Approximations of the catenary.

#### **Unit-III**

Kinematics and kinetics of the motion, Expressions for velocity and acceleration in Cartesian, polar and intrinsic coordinates; Motion in a vertical circle, Simple harmonic motion (SHM) and its geometrical representation, SHM under elastic forces, Motion under inverse square law, Motion in resisting media, Concept of terminal velocity, Motion of varying mass.

#### **Unit-IV**

Equation of motion under a central force, Differential equation of the orbit, (p, r) equation of the orbit, Apses and apsidal distances, Areal velocity, Characteristics of central orbits, Kepler's laws of planetary motion.

**References:**

1. S. L. Loney (2006). An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies. Read Books, (**Textbook**).
2. P. L. Srivastava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad,
3. J. L. Synge & B. A. Griffith (1949). Principles of Mechanics. McGraw-Hill.
4. A. S. Ramsey (2009). Statics. Cambridge University Press.
5. A. S. Ramsey (2009). Dynamics. Cambridge University Press.
6. R. S. Varma (1962). A Text Book of Statics. Pothishala Pvt. Ltd..

Title: **Metric Spaces**

Code: **MAT 302 DM 40**

LTPC: **3104**

**Objectives:** *The course aims at providing the basic knowledge pertaining to metric spaces such as open and closed balls, neighbourhood, interior, closure, subspace, continuity, compactness, connectedness etc. and providing the basic knowledge of Riemann and improper integral.*

**Outcomes:** After going through this course the students will be able to

- *Learn basic facts about the Riemann and improper integral.*
- *Understand several standard concepts of metric spaces and their properties like openness, closedness, completeness, Bolzano-Weierstrass property, compactness, and connectedness.*
- *Identify the continuity of a function defined on metric spaces and homeomorphisms*

**Contents:**

#### **Unit-I**

Definition and examples of metric spaces, Open spheres and closed spheres, Neighbourhoods, Open sets, Interior, Exterior and boundary points, Closed sets, Limit points and isolated points, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space.

#### **Unit-II**

Cauchy and Convergent sequences, Completeness of metric spaces, Cantor's intersection theorem, Dense sets and separable spaces, Nowhere dense sets and Baire's category theorem, Continuous and uniformly continuous functions, Homeomorphism, Banach contraction principle.

#### **Unit-III**

Compact spaces, Sequential compactness, Bolzano-Weierstrass property, Compactness and finite intersection property, Heine-Borel theorem, Totally bounded sets, Equivalence of compactness and sequential compactness, Continuous functions on compact spaces. Separated sets, Disconnected and connected sets, Components, Connected subsets of  $\mathbb{R}$ , Continuous functions on connected sets.

#### **Unit-IV**

Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, First mean value theorem, Bonnet and Weierstrass forms of second mean value theorems. Improper integrals, Dirichlet test and Abel's test for improper integrals.

**References:**

1. E. T. Copson (1988). Metric Spaces. Cambridge University Press, (**Textbook**).
2. Robert G. Bartle & Donald R. Sherbert (2015). Introduction to Real Analysis (4th ed.). Wiley India, (**Textbook**).
3. P. K. Jain & Khalil Ahmad (2019). Metric Spaces. Narosa, (**Textbook**).
4. S. Kumaresan (2011). Topology of Metric Spaces (2nd edition). Narosa, (**Textbook**).
5. Satish Shirali & Harikishan L. Vasudeva (2006). Metric Spaces. Springer-Verlag.
6. Micheál O'Searcoid (2009). Metric Spaces. Springer-Verlag.
7. G. F. Simmons (2004). Introduction to Topology and Modern Analysis. McGraw-Hill.

Title: **Abstract Algebra**

Code: **MAT 304 DM 40**

LTPC: **3104**

**Objectives:** *The objective of the course is to introduce modern structures of algebra like, rings and fields, field extensions and finite fields which are the main pillars of modern algebra. The course gives the student a good mathematical maturity and enables to build mathematical thinking and skill.*

**Outcomes:** *After going through this course, the students will be able to*

- *Know the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.*
- *Learn in detail about polynomial rings, fundamental properties of finite field Extensions, and classification of finite fields.*
- *Demonstrate ability to think critically by interpreting theorems and relating results to problems in other mathematical disciplines*

**Contents:**

#### **Unit-I**

Definition, examples and elementary properties of rings, Commutative rings, Integral domain, Division rings and fields, Characteristic of a ring, Ring homomorphisms and isomorphisms, Ideals and quotient rings. Prime, Principal and maximal ideals, Relation between integral domain and field, Euclidean rings and their properties.

#### **Unit-II**

Polynomial rings over commutative ring and their basic properties, The division algorithm; Polynomial rings over rational field, Gauss lemma and Eisenstein's criterion, Euclidean domain, Principal ideal domain, and unique factorization domain.

#### **Unit-III**

Constructions and Classification of finite field, Extension of a field, Algebraic element of a field, Algebraic and transcendental numbers, Splitting fields, Separable, Inseparable, Simple and normal extensions.

#### **Unit-IV**

Perfect fields, Primitive elements, Algebraically closed fields, Automorphisms of extensions. Galois extensions, Fundamental theorem of Galois theory, Solutions of polynomials by radicals, Galois group over the rationals.

**References:**

1. David S. Dummit & Richard M. Foote (2008). Abstract Algebra (2nd edition). Wiley, (**Textbook**).
2. P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul (2003). Basic Abstract Algebra (2nd edition). Cambridge University Press, (**Textbook**).
3. Surjeet Singh & Qazi Zameeruddin (2020). Modern Algebra (9th ed.) Vikash Publishing House PVT LTD, (**Textbook**).
4. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
5. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.
6. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
7. I. S. Luthar & I. B. S. Passi (2012). Algebra: Volume 2: Rings. Narosa.

Title: **Operations Research**

Code: **MAT 306 DM 40**

LTPC: **3104**

**Objectives:** *This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.*

**Outcomes** After completing this course, the students will be able to

- *Understand linear programming problems and to find their solutions by using different methods.*
- *Find optimal solution of transportation problems and assignment problems*
- *Understand and solve different queuing models.*
- *Find optimal solution of linear programming model using Game Theory. Also learn about sequencing problems.*

**Contents:**

#### **Unit-I**

Origin, definition and scope of OR. formulation and solution of LPP by graphical method, Convex sets, Basic solution, Basic feasible solutions, Extreme points, Simplex methods, Big-M and two phase methods, Degeneracy.

#### **Unit-II**

Definition of the dual problem, Relationship between the optimal primal and dual solution, Economic interpretation of duality, Primal-dual computations, Dual Simplex method, Sensitivity analysis, Integer Programming.

#### **Unit-III**

Basic feasible solutions, Optimum solution by stepping stone and modified distribution methods, Unbalanced and degenerate problems, Transshipment problem.

**Assignment Problems:** Solution by Hungarian method, Unbalanced problem, Case of maximization, Travelling salesman and crew assignment problems.

#### **Unit-IV**

**Sequencing Problems:** Processing of  $n$  jobs through 2 machines,  $n$  jobs through 3 machines, 2 jobs through  $m$  machines,  $n$  jobs through  $m$  machines.

**Game Theory:** Two persons zero sum game, Game with saddle points, Rule of dominance, Algebraic, graphical and linear programming, Concept of mixed strategy.

**References:**

1. Sharma, S. D. (2012). Operation Research, Kedar Nath Ram Nath Publications.
2. Swarup, K. and Gupta, P.K. (2010) Operations Research. S. Chand publisher.
3. Taha, H. A. (2010). Operation Research: An Introduction. 9th edition, Pearson.
4. Gupta, P.K. and Hira, D.S. (2008) Introduction to Operations Research, S. Chand & Co.
5. Sharma, J. K. (1989). Mathematical Model in Operation Research, Tata McGraw-Hill.

Title: **Special Functions**

Code: **MAT 308 DS 40**

LTPC: **3104**

**Objectives:** *This course aims to introduce students to specific mathematical functions including Beta and Gamma functions, Riemann Zeta function. The course objective also includes power series solutions of differential equations involving special functions like Legendre, Bessel, Hermite, Hypergeometric functions and understanding the properties and relations of these functions, like recurrence relations, orthogonal properties, and generating functions*

**Outcomes:** After completing this course, the students will be able to

- Analyze the properties of special functions and understand their relationship to other mathematical concepts
- Solve differential equations involving special functions and apply these functions in various contexts
- Understand the definitions, properties, and relationships between different special functions.

**Contents:**

#### **Unit-I**

Series solution of differential equations; Power series method. Legendre differential equation and its solution; Legendre functions and their properties; Recurrence relations and generating functions. Orthogonality of Legendre polynomials. Rodrigues Formula for Legendre Polynomials, Laplace Integral Representation of Legendre polynomial.

#### **Unit-II: Bessel and Hermite Functions**

Bessel equation and its solution: Bessel functions and their properties - Convergence, Recurrence relations and generating functions. Bessel's Integral. Orthogonality of Bessel functions.

Hermite equation and its solutions; Hermite function and its properties; Recurrence relations and generating functions. Orthogonality of Hermite polynomials. Rodrigues Formula for Hermite Polynomial

#### **Unit-III: Beta and Gamma Functions**

Infinite product of complex numbers, Factorization of entire functions, Gamma functions, Order symbols  $o$  and  $O$ , Beta functions, Euler reflection formula, Factorial function, Legendre's duplication formula, Gauss's multiplication formula, Integral representations for Gamma function and Beta functions, Walli's products, Stirling formula.

#### **Unit-IV**

Asymptotic expansion, Riemann Zeta functions, Euler product formula, Riemann Functional equations, Riemann hypothesis, Gauss Hypergeometric Function, Elementary Properties, Conditions of convergence, Contiguous function relations, Integral Representation, Simple transformation, Quadratic transformation. Generalized Hypergeometric Functions.

**References:**

1. Rainville E. D. (1960). Special Functions, The MacMillan Comp.
2. Bell W.W. (1968). Special Functions for Scientists and Engineers, D. Van Nostrand Comp. Ltd.
3. Andrews G.E., Askey R. and Roy R. (1999). Special Functions, Encyclopedia of Mathematics and Its Applications, Cambridge University Press.
4. Raisinghania M. D. (2002) Advanced Differential Equations, S. Chand, New Delhi.

Title: **Discrete Mathematics**

Code: **MAT 312 DS 40**

LTPC: **3104**

**Objectives:** *This course will discuss fundamental concepts and tools in discrete mathematics with emphasis on their applications to computer science. Topics include logic and Boolean circuits, sets, functions, relations, deterministic algorithms and randomized algorithms, and graphs.*

**Outcomes:** After completing this course, the students will be able to

- *Learn about partially ordered sets, lattices and their types.*
- *Understand Boolean algebra and Boolean functions, logic gates, switching circuits and their applications.*
- *Assimilate various graph theoretic concepts and familiarize with their applications.*

**Contents:**

#### **Unit-I**

Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.

#### **Unit-II**

Lattices as posets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.

#### **Unit-III**

Boolean algebras, De Morgan's laws, Boolean homomorphism, Representation theorem; Boolean polynomials, Boolean polynomial functions, Disjunctive and conjunctive normal forms, Minimal forms of Boolean polynomials, Quine-McCluskey method, Karnaugh diagrams, Switching circuits and applications.

#### **Unit-IV**

Definition, examples and basic properties of graphs, Königsberg bridge problem; Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, Eulerian circuits, Hamiltonian cycles, Adjacency matrix, Weighted graph, Travelling- salesman problem, Shortest path and Dijkstra's algorithm.

**References:**

1. Kenneth H. Rosen (2012). Discrete Mathematics and its Applications: With Combinatorics and Graph Theory (7th edition). McGraw-Hill, (**Textbook**).
2. Edgar G. Goodaire & Michael M. Parmenter (2018). Discrete Mathematics with Graph Theory (3rd edition). Pearson Education, (**Textbook**).
3. B. A. Davey & H. A. Priestley (2002). Introduction to Lattices and Order (2nd edition). Cambridge University Press.
4. Rudolf Lidl & Günter Pilz (1998). Applied Abstract Algebra (2nd ed.). Springer.
5. C. L. Liu (1985). Elements of Discrete Mathematics (2nd ed.). McGraw-Hill.

Title: **Classical Mechanics**

Code: **MAT 314 DS 40**

LTPC: **3104**

**Objectives:** *This course aims to impart knowledge in mechanics used for the derivation of important results and problems related to rigid bodies. The objective is to give the students a mechanical approach for solving the problems related to the mechanics.*

**Outcomes:** After completing this course, the students will be able to

- *Understand the notion of moment and product of inertia.*
- *Recognize the dynamics involved in projectile motion, pendulum motion, simple harmonic motion and related problems.*
- *Use the Lagrangian and Hamiltonian functions to formulate the equation of motion for mechanical systems.*
- *Evaluate canonical equations by means of generating functions and eventually develop Hamilton-Jacobi method to solve equations of motion.*

**Contents:**

#### **Unit-I**

Moments and products of inertia, theorems of parallel and perpendicular axes, principal axes, the momental ellipsoid, equimomental systems, coplanar distributions.

#### **Unit-II**

Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations, generalized coordinates, holonomic and non-holonomic systems. scleronomic and rheonomic systems, Lagrange's equations for a holonomic system, Lagrange's equations for a conservative and impulsive forces, kinetic energy as quadratic function of velocities.

#### **Unit-III**

Generalized potential, energy equation for conservative fields, Hamilton's variables. Donkin's theorem. Hamilton canonical equations, cyclic coordinates, Routh's equations. Poisson's bracket. Poisson's identity, Jacobi-Poisson theorem. Hamilton's principle, principle of least action.

#### **Unit-IV**

Poincare Cartan integral invariant. Whittaker's equations. Jacobi's equations. Statement of Lee Hwa Chung's theorem. Hamilton-Jacobi equation. Jacobi theorem. Method of separation of variables. Lagrange brackets, condition of canonical character of a transformation in terms of Lagrange brackets and Poisson brackets, invariance of Lagrange brackets and Poisson brackets under canonical transformations.

**References:**

1. Spiegel, M.R. Theory & Problems of Theoretical Mechanics, Schaum Outline Series McGrawHill, 2017.
2. Rana, N. C. and Joag, P. C. Classical Mechanics. McGraw Hill, 2013.
3. Rao, S. K. Classical Mechanics. PHI Learning Pvt. Ltd., 2005.
4. Chorlton, F. Textbook of Dynamics. CBS Publishers & Dist. Pvt. Ltd., 2004.
5. Louis N. H. and Janet D. F. Analytical Mechanics. Cambridge University Press, 1998.
6. Gantmacher, F. Lectures in Analytical Mechanics. Mir Publishers, Moscow, 1975.

**Title: Computing with Python**

**Code: MAT 110 SE 40**

**LTPC: 2044**

**Objectives:** *The main objective is to provide exposure to the students on the basics of programming in Python, writing code and debugging, and develop simple applications.*

**Outcomes:** *After going through this course the students will be able to*

- *Solve general problem using iterative, looping concepts of Python*
- *Implement functions and modules in Python*
- *Handle different types of files*
- *Develop simple applications*

**Contents:**

**Unit-I**

Installation, Running and debugging programs, Syntax, Basic data types, Variables, Input-Output

**Unit-II**

Arithmetic, assignment, comparison, logical, and bitwise operators; Decision making statements, Iterative statements, break and continue.

**Unit-III**

Working with lists, tuples, sets, and dictionaries, working with files (reading, writing, appending)

**Unit-IV**

Definition and use, passing arguments and return values, block structure, scope, recursion, importing modules and packages, Using built-in modules (e.g., math, datetime)

*Laboratory Work: To implement general problems in Python; and develop simple applications.*

**References:**

1. Y. Kanatkar, Let Us Python, BPB, 2019.
2. Martin C. Brown, Python: The Complete Reference, McGraw Hill, 2018.
3. Allen B. Downey, Think Python, O'Reilly, 2016

**Title: C Programming**

**Code: MAT 120 SE 40**

**LTPC: 2044**

**Objectives:** *To familiarize students with the fundamentals of a digital computer, and problem solving through C-programming. The course aims to give exposure to basic concepts of a computer and introduction to programming in C language. The lab component of this course is designed to provide hands-on-training and implementation of the basic programming concepts.*

**Outcomes:** After completing this course, the students will be able to

- Write, compile and run C programs and gradual improvement using efficient error handling.
- Implement selection and repetition structures in C using various control statements.
- To learn the use of arrays and strings for efficient C programming.
- Create user-defined functions for various applications.

**Contents:**

#### **Unit-I**

Overview of a digital computer and basic computing concepts. Programming through Algorithms and Flowcharts. Overview of C language, Basic structure of a C Program, C language preliminaries: Constants, Variables and Data Types, Operators and Expressions, precedence and associativity.

#### **Unit-II**

Managing reading and writing characters. Formatted input and output. Decision making with statements like if, if-else, nesting, else-if ladder, and switch. Conditional operator. Decision-making using looping structures like while, do and for statements. Nesting and Jumps in loops. break and continue statements.

#### **Unit-III**

One, two, multi-dimensional arrays, dynamic arrays. Reading and writing of character arrays, arithmetic operations on characters, various string-handling functions.

#### **Unit-IV**

Elements of user-defined functions, return values and their types, function calls and declaration, function types, nesting of functions, recursion, passing arrays to functions, searching and sorting: binary and sequential search algorithms, bubble and insertion sort algorithms; passing string to functions, scope, visibility and lifetime of variables, Introduction to structures and unions.

**References:**

1. Balagurusamy E. (2019). Programming in ANSI C, 8th Ed., Tata McGraw-Hill.
2. Y. Kanetkar (2020), Let us C, 15th edition, BPB Publication.
3. Brian W. Kernighan & Dennis M. Ritchie (2019). The C Program Language, Prentice Hall.
4. Samuel P. Harkison and Gly L. Steele Jr. (2014). C: A Reference Manual, 2nd Ed., Prentice Hall.
5. Byron, S. Gottfried (2017). Theory and Problems of Programming with C, 2nd Ed. (Schaum Series), Tata McGraw-Hill Publishing Co. Ltd.
6. Venugopal K. R. and Prasad S. R. (2020) Programming with C, Tata McGraw-Hill.

Title: **MATLAB and Maple Programming**

Code: **MAT 210 SE 30**

LTPC: **1043**

**Objectives:** *The course objective is to familiarize the students with problem solving through MATLAB. The course aims to give exposure to basic concepts of the MATLAB programming. The course aims to design the MATLAB programs for various numerical methods.*

**Outcomes:** After completing this course, the students will be able to

- *Overview and display format of MATLAB programs*
- *Acquire knowledge of various elementary built-in functions, data types and Matrix operations*
- *Learn about control flow and loop structures*
- *Write MATLAB programs for various numerical methods use to solve nonlinear equations, system of linear equations, interpolation, numerical differentiation and integrations, differential equations.*

**Contents:**

#### **Unit-I**

Overview of MATLAB, operators, display format, elementary built-in functions, working with variables, general commands, data types, data import, arrays, operations with arrays, Matrices: eigenvalues and eigenvectors, similarity transformation and diagonalization, functions, script files, operators, loops and conditional statements

#### **Unit-II**

Programming in MATLAB, graphics- 2-D and 3-D plots, input and output. introduction to working with modules in MATLAB

#### **Unit-III**

Applications of MATLAB in numerical methods: bisection method, false position (Regula-Falsi) method, Newton–Raphson method, Gauss elimination method, Gauss Seidel method, Lagrange and Newton interpolations, Trapezoidal method and Simpson method, Runge–Kutta method.

#### **Unit-IV**

Overview of Maple software, commands and expressions, perform basic calculations, commands in various fields of mathematics like calculus, vector calculus, linear algebra, group theory, differential equations, numerical computations, optimization techniques and number theory, how to create more sophisticated graphics in Maple, including animations with multiple layers, 3-D models of physical systems, and statistical plots.

**References:**

1. Kumar, S. S. and Lenina, S. V. B. Matlab: Easy Way of Learning. PHI Learning Pvt. Ltd., 2016.
2. Pratap, R. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers. Oxford University Press, 2016.
3. Chapman, S. J. Matlab Programming for Engineers, 5th edition, Cengage Learning, 2015.
4. Otto, S.R. and Denier, J.P. An Introduction to Programming and Numerical Methods in MATLAB. Springer-Verlag, 2005.
5. Yang, W. Y., Cao, W., Chung, T. and Morris, J. Applied Numerical Methods using MATLAB. John Wiley Interscience, 2005.
6. Getting Started with MATLAB, Maths Works Inc. [www.in.mathsworks.com](http://www.in.mathsworks.com).
7. Philip Anton de Saint-Aubain; Philip Michael, The Maple Syntax, Polyteknisk Forlag, 2013
8. [https://www.maplesoft.com/documentation\\_center](https://www.maplesoft.com/documentation_center)

Title: **Digital Office Applications**

Code: **MAT 100 VE 40**

LTPC: **2044**

**Objectives:** *To familiarize students with the fundamentals of office applications. The course aims to give exposure to foundational office tools and their basic functions.*

**Outcomes:** After completing this course, the students will be able to

- *Use open-access tools to prepare various types of documents through basic and advanced formatting features*
- *Use spreadsheets for various applications in general office work and for scientific computation*
- *Prepare Slides and create effective presentations*
- *Create simple websites for various applications.*

**Contents:**

**Unit-I**

Word processing: Typing letters, Tables, Figures, Picture Insertion and Formatting, Mathematical Symbols and Equations, Margins, Header & Footers, Pagination, Built-in Templates, Reports, Formatting Documents, Sharing Documents

**Unit-II**

Introduction, Export/Import from Excel, Basic Functions, Absolute and Relative Referencing, Conditional Formatting, Data Entry and Validation, Named Ranges, Data Types, Vlookup and Match, Charts, Budgeting, Sharing Spreadsheet for Collaborative work.

**Unit-III**

Presentations: Creation of simple and high-impact slides using Smart Art Graphics such lists, process, cycle, hierarchy, relationship, pyramid; Insertion of pictures, charts, equations, audio & video; slideshows, visual storytelling

**Unit-IV**

Creating site, Choosing and customizing templates, Layouts and sections, formatting text/image/multimedia, applying themes, Embedding HTML/YouTube/Maps, integrating tools: Docs/Forms/Sheets/Slides/ Calendar, Sharing and collaboration settings, setting viewer/editor permissions, publishing websites and using custom URLs.

**References:**

1. Alexander, M., & Kusleika, D. (2025). Microsoft Excel 365 Bible. John Wiley & Sons.
2. Zen: Simple ideas on presentation design and delivery. New Riders.
3. Tyson, H. (2007). Microsoft Word 2007 Bible (Vol. 434). John Wiley & Sons.
4. Teeter, R., & Barksdale, K. (2009). Google Sites and Chrome for dummies. John Wiley & Sons.
5. <https://www.geeksforgeeks.org/ms-word-tutorial/>
6. <https://www.youtube.com/@ProlificOaktree>

**Title: Mathematics for Professional Success**

**Code: MAT 110 VE 40**

**LTPC: 3104**

**Objectives:** *This course aims to impart knowledge in basic mathematics to succeed in various professional entrance tests. This will also enable to students to sharpen logical and analytical abilities.*

**Outcomes:** After completing this course, the students will be able to

- Solve basic and mid-level problems in logic and reasoning aptitude
- Do computations for widely used concepts of basic mathematics

**Contents:**

**Unit-I**

Logical and Analytical Reasoning: Series, Coding and Decoding, Clock, Calendar, Direction and Distance, Sitting Arrangement, Blood Relation, Problems Based on Ages, Ranking, Puzzles, Syllogism, Cubes and Dice, Non-Verbal and Visual Reasoning, Verbal and Analytical Reasoning, Inequalities, Venn Diagram.

**Unit-II**

Basic Arithmetic and Number System: Number System, Fractions, LCM and HCF, Elementary Algebra, Surds and Indices, Average, Percentage, Ratio, Mixture and Proportion

**Unit-III**

Applied Arithmetic: Profit, Loss and Discount, Simple and Compound Interest, Time, Speed and Distance, Time and Work.

**Unit-IV**

Higher Mathematics and Data Handling: Permutation and Combination, Probability, Sequence and Series, Statistics, Plane Geometry, Mensuration, Data Interpretation, Data Sufficiency.

**References:**

1. R.S. Aggarwal, Quantitative Aptitude for Competitive Examinations, S. Chand Publishing, 2024-2025.
2. Rakesh Yadav, Advance Maths, Readers Publication Pvt. Ltd., 2023-24.
3. Kiran Prakashan, SSC Mathematics Chapterwise Solved Papers, Kiran Prakashan, 2023.
4. Arihant Experts, TMH – CSAT Paper 2 Manual, Arihant Publications India Limited, 2023.

**Title: Vedic Mathematics**

**Code: MAT 100 VA 20**

**LTPC: 2002**

**Objectives:** The course aims to discuss mathematical ideas and techniques from the Vedic period. Its purpose is to enable learners to explore the power of Vedic Mathematics and develop their understanding of arithmetic calculations, trigonometry, and coordinate geometry.

**Outcomes:** After completing this course, the students will be able to

- Utilize the principles of Vedic Mathematics for daily calculations, achieving accuracy and speed.
- Generate tables of any number and perform products of large numbers quickly
- Understand the properties of trigonometric ratios and trigonometric identities
- Understand the properties of straight lines and complex numbers system

**Contents:**

**Unit-I**

History and Evolution of Vedic Mathematics, Introduction of Basic Vedic Mathematics Techniques in Multiplication (Special Case, Series of 9, Series of 1 etc.), Tables etc., Comparison of Standard Methods with Vedic Methods.

**Unit-II**

Multiplication Methods 1. Ekadhikenpurven method (multiplication of two numbers of two digits) 2. Eknunenpurven method (multiplication of two numbers of three digits) 3. Urdhvatiragbhyam method (multiplication of two numbers of three digits) 4. NikhilamNavtashchramamDashtaha (multiplication of two numbers of three digits) 5. Combined Operations 6. Multiplications by numbers near base, Verifying answers by use of digital roots.

**Unit-III**

Definitions of trigonometric ratios, Trigonometric Identities

**Unit-IV**

Co-ordinate Geometry: Different forms of straight lines Complex Numbers: Multiplication and Division

**References:**

1. Vedic Mathematics, Motilal Banarsi Das, New Delhi.
2. Vedic Ganita: Vihangama Drishti-1, SikshaSanskritiUthana Nyasa, New Delhi.
3. Vedic GanitaPraneta, SikshaSanskritiUthana Nyasa, New Delhi.
4. Vedic Mathematics: Past, Present and Future, SikshaSanskritiUthana Nyasa, New Delhi.
5. Beejganitam, ChokhambbaVidyaBhavan, Varanasi.
6. Bharatiya Mathematicians, Sharda Sanskrit Sansthan, Varanasi.

Title: **Basics of Financial Mathematics**

Code: **MAT 110 VA 20**

**LTPC: 2002**

**Objectives:** *This course aims to Introduce the fundamental concepts and principles of financial mathematics.*

**Outcomes:** After completing this course, the students will be able to

- Calculate simple and compound interest,
- Explain and apply the concept of the time value of money to various financial scenarios.
- Apply discounting techniques and rate conversions to solve real-world financial problems
- Evaluate annuities, analyse and construct loan amortization schedules and compute payments.
- Use financial mathematics principles in investment decision-making and financial planning.

**Contents:**

**Unit-I**

**Introduction and Interest Rates:** Introduction to growth and decay curves. Interest Rates: Simple and compound interest, bank discount, and the concept of effective interest rate

**Unit-II**

**Present and Future Values:** Calculating present and future values, including using discounting and compounding techniques

**Unit-III**

**Annuities and Loans:** Understanding annuities, amortization schedules, and loan calculations.

**Unit-IV**

**Financial Markets and Instruments:** Introduction to financial markets and various instruments like stocks, bonds, and derivatives

**References:**

1. S.P. Gupta and S K Jain, Financial Mathematics (ISBN: 9789351732952), Sahitya Bhawan Publications, 2022
2. B.L.Bajpai and Ashutosh Bajpai. Financial Mathematics. New Royal Book Company, 2014.
3. Vignesh Mehta and Akash Rughani. Financial Mathematics. Blue Rose Publishers Pvt. Ltd. 2023

## SDG Mapping

Course Name	SDG Name	Rationale
Algebra & Geometry	SDG 3: Good Health and Well-being	Algebraic models help track disease spread, analyze healthcare data, and optimize medical
	SDG 4: Quality Education	Promotes analytical and problem-solving skills needed for innovation and higher education.
	SDG 9: Industry, Innovation and Infrastructure	Algebra supports the development of algorithms in engineering and technology.
Calculus	SDG 4: Quality Education	Promotes analytical and problem-solving skills needed for innovation and higher education.
	SDG 6: Clean Water and Sanitation	Calculus models the <b>flow of water through pipes and natural systems</b> .
	SDG 2: Zero Hunger	Used in precision agriculture to <b>model crop growth, nutrient flow, and weather impacts</b> .
Real Analysis	SDG 4: Quality Education	Teaching real analysis strengthens <b>logical thinking, proof techniques, and precision</b> , which are core to higher-level STEM education.
	SDG 11: Sustainable Cities and Communities	Real analysis supports models for <b>traffic flow, resource consumption, and environmental dynamics</b> in cities.
	SDG 9: Industry, Innovation and Infrastructure	Real analysis ensures the <b>mathematical soundness of algorithms</b> in simulations, control systems, and optimization problems.
Probability & Statistics	SDG 4: Quality Education	Probability is used to evaluate <b>the reliability of standardized tests and learning outcomes</b> under uncertainty.
		Statistics assess <b>student performance, education equity, and curriculum effectiveness</b> .
	SDG 5: Gender Equality	Statistical tools identify <b>gaps in income, education, health, and employment</b> between genders.
	SDG 13: Climate Action	Statistics validate <b>climate models</b> and analyze <b>emissions data</b> for informed decision-making.
Probability models forecast extreme weather events, temperature trends, and sea level rise.		
Numerical Analysis	SDG 3: Good Health and Well-being	Numerical methods are used in <b>MRI, CT scans, and ultrasound image reconstruction</b> .
		Numerical solutions of differential equations help model the spread of infectious diseases, enabling better responses and resource allocation.
	SDG 6: Clean Water and Sanitation	Numerical simulations are utilized for groundwater flow, pollutant transport, and the design of wastewater treatment processes.

	SDG 9: Industry, Innovation and Infrastructure	Numerical simulations are integral to designing efficient infrastructure, from bridges to smart cities.
Multivariable Calculus	SDG 9: Industry, Innovation and Infrastructure	Gradient and divergence in elasticity theory help determine the stress distribution in buildings and bridges.
	SDG 11: Sustainable Cities and Communities	Multiple integrals and PDEs used to model heat distribution or optimize traffic systems across 3D city maps.
	SDG 13: Climate Action	Multivariable vector fields describe temperature, pressure, and wind changes in weather models.
Group Theory	SDG 3: Good Health and Well-being	Identifying symmetrical properties of molecules using group theory helps in predicting how they interact with biological systems, supporting pharmaceutical development.
	SDG 4: Quality Education	Introducing group theory in advanced curricula fosters problem-solving and logical skills essential for innovation and research.
		Group theory enhances mathematical thinking and abstract reasoning, promoting STEM education.
	SDG 9: Industry, Innovation and Infrastructure	Group theory underpins coding theory and cryptography used in secure digital communication and control systems in industry.
Symmetric and permutation groups are the basis of error-correcting codes used in communication systems, supporting reliable and secure infrastructure.		
Ordinary Differential Equations	SDG 15: Life on Land	ODEs describe predator-prey dynamics and ecological interactions.
	SDG 13: Climate Action	ODEs simulate carbon cycle dynamics, atmospheric CO <sub>2</sub> levels, and temperature changes.
	SDG 9: Industry, Innovation and Infrastructure	ODEs govern the behavior of dynamic systems in engineering — from robotics to control systems.
Vector Calculus	SDG 14: Life Below Water	Vector fields simulate ocean current patterns that affect marine biodiversity or track pollutant movement, affecting ecosystems.
	SDG 15: Life on Land	Studies animal migration, ocean currents, and ecosystem flows.
	SDG 7: Affordable and Clean Energy	Optimizes energy flow in systems like wind turbines, solar fields, and electrical circuits.
Abstract Algebra	SDG 3: Good Health and Well-being	<b>Finite fields and linear algebra</b> are used in algorithms for reconstructing images in MRI and CT scans, improving diagnostic accuracy.
	SDG 4: Quality Education	Abstract algebra fosters critical thinking and mathematical reasoning, essential for high-quality STEM education.
	SDG 16: Peace, Justice and Strong Institutions	<b>Cryptography</b> , critical for digital privacy, online security, and secure voting systems, is built on abstract algebra.

		<b>Elliptic curve cryptography</b> (based on algebraic structures over finite fields) is used to secure online communications and protect human rights.
Partial Differential Equations	SDG 7: Affordable and Clean Energy	The <b>heat equation</b> (a parabolic PDE) models temperature distribution in solar panels or thermal energy storage systems.
	SDG 11: Sustainable Cities and Communities	PDEs model air pollution diffusion in city environments and heat islands, supporting sustainable urban planning.
	<b>SDG 13: Climate Action</b>	Climate models use systems of <b>nonlinear PDEs</b> to simulate temperature, wind, and ocean dynamics etc.
Number Theory	SDG 4: Quality Education	Teaching number theory concepts strengthens critical thinking essential for STEM education and innovation.
	SDG 9: Industry, Innovation and Infrastructure	Prime numbers and modular arithmetic are used in encryption algorithms (e.g., RSA), ensuring secure communication and data integrity in industry and infrastructure.
	SDG 16: Peace, Justice and Strong Institutions	Number theory underpins cryptographic protocols protecting privacy, enabling secure online voting, banking, and government services.
Integral Transforms & Fourier Analysis	SDG 3: Good Health and Well-being	<b>Fourier transforms</b> are fundamental in MRI, CT scans, and ultrasound, converting raw data into images for accurate diagnosis.
	SDG 7: Affordable and Clean Energy	Fourier analysis is used to study electrical signals in smart grids and optimize energy consumption patterns.
	SDG 9: Industry, Innovation and Infrastructure	Integral transforms solve differential equations in engineering, and Fourier analysis detects faults in mechanical systems via vibration signals.
Mechanics	SDG 9: Industry, Innovation and Infrastructure	Studying impact forces, vibrations, and machinery motion to improve industrial processes and infrastructure resilience.
	SDG 11: Sustainable Cities and Communities	Modeling traffic flow and crowd movement to reduce accidents and enhance mobility.
		Designing stable infrastructure for urban development, including buildings and transport systems.
	SDG 15: Life on Land	Analyzing animal locomotion and movement dynamics to support biodiversity and habitat preservation.
		Studying equilibrium in natural structures (e.g., tree stability) to aid conservation efforts.
Metric Spaces and Integration	SDG 4: Quality Education	Develop rigorous mathematical thinking and foundational concepts used in advanced technologies.
	SDG 11: Sustainable Cities and Communities	Distance metrics model urban planning problems — such as optimal location of resources, emergency services, or transportation networks — improving city sustainability.

	SDG 13: Climate Action	Used in spatial analysis and environmental data clustering to detect climate patterns and anomalies.
Linear Algebra	SDG 3: Good Health and Well-being	Techniques like MRI and CT scan image reconstruction use linear algebra for processing large data sets. Also used in modeling genetic data for disease research.
	SDG 4: Quality Education	Develops critical thinking and problem-solving skills essential for STEM fields.
	SDG 13: Climate Action	Large-scale climate models use linear algebra to solve systems of equations describing atmospheric dynamics.
Operations Research	SDG 2: Zero Hunger	OR models minimize food waste, improve logistics for food delivery, and optimize agricultural resource allocation.
	SDG 3: Good Health and Well-being	Scheduling of hospital staff, optimizing vaccine distribution, and modeling disease outbreak responses.
	SDG 9: Industry, Innovation and Infrastructure	Optimizing manufacturing processes, logistics, and infrastructure investments to improve sustainability.
Discrete Mathematics	SDG 4: Quality Education	Teaching discrete math develops critical thinking necessary for STEM fields and innovation.
	SDG 9: Industry, Innovation and Infrastructure	Graph theory helps design efficient transportation and communication networks; combinatorics optimizes manufacturing and logistics.
	SDG 17: Partnerships for the Goals	Efficient processing of large datasets helps monitor progress and coordinate global development efforts.
Classical Mechanics	SDG 3: Good Health and Well-being	Understanding body motion and forces leads to better orthopedic implants and rehabilitation systems.
	SDG 9: Industry, Innovation, and Infrastructure	Mechanical engineers use Newton's laws to create safer, more efficient industrial machines and infrastructure.
	SDG 13: Climate Action	Mechanics helps simulate storm surges, landslides, and wind patterns to improve climate resilience and disaster planning.
Special Functions	SDG 3: Good Health and Well-being	<b>Bessel functions</b> are used in modeling wave propagation in MRI and ultrasound imaging systems. <b>Gamma functions</b> appear in statistical distributions for epidemiology and public health modeling.
	SDG 6: Clean Water and Sanitation	<b>Legendre polynomials</b> and <b>Bessel functions</b> help solve boundary value problems in fluid flow and water purification systems, optimizing clean water access.
	SDG 9: Industry, Innovation and Infrastructure	<b>Hermite polynomials</b> are used in quantum mechanics and vibration analysis, aiding in the design of resilient materials and infrastructure.

## IKS Mapping

Course Name	IKS Mapping	Rationale
Real Analysis	Abstract Reasoning in Indian Philosophy	Supports abstract mathematical reasoning; Indian logic schools like Nyaya and Vedanta explore similar themes.
Abstract Algebra	Vedic Algebra and Number Systems	Indian mathematicians developed algebraic methods, including solving linear and quadratic equations.
Linear Algebra	Cosmological Dimensions in IKS	Indian cosmology describes space using multi-dimensional constructs, similar to vector space theory.
Ordinary Differential Equations	Ayurvedic Systems and Planetary Models	Indian thinkers modeled planetary and bodily dynamics in Ayurveda with differential methods.
C Programming	Algorithmic Logic in Panini's Grammar	Panini's rules mirror logic used in modern programming structures.
Numerical Analysis	Jyotisha and Numerical Methods	Traditional Jyotisha used iterative numerical approximations.
Operations Research	Optimization in Ancient Planning Texts	Indian planning texts focused on optimization of resources and logistics.
Advanced Algebra	Historical Developments in Indian Algebra	Indian algebra evolved through Brahmagupta's and Bhaskara's works.
Differential Geometry	Geometry in Sacred Architecture	Indian altars and architecture embedded principles of non-Euclidean geometry.
Mathematical Modelling	Holistic Modelling in Ancient Texts	Holistic systems modeling appears in Ayurveda and ancient city planning.
Advanced Numerical Analysis	Astronomical Calculations in Siddhanta	Interpolation used in Indian ephemerides mirrors numerical approximation methods.
Advanced Complex Analysis	Metaphysical Continuity Theories	Involves residue theorems and analytic continuation—mirrored in metaphysical ideas.
Mechanics	Karma Theory and Motion	Karma theory involved modeling motion and impact similar to Newtonian mechanics.
Number Theory	Sulba Sutras and Modular Arithmetic	The Bakhshali manuscript shows early use of primes and modularity.
Fluid Dynamics	Panchabhuta and Hydrodynamics	Flow models reflect Panchabhuta (five elements) interactions.
Basic Mathematics for Social Sciences	Planning Strategies in Arthashastra	Public planning in ancient India optimized social and economic outcomes.
Numerical Methods	Interpolation Techniques in Siddhantas	Interpolation formulas used in Siddhantas similar to numerical methods.
Discrete Mathematics	Automata in Panini's Sutras	Discrete modeling like automata is embedded in Sanskrit grammar frameworks.

# General Information (UG)

## VISION AND MISSION

### University

#### **Vision**

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavors and scholarly inquiry

#### **Mission**

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

### Department

#### **Vision**

To be an internationally recognized centre for research and teaching in Mathematics. To encourage excellence, innovation, integrity and values for society in the department. To produce global leaders for academic and industry by imparting multidisciplinary and contemporary mathematical knowledge to the students.

#### **Mission**

- To contribute towards building calibre of the students by providing quality education and research in Mathematics through updated curriculum, effective teaching learning process.
- To impart innovative skills, team-work, and ethical practices to the students so as to meet societal expectations.
- To build a strong base in Mathematics for various academic programs across the institute.

## **1. Background**

### **i) Preamble**

The LOCF (Learning Outcomes based Curriculum Framework) committee constituted by University Grants Commission (UGC) submitted its report concerning the syllabi for Integrated BSc-MSc (Mathematics). The committee discussed the framework of syllabi in its meetings and suggested implementation of these syllabi in the Departments/Schools of Mathematics in Universities/Colleges/Institutes based on following facts:

1. The learning outcomes of each course/paper are designed so that these may help learners to understand the main objectives of studying the course.
2. This will enable learners to select elective courses/papers depending on the individual inclinations and contemporary requirements.

3. The objectives of LOCF are to mentally prepare the students to learn Mathematics leading to graduate degree with honours in Mathematics or with Mathematics as a subject.
4. These syllabi in Mathematics under CBCS are recommended keeping in view applications of Mathematics in science, engineering, social science, business and a host of other areas.
5. The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and healthcare sectors.
6. The LOCF committee in Mathematics has prepared this draft paying suitable attention to objectives and learning outcomes of the courses/papers. These syllabi may be implemented with minor modifications with appropriate justifications keeping in view regional, national and international context and needs.
7. The outcomes of each course/paper may be modified as per the local requirements.
8. The text books mentioned in references are denotative/demonstrative. The divisions of each paper in units are specified to the context mentioned in courses. These units will help learners to complete the study of concerned paper in certain periods and prepare them for examinations.
9. The papers are organized considering the credit load in a particular semester. The core courses/papers of general interest are suggested for semesters I to IV. The elective courses and advanced courses are proposed for the Integrated BSc-MSc (Mathematics) students of semesters V and VI.
10. Mathematics is a vast subject with immense diversity. Hence, it is very difficult for every student to learn each branch of Mathematics, even though each paper has its unique importance. Under these circumstances, LOCF in Mathematics suggests a number of elective papers along with compulsory papers. A student can select elective papers as per her/his needs and interests.
11. The committee expects that the papers may be taught using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB, Maxima and R to strengthen the conceptual understanding and to widen up the horizon of students' self-experience.
12. The committee of the LOCF in Mathematics expects that the concerned departments/colleges/institutes/universities will encourage their faculty members to include necessary topics in addition to courses suggested by LOCF committee. It is hoped that the needs of all round development in the careers of learners/students will be fulfilled by the recommendations of LOCF in Mathematics.

## **ii) Introduction:**

One of the significant reforms in the undergraduate education is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. Outcome based learning is the principal end of pedagogical transactions in higher education in today's world in the light of exponential changes brought about in science and technology, especially in Mathematics, and the prevalent utilitarian world view of the society. The learning outcomes are attained by students through skills acquired during a Program of study. Program learning outcomes will include subject-specific skills and generic skills, including transferable global skills and competencies. It would also focus on knowledge and skills that prepare students for further study, employment, and citizenship. They help ensure comparability of learning levels and academic standards across colleges/universities and provide a broad picture of the level of competence of graduates.

The quality education in a subject like Mathematics is a very challenging task for Higher Education System in India. UGC has already taken an appropriate measure to define the minimum levels of learning for Mathematics courses for undergraduate and post-graduate levels. The quality of higher education in Mathematics should be improved in such a manner that young minds are able to compete in this field globally in terms of their knowledge and skills in the globalized era of the date. Also, there is an urgent need of sustained initiatives to be taken by colleges/institutes/universities for outcome-oriented higher education in Mathematics so that

graduates are enabled to enhance the chances of employability. Presently, the goal of higher education in Mathematics may be achieved using the following measures:

- i. Curriculum reform based on learning outcomes-based curriculum framework (LOCF).
- ii. Improving learning environment and academic resources.
- iii. Elevating the quality of teaching and research.
- iv. Involving students in discussions, problem-solving and out of box thinking about various ideas of Mathematics and their applicability, which may lead to empowerment and enhancement of the social welfare at large.
- v. Encouraging the learners to make use of LOCF to learn Mathematics through distance education.
- vi. Motivating the learners to understand various concepts of Mathematics keeping in view the regional context.
- vii. Enabling learners to create research atmosphere in mathematical sciences in their colleges/institutes/universities.
- viii. Teach courses of Mathematics based on Choice Based Credit System (CBCS).

One of the benchmarks to measure progress of a country is the advancement of knowledge of Mathematics. Hence, innovative measures should be taken to improve the quality of mathematical knowledge in our society. This is also because Mathematics has wide ranging applications in engineering, technology and a host of other areas.

### **iii) Learning Outcomes Based Approach to Curriculum Planning:**

The Integrated BSc-MSc (Mathematics) degree is awarded to the students on the basis of knowledge, understanding, skills, attitudes, values and academic achievements sought to be acquired by learners at the end of these Programs. Hence, the learning outcomes of Mathematics for these courses are aimed at facilitating the learners to acquire these attributes, keeping in view of their preferences and aspirations for knowledge of Mathematics.

The LOCF in Mathematics has helped in designing courses in the light of graduate attributes, description of qualifications, courses and Program learning outcomes. The committee has tried to frame the syllabi of Mathematics courses in such a way that it may lead to all round development and delivery of complete curriculum. Hence, it provides specific guidelines to the learners to acquire sufficient knowledge during this Program.

The objective of LOCF (Mathematics) is to prepare the syllabi having standard level of study. It is also aimed at prescribing standard norms for teaching-learning process and examination pattern. Hence, the Program has been chalked out in such manner that there is scope of flexibility and innovation in

- i. modifications of prescribed syllabi.
- ii. teaching-learning methodology.
- iii. assessment technique of students and knowledge levels.
- iv. learning outcomes of courses.
- v. inclusion of new elective courses subject to availability of experts in colleges/institutes/universities across the country.

### **iv) Nature and Extent of Integrated BSc-MSc (Mathematics) Program:**

Mathematics is the study of quantity, structure, space and change. It has very broad scope in science, engineering and social sciences. The key areas of study in Mathematics are:

1. Calculus
2. Algebra
3. Geometry
4. Differential Equations
5. Analysis
6. Mechanics

Degree programs in Mathematics cover topics which are already mentioned in details under various headings in Section 6. The depth and breadth of study of individual topics depend on the nature and devotion of learners in specific Mathematics Programs.

As a part of effort to enhance employability of Mathematics graduates, the courses have been designed to include learning experiences, which offer them opportunities in various sectors of human activities. In this context, the experience of the project work in the areas of applications of Mathematics has a key role.

## **2. Aims of Integrated BSc-MSc (Mathematics) Program:**

The overall aims of Integrated BSc-MSc (Mathematics) Program are as follows:

- To create deep interest in learning Mathematics.
- To develop broad and balanced knowledge and understanding of definitions, concepts, principles and theorems.
- To familiarize the students with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences.
- To enhance the ability of learners to apply the knowledge and skills acquired by them during the Program to solve specific theoretical and applied problems in mathematics.
- To provide students/learners sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics.
- To encourage the students to develop a range of generic skills helpful in employment, internships and social activities.

### **2.1. Key Outcomes Underpinning Curriculum Planning and Development**

The LOCF in Mathematics desires to propose the courses of Mathematics for Integrated BSc-MSc (Mathematics), based on the expected learning outcomes and academic standards which are necessary for the graduates after completing these Programs. The committee considered and discussed the following factors seriously:

- i. Framing of syllabi
- ii. Learners attributes
- iii. Qualification descriptors
- iv. Program learning outcomes
- v. Course learning outcomes
- vi. Necessity of having elective courses
- vii. Applications of Mathematics
- viii. Employability in banking, finance and other sectors.

## **3. Integrated BSc-MSc Attributes**

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.

### **3.1. Disciplinary knowledge:**

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

### **3.2. 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 communicate long standing unsolved problems in Mathematics.

- iv. Ability to show the importance of Mathematics as a precursor to various scientific developments since the beginning of the civilization.
- v. Ability to explain the development of Mathematics in the civilizational context and its role as queen of all sciences.

### **3.3. 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 them in various problems appearing in different branches of Mathematics.

### **3.4. Problem solving:**

- i. Capability to solve problems in computer graphics using concepts of linear algebra.
- ii. Capability to solve various models such as growth and decay models, radioactive decay model, drug assimilation, LCR circuits and population models using techniques of differential equations.
- iii. Ability to solve linear system of equations, linear programming problems and network flow problems.
- iv. Ability to provide new solutions using the domain knowledge of Mathematics acquired during this Program.

### **3.5. 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.

### **3.6. Information/digital literacy:**

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

### **3.7. Self-directed learning:**

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

### **3.8. 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.

### **3.9. Lifelong learning:**

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

## **4. Qualification descriptors for Integrated BSc-MSc (Mathematics) Program**

The qualification descriptors suggest generic outcomes and attributes to be obtained while obtaining the degree of Integrated BSc-MSc (Mathematics) Program. The qualification descriptors indicate the academic standards on the basis of following factors:

- i. Level of knowledge
- ii. Understanding
- iii. Skills

- iv. Competencies and attitudes
- v. Values.

These parameters are expected to be attained and demonstrated by the learners after becoming graduates in these Programs. The colleges/institutes/universities should consider the above mentioned parameters at the time of designing, approving, assessing and reviewing academic Programs containing common courses for Integrated BSc-MSc (Mathematics) Program. The learning experiences and assessment procedures should be so designed that every graduate with Mathematics may achieve the Program learning outcomes with equal opportunity irrespective of the class, gender, community and regions. Each graduate in Mathematics should be able to:

- i. demonstrate fundamental systematic knowledge of Mathematics and its applications in engineering, science, technology and mathematical sciences. It should also enhance the subject specific knowledge and help in creating jobs in various sectors.
- ii. demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.
- iii. apply knowledge, understanding and skills to identify the difficult/unsolved problems in Mathematics and to collect the required information in possible range of sources and try to analyse and evaluate these problems using appropriate methodologies.
- iv. fulfill one's learning requirements in Mathematics, drawing from a range of contemporary research works and their applications in diverse areas of mathematical sciences.
- v. apply one's disciplinary knowledge and skills in Mathematics in newer domains and uncharted areas.
- vi. identify challenging problems in Mathematics and obtain well-defined solutions.
- vii. exhibit subject-specific transferable knowledge in Mathematics relevant to job trends and employment opportunities.

## 5. Program Learning Outcomes of Integrated BSc-MSc (Mathematics)

Bachelor's degree in Mathematics is the culmination of in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of Mathematics. This also leads to study of related areas like computer science and statistics. Thus, this Program 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 Program 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 to behave responsibly in a rapidly changing interdependent society.
3. Students completing this Program 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 Program will also enable the learners to join teaching profession in primary and secondary schools.
5. This Program 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.

## **6. Structure of Integrated BSc-MSc (Mathematics) Program**

The Integrated BSc-MSc (Mathematics) is five-year degree program divided into 10 semesters. A student is to earn the required credits as per University ordinance and UGC guidelines. The scheme and syllabi of the program are subject to change according to the UGC guidelines, NEP 2020 and University ordinance.

**Duration:** Integrated BSc-MSc (Mathematics) is a full-time integrated program offered by the Department of Mathematics. This is a 5-year program, consisting of 10 semesters, two per year.

**Eligibility:** 10+2 in Science Streams or equivalent from any recognized board in India with Mathematics as one of the subjects having minimum 50% marks or equivalent grade in aggregate for UR category and 45% or equivalent grade for SC/ST/OBC/PWD/EWS candidates.

### **6.1. Course learning outcomes**

Course learning outcomes of each course in Integrated BSc-MSc (Mathematics) Program have been enshrined in the beginning of course contents of each course.

<b>B.Sc. (Hons) Mathematics</b>															
<b>CORE COURSES (14)</b>															
<b>Program outcomes</b>	<b>Calculus</b>	<b>Algebra and Geometry</b>	<b>Multivariable Calculus</b>	<b>Ordinary Differential Equations</b>	<b>Real Analysis</b>	<b>Group Theory</b>	<b>Probability and Statistics</b>	<b>Mechanics</b>	<b>Linear Algebra</b>	<b>Partial Differential Equations and Calculus of Variations</b>	<b>Set Theory and Metric Spaces</b>	<b>Advanced Algebra</b>	<b>Complex Analysis</b>	<b>Numerical Analysis</b>	
Disciplinary knowledge	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Communication skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Critical thinking	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Analytical thinking	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Problem solving	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Research related skills				√						√		√	√		
Information literacy	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Digital literacy			√			√								√	
Self-directed learning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Lifelong learning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Professional skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Applicational skills	√		√	√			√	√	√	√				√	
Experimental learning	√	√	√	√	√		√	√	√	√			√	√	
Employability options	√		√				√		√	√				√	
<b>DISCIPLINE SPECIFIC ELECTIVE COURSES</b>															
<b>Program</b>	<b>Tensors and Differential Geometry</b>	<b>Mathematical Logic and Fourier Analysis</b>	<b>Integral Transform and Coding</b>	<b>Linear Programming</b>	<b>Information Theory and Coding</b>	<b>Graph Theory</b>	<b>Special Theory and Relativity</b>	<b>Discrete Mathematics</b>	<b>Waves and Applications</b>	<b>Number Theory</b>	<b>Mathematical Finance</b>	<b>C++ Programming for Mathematics</b>	<b>Cryptography</b>	<b>Advanced Mechanics</b>	<b>Dissertation on Any Topic of Mathematics</b>
Disciplinary knowledge	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Communication skills	√	√			√	√		√			√	√		√	
Critical thinking	√	√	√	√	√	√		√	√	√	√	√	√	√	√
Analytical thinking	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Problem solving	√	√	√	√	√	√	√	√	√	√	√	√	√	√	

Research related skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Information literacy			√	√	√			√			√				
Digital literacy			√	√	√			√			√				
Self-directed learning	√	√	√	√	√	√		√	√	√	√	√		√	√
Lifelong learning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Professional skills	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Application skills			√	√	√	√		√	√		√	√	√		
Experimental learning				√	√	√		√	√		√	√	√		
Employability options				√	√			√	√		√	√	√		